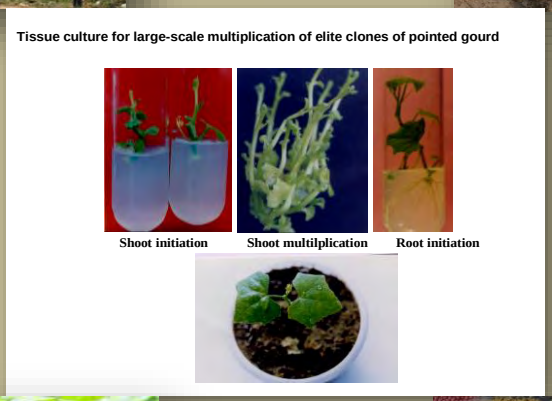
# Hi -tech Nursery and Quality Transplant Production in Vegetable Crops

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# FOREWORD

India is a leading vegetable producing country in the world with an annual production of 184.9 million MT in an estimated area of 10.26 million ha, having the productivity of 18.43 MT/ ha (NHB, 2018-19), ranking next to China. In the recent past, the country has made quantum jump in production but our productivity in most of the vegetables is low as compared to China and other leading vegetable producing countries. The higher productivity in these countries is due to the coverage of maximum area under hybrids unlike open pollinated varieties in India. The area under hybrids varies with the crop, season and availability of hybrid seeds in our country for example, area under hybrid tomato is 40 %, cabbage 68.6%, brinjal 82% and okra covers around 10 percent whereas, a country like Japan is having entire area under hybrid in most of the vegetables. In our country, the major bottle neck in expansion of area under hybrid vegetables can be attributed to the limited availability of high-quality seeds of released hybrids and escalating cost of hybrid seeds in the market. Further, traditional practices of nursery raising deprive the farmers of the opportunity of converting each viable hybrid seed into vigorous seedling. This warrants growers to adopt hi -tech nursery raising techniques to harness the full potential of hybrids and getting maximum return on account of initial expenditure incurred on seed cost.

Nurseries specialized in quality transplant production, grow plants in greenhouses, buildings of glass or plastic tunnels, designed to protect young plants from harsh weather, while allowing access to light and ventilation. Modern greenhouses allow automated control of temperature, ventilation, light, watering and feeding. Modern nurseries provide employment opportunities for technical, skilled, semi-skilled, and unskilled labourers. Further, “success of any production system depends on the kind of seed we are sowing", so is true with seedlings. Healthy vegetable seedlings grown in a well-managed nursery will decide the yield and consequently the profit of growers. Thus, nursery can itself be a very remunerative enterprise in enhancing the vegetable production in our country.

I appreciate the efforts of the author and contributors who have worked meticulously to bring out this manual on “Hi -tech Nursery and Quality Transplant Production in Vegetable Crops”. I am sure that practical information given on the various aspects of quality seedlings production in vegetable crops will be of immense use to the vegetable growers, students and extension functionaries who are directly or indirectly associated with vegetable farming.

(Arvind Kumar)

# Preface

The Country has made quantum jump in vegetable production, which has increased from 58.53 MT to 184.40 MT since 1991-92 to 2017-18. Apart from nutritional benefits, the production of vegetables improves the economy of a country as these are a very good source of income and employment. The contribution of vegetables remains highest (59 – 61%) in horticulture crop productions over the last five years (NHB-2017-18). In view of the burgeoning population, ceaseless fragmentation of land holdings and incessant growth of urbanization, our effort should be in the direction of enhancing the vegetable production in vertical mode through increasing productivity per unit area. Vegetable productivity (17.97t/ha) in India is comparatively low as compared to China. Healthy seedlings are indispensable component among all inputs of vegetable cultivation. In the recent past, with the introduction of promising hybrids and their costly seeds have compelled the growers to switch over from traditional practices of nursery rising to opt for modern scientific methods of nursery raising. In vegetable crops, genetic improvement is a continuous process to breed new varieties and hybrids having significant superiority over existing one in terms of yield potential, ability for biotic and a-biotic resistance. In our country, AICRP (Vegetable Crops) is one of the most efficient platforms, knitting the organizations working under Public Sectors as well as Private Sectors to identify the varieties/ hybrids suitable for different agro-climatic zones of the country. A number of promising varieties and hybrids of more than 20 important vegetables grown in the country have been evolved under this umbrella which has been recommended for cultivation under specific climatic zone. AICRP (VC) also monitors breeder seed production of released varieties, thus enabling the availability of seeds to the growers. Under introductory chapter of Hi -tech Nursery and Quality Transplant Production in Vegetable Crops' manual, a detailed list of promising varieties and hybrids of important Solanaceous and *Brassica* vegetables have been given, which will be very helpful to the growers in selecting the suitable varieties and hybrids for cultivation.

In the recent past, significant advances have been made in strengthening the seed health in a number of crops. Among various steps followed to strengthen the seed health, seed coating is a tool for establishing and stimulating seed quality with the application of a number of chemicals, bio-formulations and protectants. Further, priming treatments of the seeds enhances the germination mechanisms resulting in increased germination, uniform emergence, germination under optimal and sub optimal environments and improved seedling vigor and growth. These techniques have been briefly summarized in the users' language under the Chapter- III of the manual. Further, significant advances have been made in standardizing the various rooting media which not only facilitates in germination of seeds and growth of vigorous seedlings but also avoid the number of soils borne diseases which are major bottle neck in raising the nursery in open field condition. In this manual, under Chapter -2, practical information about different rooting media, their merits and chemical properties have been described in a very comprehensive manner which is very useful for those gardeners/ vegetable growers who are attempting to raise quality seedlings and off-season seedling production under protected conditions to fetch early market. As the seeds of hybrid vegetables are very costly, grower's every effort should be to convert each seed in to vigorous seedlings. In this context,

raising the seedlings under protected structures provide an ample opportunity to save the emerging seedlings from uncomfortable weather conditions prevailing under open field conditions, scorching heat and rain drops. Under Chapter-4 of the manual, complete information about different types of protected structures and potting plugs etc. have been given which are grower- friendly technologies. Seedlings raised in nursery/ protected structures are sometime too delicate to bear the shocks when transplanted under open field conditions, warrants attention of nurserymen / growers to follow the tips of hardening of seedlings. Apart from this, adaptation of effective plant protection measures right from selection of disease resistant varieties/ hybrids to seed treatments and dressing the nursery soil with eco-friendly bio-inoculants and avoiding the tender seedlings from attack of any serious disease and pests in the nursery is an important task to obtain the healthy seedlings. Chapter VIII of the manual covers valuable and practical information to address this menace in nursery raising operations.

Among the different groups of vegetables, cucurbitaceous vegetables occupy an importance place, owing to highest number of vegetables falling under family Cucurbitaceae, further with great diversity in the nature of their flowering mechanism and fruiting behavior, annual to perennial nature etc. Pointed gourd, ivy gourd, sweet gourd, *Momordica dioica* and *Solena amplexicaulis* are dioecious in nature and mainly propagated by their tuberous roots. Dioecism laced with ticklish propagation nature makes it difficult for new users to get ample planting materials resulting in very meager area under these under-exploited but nutritionally rich vegetables. Chapter -7 of the manual under head "Quality transplant production in dioecious cucurbits'' contain detail and practical tips to regenerate the planting materials of these nutritionally rich minor vegetables.

The author is extremely thankful to Prof. Arvind Kumar Hon'ble Vice Chancellor Rani Lakshmi Bai Central Agricultural University, Jhansi for giving his consent of organize Webinar/ Training on "Nursery Management and Quality Transplant Production in Vegetable Crops" on 17$^{th}$ July 2020 and giving his valuable suggestions and guidance for developing modern scientific vegetable nursery for quality transplant production. The author is also thankful to all contributors who meticulously drafted their chapters in very efficient and scientific manner. The author firmly believes that information given in the manual will be of immense use to vegetable growers, nurserymen, extension functionaries and all those who are directly or indirectly involved in vegetable farming.

(A.K. Pandey)

# Content

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# Chapter-1

# Quality Transplant Production in Vegetables: Needs and Importance

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India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Over the last decade, the area under horticulture grew by 2.6% per annum and annual production increased by 4.8%. During 2017-18, production of horticulture crops was 311.71 Million Tonnes from an area of 25.43 Million Hectares (Fig.1.1).

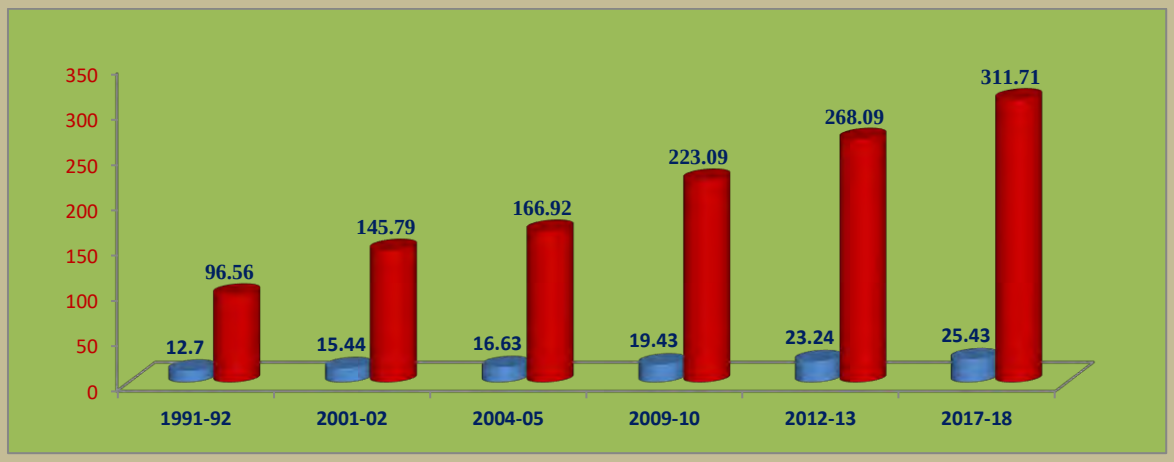


Fig.1.1.Growth of Horticulture in India (Area million ha and production m MT)

**Vegetables**

The intake of 350-400 g vegetables per caput per day is associated with reduced incidence of many common forms of cancer, and diets rich in plant foods are also associated with a reduced risk of heart disease and many chronic diseases of ageing. Vegetables contain phyto-chemicals that have anti-cancer and anti-inflammatory properties which confer many health benefits. Many phyto-chemicals are colourful, and recommending a wide array of colourful vegetables to avoid a number of diseases. For example, tomato contains lycopene which is localized in the prostate gland and may be involved in maintaining prostate health, and which has also been linked with a decreased risk of cardiovascular disease. Broccoli,

Brussels sprouts and Kale, contain glucosinolates which have also been associated with a decreased risk of cancer. Garlic and other alliums contain allyl sulphides which may inhibit cancer cell growth. Several studies have suggested a strong link between dietary phyto-chemical intake and a reduced risk for cardiovascular disease. Dietary flavonoids have been inversely correlated with mortality from coronary artery disease, plasma total cholesterol and low-density lipoprotein (LDL). Oxidized LDL has been proposed as an atherogenic factor in heart disease, promoting cholesterol ester accumulation and foam cell formation. Dietary antioxidants from vegetables get incorporated into LDL, and become oxidized themselves, thus preventing oxidation of polyunsaturated fatty acids. Phyto-chemicals also reduce platelet aggregation, modulate cholesterol synthesis and absorption and reduce blood pressure. Systemic inflammation may also be a critical factor in cardiovascular disease. C-reactive protein, an inflammatory marker, may be a stronger predictor of cardiovascular disease that LDL cholesterol, and the anti-inflammatory activity of phytochemicals may play an important role in the health of the heart.

In the country, production of vegetables has increased from 58.53 Million Tonnes to 184.40 Million Tonnes since 1991-92 to 2017-18 (Fig.1.2). Apart from nutritional benefits, the production of vegetables improves the economy of a country as these are very good source of income and employment. The contribution of vegetables remains highest (59 – 61%) in horticulture crop productions over the last five years (NHB-2017-18).

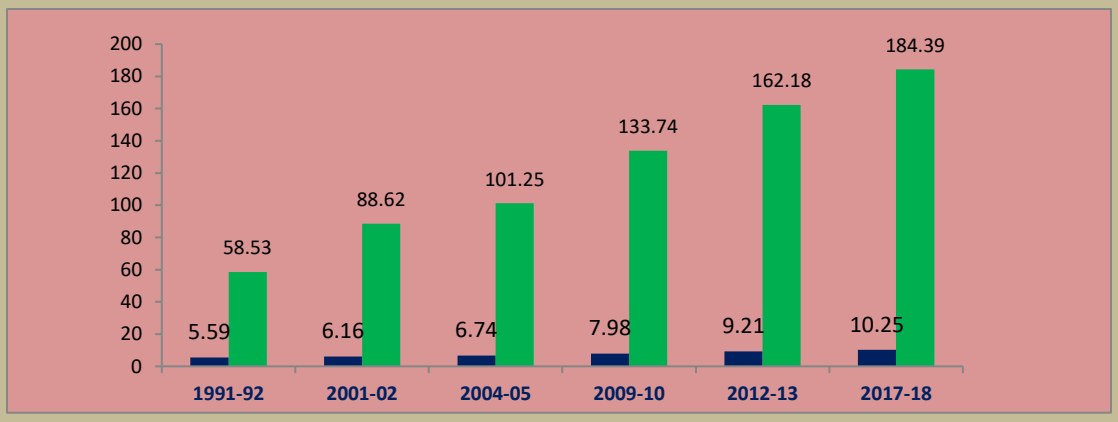


Fig.1.2. Vegetable production in India (Area million ha and production mMT)

**Quality seed - fulcrum of production**

Seed is a key component among all inputs for sustainable crop production. It is estimated that quality of seed accounts for 20-25% of productivity. The importance of quality seed has been realized by mankind long ago. The need for a good viable seed for prosperity of human race is mentioned in Rigveda of ancient India. It is mentioned in the primeval

*Manusmriti* as "*Subeejam Sukshetre Jayate Sampadyate* (Poonia, 2013) which literally means "A good seed in a good field will win and prosper". It clearly indicates that use of high quality seed plays a pivotal role in the crop production. The use of poor quality seeds nullifies the utility of all agronomic practices and every other input applied to the crop no matter how lavishly they are applied. Economically, the cost of seed is a very small component of the total cost of production. It is therefore, important to use the seed confirming to the prescribed standards in terms of high genetic purity, physical purity, physiological quality and health quality.

**Global Seed Market**

International Seed Federation (ISF) estimates that global seed market is expected to grow at an annual growth rate of 9.4 per cent over the next 5 years. Global commercial seed market has been predicted to reach USD 92 Billion by the year 2020 (Fig.1.3), driven primarily by the increasing demand for food in tandem with the growing global population, rising standards in global farming, and extensive use of biotechnology in seed development. In last 10 years, global seed industry has grown by almost 100 per cent reaching $ 45 billion and is posed to see the same growth by 2020 ( around$ 92billion ) ( Fig. .3) .

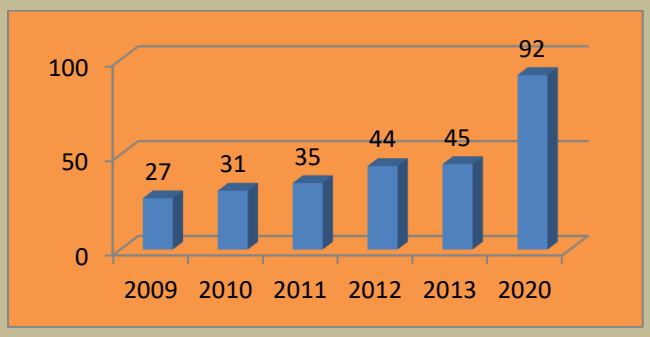


Fig.1.3. Global seed market (Value in USD)

Source: ISF and Sathguru analysis

**Indian Seed Industry**

In 2018, the Indian seeds market reached a value of US$ 4.1 Billion, registering a CAGR of 15.7% during 2011- 2018(Fig.1.4). It is further expected to grow at a CAGR of 13.6% during 2019-2024, reaching a value of US$ 9.1 Billion by 2024. Coupled with increasing domestic demand and demand for quality seeds in various foreign countries, mainly the South East Asian countries, seed industry in India is witnessing new paradigms of growth and development. The use of hybrid seeds has silently but consistently witnessed growth along with several other driving factors.

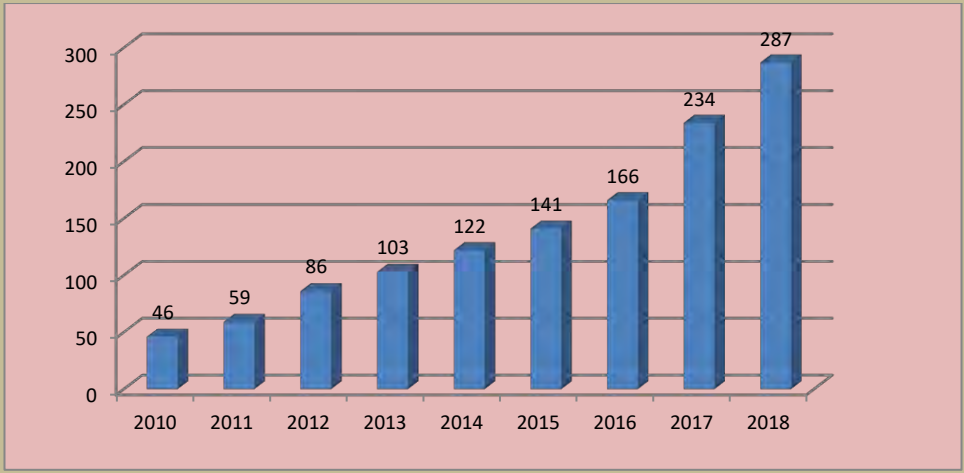


Fig.1.4. Value: Billion rupees

**Vegetable Seed Market**

The Global Vegetable Seeds Market is estimated to be valued at USD 8.77 billion in 2018 and is projected to reach USD 14.00 billion by 2025, at a CAGR of +8.10% from 2019.Increasing health consciousness among consumer and growth in the food industry is driving the Hybrid Vegetable Seeds Market. The increasing global population is leading to hike in the demand for vegetables which a major reason for commercial seed growers constantly investing in production facilities which focuses mainly on the quality and sustainability of hybrid vegetable seeds.

The Indian market for vegetable seed is projected to grow at a CAGR of 9.8% for the forecast period between 2020-2025. Most of the vegetable seeds companies in the country are focused on the production of tomato, cabbage, brinjal, chili, okra, and cucumber seeds. Among all the vegetable seeds, cabbage and tomato hold the highest seed replacement rate. At present, only less than 15% of seeds used by the farmer are good quality seeds, and the rest of the seed demand is being satisfied by the saved seeds of farmers from the previous season.

**Import of Vegetable Seeds**

India is the tenth largest importer of vegetable seeds by value and seventh largest importer by volume, in the world. It accounted for about 1% of the total vegetable seed imports by volume during 2018. Chile, Thailand, Italy, China, New Zealand, South Korea, Philippines, Indonesia, and the Netherlands are the major countries exporting vegetable seeds to India. Chile, Thailand, and Italy are the largest exporters, which, collectively, account for more than 50% of the total import of vegetable seeds by India.

**India's Export of Vegetable Seeds**

Export of Vegetable Seeds from India is 11.99,000 MT, valuing Rs. crores 745.95 / US$ Mill

107.76 during 2018-19. Major destinations of vegetable seeds exports from India are Netherlands (25.42 Mill USD), followed by USA (22.25 Mill USD), and Pakistan (17.1 Mill USD) (Fig.1.5).

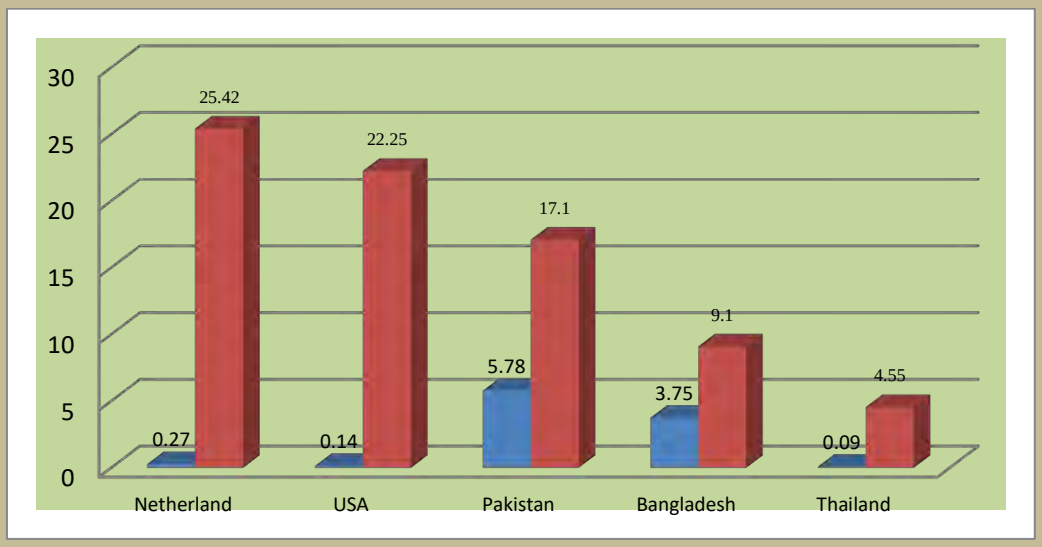


Fig.1.5. Export of vegetable seeds (Quantity 000MT, Value USD)

**Vegetable Seed Production**

The state of Karnataka produces nearly 90% of the total hybrid vegetable seeds, the major areas being located around Rane Bennur in the northern part of the State. Availability of trained labour and guaranteed returns and incentives for quality has helped in setting up of several seed villages. The returns can be as high as three times as that of crops for market purpose from the same area. This has also helped in improving the socio-economic scenario of these regions, including overall prosperity, narrowing down of rural / urban divide and employment generation especially for village women and youth. It is estimated that the total employment generation is over 7,00,000 in this sector. This is one of the most significant achievements of this agricultural activity leading to improved per capita income and quality of life. Hard work and diligence of the farm workers involved have helped in meeting the international seed quality standards, which in turn has led to continued growth of the business. New areas for production are also being added, extending this benefit to other rural areas. India has a major advantage in having a choice of latitudes and altitudes to select appropriate seed production areas. Some of the progressive companies have also set up greenhouses for successful production for difficult-to produce crops like capsicum. Availability of quality technical expertise, increased production and productivity of hybrid seeds of international standards,

reduced risks and maintaining low costs have helped to make custom seed production a viable opportunity for foreign companies in India.

**Hybrid Technology**

Hybrid technology in vegetable production is one of the most novel options particularly due to the fact that full potential of hybrid vegetable crops have not been exploited as compared to other crops in spite of realizing the potential of vegetable more than 4 to 5 times as compared to cereals. In recent past, much emphasis has been given to exploit heterosis in several economically important vegetable crops like tomato, brinjal, pepper, cabbage, and cauliflower, other cole crops radish, carrot and cucurbits, etc. Tremendous efforts have been made by both public and private sectors in developing the hybrid in a number of vegetable crops. The share of hybrid varieties in several vegetable crops has gradually been increasing.

With intensive cultivation using hybrids, the average yields under open field condition in India has been steadily increasing and the yield difference with developed countries is getting narrower. It is not uncommon to see growers achieving yields of 100 tonnes per hectare in tomato, 50 tonnes/ha in watermelon, 70 tonnes/ha in eggplant and 35 tonnes/ha in chilli pepper. The advantages conferred by hybrids include higher yields, increased harvesting period, better adaptability, better transport quality favoring the growers and occasional disease resistance. The consumers are benefited by better quality of hybrids, in terms of eye appeal, keeping quality and the hidden and yet, all-important nutritional value. Realizing the benefits that accrue in terms of productivity and the possibility of enhanced income, hybrid cultivation has become popular in traditional vegetable belts, besides having high productivity that attracts the farmers to buy the quality seeds. The seed companies have several direct and indirect benefits of marketing $F_1$hybrid vegetable varieties like i) Advanced plant breeding techniques, ii) Wide range of pollination systems, iii)Low seed rate, iv) Built-in protection of hybrids, v) 100% Seed replacement and vi) Negligible scope of degeneration.

**Hybrid varieties**

Hybrid varieties have been evolved in those high valued vegetable crops which exhibit marked heterosis such as solanaceous vegetables (tomato, eggplant, chilli, sweet pepper), cucurbits (melons, watermelon, cucumber, squash, pumpkin and gourds), cole crops (cabbage and cauliflower), root and bulb crops (onion, radish, carrot) and fruit vegetable like okra. The popularity of F1 hybrid cultivars is due to their vigour, uniformity, disease resistance, stress

tolerance and good horticultural traits including earliness and long shelf-life expressed and therefore giving consistent stable high yield.

**Enhancement of Seed Replacement Rates**

The socio-economic status of the farmer does not permit to purchase quality seeds. Therefore, the seed replacement rate is very low. The realistic indents and production of breeder seed of different crop varieties by maintaining quality can enhance SRR. Seed Replacement Rate is the rate at which the farmers replace the seeds instead of using their own seeds. Seed replacement rate in different vegetables have been given in fig (1.6).

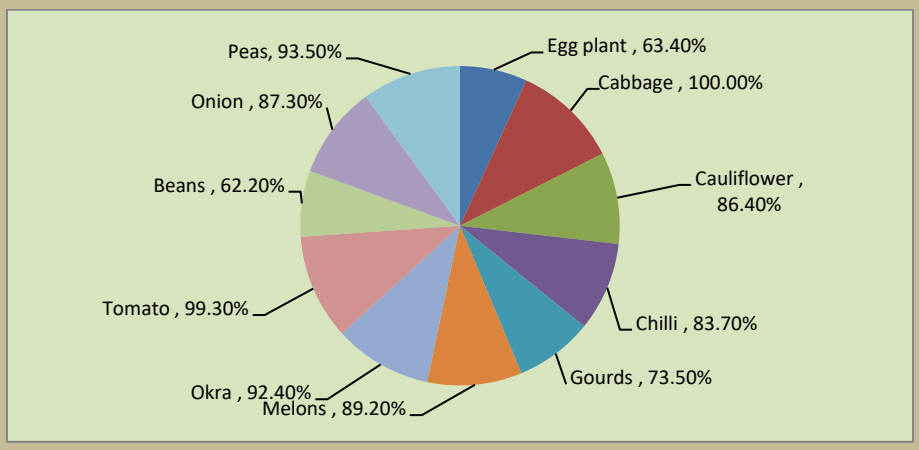


Fig. 1.6.Seed Replacement rate in vegetables

**Advantages of Nursery Raising:** Nursery raising is an essential practice owing to the following reasons (Nandpuri and Surjan Singh, 1986):

1. It is convenient to look after the 'baby seedlings' with better care in nursery bed.
2. The size of seeds being small, it is almost impossible to do direct sowing properly.
3. The hybrid seeds being expensive can receive better care and thus ensuring uniform crop stand.
4. The land can be economically used as it can be put under some other crop when the nursery is being raised.
5. Less expense is involved in controlling insect-pests and diseases in nursery beds.
6. Undesirable seedlings can be discarded at the time of transplanting.
7. Availability of sufficient time for field preparation, manure and fertilizer application after harvesting the previous crop.

**Selection of Vegetable Varieties and Hybrids for Raising the Quality Transplants**

Enhanced and quality production of vegetables greatly depend upon selection of promising varieties and hybrids that are better adapted to ecologically based production

practices than those currently available, which were bred for high-input agriculture. Selected varieties/ hybrids should use nutrients and water more efficiently, have greater resistance to insect pests and diseases, and are more tolerant to drought, flood, frost and higher temperatures. Recommended varieties need to be adapted to less favoured areas and production systems, produce food with higher nutritional value and desirable organoleptic properties, and should have excellent horticultural traits for alluring the consumers to fetch better price in the markets besides having traits to improve the provision of ecosystem services. A list of promising varieties and hybrids of solanceous vegetables and cauliflower is given as under:

**Promising varieties of Tomato and their attributes**

| Varieties | Description | Photograph |
|---|---|---|
| **Arka Vikas** | Developed through pure line selection from a American variety Tip-Top at ICAR-IIHR, Bengaluru in 1999. Plants are semi-determinate with narrow dark green foliage and good canopy. Fruits medium large (80-90 g), oblate with light green shoulder, which develop deep red on ripening. Bred for fresh market. Adapted to both rainfed and irrigated conditions .It has yield potential of 400-425 q/ha in 140 days of crop duration. Recommended for cultivation in J&K, H.P., Uttarakhand, Punjab, U.P., Bihar, Jharkhand, Chhattisgarh, Orissa, A.P., Rajasthan, Gujarat, Haryana, Delhi, M.P., Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **Arka Alok** | Developed through pure line selection from IIHR-719-1-6 (CL-114-5-1-0) from AVRDC, Taiwan.at ICAR-IIHR, Bengaluru in 1992.A Fruits on the lower clusters are round, large (120g) and in later clusters oblong, medium (80g) firm fruits with light green shoulder. It has yield potential of 300-320 q/ha in 130 days of crop duration. Resistant to bacterial wilt. Bred for fresh market. Recommended for cultivation in West Bengal and Assam. |  |

| | | |
|---|---|---|
| **Arka Meghali** | Developed through pedigree selection (F8) of the cross ArkaVikas x IIHR-554 at IIHR, Bengaluru in 1996. Fruits medium (65g), oblate with light green shoulder and deep red fruits. Suitable for fresh market. The potential yield is 760.0q/ha. Suitable for rain fed cultivation in Karnataka as *Kharif* seasons crop. |  |
| **Arka Abhijit** | Developed at ICAR-IIHR, Bengaluru in 1998. Plants are semi indeterminate and leaves are dark green with good canopy. Fruits are medium (65-70 g), round with green shoulder, deep red and firm. It has yield of 600-650 q/ha. Highly resistant to bacterial wilt. Recommended for cultivation in M.P., Maharashtra and Goa. |  |
| **Pant T-10 (Pant Tomato-10)** | Developed by GBPUAT, Pantnagar in 2009. It is a determinate variety tolerant to blight. TSS of fruit is 6.0. It has fruit yield of 350-450 q/ha. Recommended for cultivation in J&K, H.P., Uttarakhand, Punjab, U.P., Bihar and Jharkhand |  |
| **PAU-2372** | Developed by PAU, Ludhiana, 2011. Its plants are indeterminate, vigorous and fruits are flattish round. Average yield of this variety is 450-550q/ha. Recommended at National level for cultivation in J&K, H.P.and Uttarakhand. |  |
| **ATL-O1-19 (Anand Tomato-4)** | Developed by AAU, Anand in 2011. It is a determinate variety possesses tolerant to tomato leaf curl virus disease. Plants are determinate type. Dark green shoulder on fruit at breaker stage. Circular fruit shape and big size. Red colour at maturity. It takes 80-90 days to first ripening from transplanting. It has average fruit yield 350-400 q/ha. Recommended at National level for cultivation in Rajasthan, Gujarat, Haryana and Delhi. |  |
| **VRT-0801 (Kashi Aman)** | This is a determinate tomato variety, developed by ICAR-IIVR, Varanasi in the year 2013. The | |

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| | fruits of this variety are round and firm with pericarp thickness of 0.52-0.57cm. Average fruit weight ranges from 80-110 g with 3-4 locules. The fruits are attractive red in colour with an average total soluble solid content of 4.6o Brix at red ripe stage. The yield potential of the variety ranges from 500-600 q/ha. This variety is resistant to ToLCV. Recommended at national level for cultivation Punjab, U.P., Bihar and Jharkhand. |  |
| **DARL-68** | Developed by DIBER, Pithoragarh, in 2014. It is an indeterminate variety, fruits are long oval, red coloured with thick pericarp, good keeping quality and suitable for long transit. Edible fruits contain 6.0% total soluble solids (TSS) and 4.67% dry matter content. It is tolerant to Powdery mildew under field condition. Yield potential is 320 q/ha in open field conditions and suitable for cultivation in open as well as protected conditions.Recommended for cultivation in Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunachal Pradesh, Andaman & Nicobar Islands, Punjab, U.P., Bihar and Jharkhand |  |
| **Punjab Ratta** | Developed by PAU, Ludhiana, in 2014. It is a determinate variety, having oval shaped fruits, medium sized, firm and deep red, suitable for processing.Average fruit length ranges from 4.87-6.43, fruit girth 12.38-18.29 and fruit weight 57.0 -97.33 g. TSS ranged from 4.94-6.43%. It has average yield of 562q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. | |

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| **ATL 08-21** | Developed by AAU, Anand, in 2016. Determinate variety with dark green foliage .Red colour, medium size, round shape fruitswith minimum per cent of damage by fruit borer and leaf miner. The average fruit yield of this is 450-500 q/ha. Recommended for cultivation in Rajasthan, Gujarat, Haryana and Delhi. |  |
| **Kashi Amul (VRT-1202)** | Developed by ICAR-IIVR, Varanasi, 2016. It is a semi determinate.The fruits of this variety are round and firm with a pericarp thickness of 0.5-0.6 cm and an average fruit weight of 90 g in the initial three pickings. The fruits are attractive red in colour with 3-4 locules. This variety has also shown high level of resistance in artificial screens and field tests conducted over years in disease hot spot at ICAR-IIVR, Varanasi. Average yield of 500-600 q/ha could be realised with this variety. Recommended for cultivation in Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **Kashi Adarsh (VRT-1201)** | Developed by ICAR-IIVR, Varanasi, in 2016. It is a semi-indeterminate. The fruits of this variety are round and firm with a pericarp thickness of 6 mm. Average fruit weight ranges from 80-115 g with 3-4 locules. The fruits are attractive red in colour. This variety has shown resistance to both monopartite and bipartite viruses in artificial screens, and high level of resistance in field tests conducted over years in disease hot spot at ICAR-IIVR, Varanasi. The average yield of this variety is 600 q/ha. Recommended at National level for cultivation in M.P., Maharashtra and Goa. |  |
| **BT 19-1-1-1** | Developed by OUAT, Bhubaneswar, 2019. Fruit weight 70-80g; Fruit shape: Round; Tolerant to Bacterial Wilt and has average yield 300.0q/ha. Recommended for cultivation in Jammu & |  |

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| | Kashmir (J&K), Himachal Pradesh and Uttarakhand. | |
| **Kashi Chyan** | Developed by ICAR-IIVR, Varanasi in 2019. It is an indeterminate variety, resistant to ToYLCVD carrying Ty3 gene and tolerant to early blight. Yield potential is 600 -700 q/ha in crop duration of 140 days. Recommended at National level for cultivation in Punjab, U.P., Bihar, Jharkhand, Madhya Pradesh, Maharashtra and Goa. |  |

**Promising hybrids of Tomato and their attributes**

| Hybrids | Description | Photograph |
|---|---|---|
| **Arka Ananya** | A $F_1$ hybrid of the cross TLBR-6 X IIHR-2202 developed at IIHR, Bengaluru in 2005. Plants are semi-indeterminate and dark green foliage. Medium round fruits (65-70g), firm and deep red colored having combined resistance to ToLCV and bacterial wilt. Suitable for fresh market.Recommended for cultivation throughout the country and has yield potential of 650-700q/ha. |  |
| **Arka Samrat** | High yielding $F_1$ hybrid developed by crossing IIHR-2835 X IIHR-2832developed at IIHR, Bengaluru in 2015. First $F_1$ Hybrid with triple disease resistance to ToLCV, BW and early blight. Fruits oblate to high round, large (90-110g), deep red and firm. Suitable for fresh market .Yields:80-85 t/ha. in 140 days .It has beenrecommended at National level for cultivation in Karnataka, Tamil Nadu, Pondicherry. |  |
| **Arka Rakshak** | High yielding $F_1$ hybrid developed by crossing IIHR-2834 X IIHR-2833 developed at IIHR, Bengaluru in 2010. First $F_1$ hybrid with triple disease resistance to ToLCV, Bacterial wilt and | |

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| | Early blight. Fruits square round, large (90-100g), deep red colored and firm. Suitable for fresh market and processing. Yield: 750-800 q/ha in 140 days of crop duration.This very popular hybrid attracts the interest of growers throughout the country. |  |
| **Arka Abhed** | This is a high yielding $F_1$ hybrid with multiple disease resistance to Tomato Leaf Curl Disease (*Ty2+Ty3*), Bacterial wilt, Early blight and Late blight (*Ph2 + Ph3*) developed at IIHR, Bengaluru. Plants are semi-determinate with dark green foliage, Fruits are firm, oblate round & medium large (90-100g).Suitable for summer, *kharif* & *rabi* cultivation . Bred for fresh market & yields 700-750q/ha in 140-150 daysof crop duration. |  |
| **Arka Apeksha (H-385)** | It is a high yielding hybrid developed by crossing ITHR 2834 and ITHR 2918. It has triple disease resistance to Tomato Leaf Curl Disease (Ty1+Ty2), Bacterial wilt and Early blight developed at IIHR, Bengaluru. Plants are semi-determinate with dark green foliage. Fruits are firm, deep red, oblong, medium large (90-100g) with joint-less (j2) pedicel. Fruits are suitable for processing as they have TSS (4.7° Brix), acidity (0.36%), lycopene (14.15mg/100g fresh weight). Recommended for summer, *Kharif* &*Rabi* cultivation. It has a yield potential of 430 to 900q/ha in 140- 150 days. |  |

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| **Arka Vishesh (H-391)** | It is a high yielding $F_1$ hybrid developed by crossing ITHR 2834 and ITHR 2917developed at IIHR, Bengaluru. It has triple disease resistance to Tomato Leaf Curl Disease (7y/+7y2), bacterial wilt and early blight. Plants are semi-determinate with dark green foliage and joint-less pedicle. Recommended for *Zaid*, *Kharif* &*Rabi* cultivation. It has a yield potential of 433-900q/ha in 140-150 days. Fruits are firm, deep red, oblong and medium large (90-100g). Fruits have a TSS of 4.6° Brix), acidity (0.36%) and lycopene content of 14.14 mg / 100 g fresh weight. |   |
| **BSS-488** | Developed by Bejo Sheetal Company, Jalana, in 2009. It is an indeterminate hybrid. Fruits are red and 75-80 g of weight with average TSS of 4.50 Brix. Fruits would be ready for picking in 95 days after transplanting. It gives an average yield of 550 q/ha. Recommended for cultivation in Chhattisgarh, Orissa and A.P. |  |
| **VRTH-101 (Kashi Abhiman)** | Developed by ICAR-IIVR, Varanasi, in 2011. Determinate hybrid, tolerant to tomato leaf curls virus diseaseas it carries Ty-2 gene.Fruits mature at 65-75 days after transplanting, square round fruits shape and colour is deep red when ripe. Fruits record length of 5.4 cm and 5.5 cm diameter. Locule number varies from 3 to 4. It has yield potential of 600-700 q/ha. Recommended for cultivation in J&K, H.P., Uttarakhand, Punjab, U.P., Bihar and Jharkhand. |  |
| **Bhagya** | It is a determinate hybrid developed by Nuziveedu Seeds Pvt. Ltd., in 2013. The plant growing habit of this hybrid is determinate type. Fruits are flat round, bright red in colour with uniform green on fruit shoulders, having sour taste, good firmness suitable for transportation. The average fruit weight is 80-90 |  |

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| | g. This is an early hybrid, ready for harvest after 60-65 days after transplanting. The yield potential is 300-350 q/ha. This is tolerant to ToLCV. Recommended for cultivation in Rajasthan, Gujarat, Haryana and Delhi. | |
| **CTH-1** | Developed by TNAU, Coimbatore in 2019 . Fruits flat round, thick pericarp (5.84 mm) shelf life 10 days at room temp. Fruit yield 800-900 q/ha. Recommended for cultivation in Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **Improved Bhagya** | It is a determinate tomato hybrid developed by Nuziveedu Seeds and identified for release and notification through AICRP- VC in the year 2014.It has jointed pedicle, flat round fruit shape, good firmness of fruits suitable for transportation, deep red fruit colour at ripening, 3-4 number of fruits per cluster, 5-6 mm pericarp thickness and 90-100 g per fruit weight. It is tolerant against ToLCV. Fruits are ready for harvest at 65-70 days after transplanting. The yield potential is 350-400 q/ha. This hybrid recommended for cultivation in Punjab, U.P., Bihar, Jharkhand, M.P., Maharashtra and Goa. |  |
| **Kaveri - 304 (KTH-304)** | This hybrid has been developed at Kaveri Seeds Private Limited, Nagpur and identified for release and notification through AICRP-VC in 2016. It is semi determinate to indeterminate and prolific bearer hybrid. Fruits are oval shape, deep red, big size, 90-100 g, 2-3 locules, 4-5 fruits / cluster with good firmness. Fruits are ready for first harvest in 60-65 days after transplanting. It has yield potential of 900-1000 q/ ha. It is also tolerant to blight &ToLCV. It is recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |

## Promising varieties of Brinjal and their attributes

| Varieties | Description | Photograph |
|---|---|---|
| **PB-67** | Developed by GBAU&T,Pantnagar in 2009. It is an early maturity variety, resistant to bacterial wilt and Phomopsis blight. Plants are semi erect medium tall, foliage green, fruits are green long slender with green calyx. It gives first harvest in 60 days of transplanting and has yield potential of 410q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |
| **HABR-21** | Developed by ICAR-RCER, Ranchi in 2013. The plants are intermediate in growth habit, with semi upright, stems and leaves are green. Fruits are oblong and blackish purplewith dark purple calyx. The average fruit weight varies from 300-350 g and has fruit yield of 550-600q/ha. Recommended for cultivation in Punjab, Bihar, U. P. and Jharkhand |  |
| **PBL-232** | Developed by PAU, Ludhiana, in 2019. It is an early maturing variety, Fruits medium long (16.3 cm), deep purple and shining. Calyx green; Yield: 360 q/ha. Recommended for cultivation in Rajasthan, Gujarat, Haryana, Delhi, Madhya Pradesh, Maharashtra and Goa |  |
| **Kashi Himani (IVBL-26):** | Developed by ICAR-IIVR, Varanasi, in 2019. Medium long shiny white fruits with less seeds. Suitable for *Kharif* season and have medicinal value for diabetic patient. Variety is tolerant to fruit and shoot borer, moisture deficit and lodging. It has fruit yield of 400-430q/h. |  |
| **IVBL-23** | Developed by ICAR-IIVR, Varanasi, in 2019. Tolerant to Phomopsis blight and Fusarium wilt. It is an early maturing, Fruits 14 cm, crimson colour, Fruit Wt. 150 g ; Yield: 400 q/ha yield . Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |

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| **PusaVaibhav** | Developed from ICAR-IARI, New Delhi in 2019 .Plants are tall (105-110 cm); Fruits are round (15 cm length, 7.5 cm diameter), shiny purple in colour with non-spiny green calyx, frt. Wt. 250 g; Yield potential 410 q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand |  |
| **PB-70** | Developed from GBPUAT, Pantnagar in 2010.Plants are tall, sturdy with green foliage. Resistant to Phomopsis blight, bacterial wilt and shoot and fruit borer. Fruits are oblong with green striped. Variety has yield potential of 400 q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand, Chhattisgarh, Orissa, A.P., M.P., Maharashtra, Goa, Karnataka, Tamil Nadu, Kerala and Pondicherry |  |
| **DBL-02** | Developed from ICAR- IARI, New Delhi in 2010. Plants are non-spiny, semi-erect and light pigmentation partially on younger leaves. Fruits are long and violet-purple in colour. Fruits are ready for harvest in 50-55 days after transplanting. It has fruit yield of 370-390 q/ha. Recommended for cultivation in J&K, H.P. and Uttarakhand, Punjab, U.P., Bihar, Jharkhand, Rajasthan, Gujarat, Haryana and Delhi. |  |
| **DBL-175** | Developed by ICAR-IARI, New Delhi in 2018. Plants are non-spiny having semi-erect branches with purple pigmentation on stem. Flowers are purple and medium in size. Average plant height is 60-65 cm. Fruits are long (18-20 cm), cylindrical (3.5-4.5 cm diameter), shiny purple in colour with non-spiny green calyx and average fruit weight is 100-125 g. It has fruit yield of 350-400 q/ha. Recommended for cultivation in Rajasthan, Gujarat, Haryana, Delhi, M.P., Maharashtra and Goa. |  |

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| **Arka Neelachal Shyama (IC0598429)** | Developed by IIHR-CHES, Bhubaneswar in 2018. Plants are medium in height and flowering initiates around 42 days after transplanting. Fruits oval, and purple green in colour with white patches with pink tinge towards bottom of the fruit. It has fruit yield of 350-360 q/ha. Recommended at National level for cultivation in Chhattisgarh, Orissa and A.P. |  |

**Promising hybrids of Brinjal and their attributes**

| Hybrids | Description | Photograph |
|---|---|---|
| **Rasika** | Developed by BejoSheetal Seeds Pvt. Ltd. Jalana in 2009. It has an average fruit length of 16.37 cm, fruit wt. of 94.48 g and bearing on an average 87.79 fruits/plant. The yield of the hybrid ranges from 400-580 q/ha. Its yield ranges from 400-580 q/ha. Recommended at National level for cultivation in Punjab, U.P., Bihar, Jharkhand |  |
| **Shamli** | Developed by Seminis Seeds in 2009. Long fruited hybrid.It has an average fruit length of 17.75 cm, fruit wt. of 94.49 g and bearing on an average 73.75 fruits/plant. It has yield potential of 350-650 q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |
| **VNR-51C** | Developed by VNR Seeds Pvt. Ltd., Raipur in 2009. It is a small round hybrid having average fruit weight of 60 g. It has fruit yield ranging from 450 – 500 q/ha.. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |
| **HABH-8** | Developed by ICAR-ICER, RC, Ranchi in 2009. It is a small round fruited hybrid with an average fruit wt. of 50.17 g. and has fruit yield 375-544 q/ha yield. | |

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| | Recommended for cultivation in Karnataka, Tamil Nadu, Kerala and Pondicherry. | |
| **PHBL-51** | Developed by PAU, Ludhiana in 2012. Plants are medium tall, green, flowers purple, born solitary and in cluster. Fruits are medium-long, thin, shining deep purple, calyx green. First picking starts 55-65 days after transplanting. This hybrid has yield 550-650 q/ha. Recommended at National level for cultivation in Punjab, U.P., Bihar and Jharkhand |  |
| **PBHSR-31** | Developed by PAU, Ludhiana in 2012. Plants medium tall and greenish- purple. Flowers purple and born in cluster. Fruits small-oblong, shining purple and calyx partial green. It can be harvested 50 days after transplanting. It has fruit yield 600-650 q/ha yield. Recommended for cultivation in Punjab, U.P., Bihar, Jharkhand, Rajasthan, Gujarat, Haryana and Delhi |  |
| **VNR-218** | Developed by VNR Seeds Pvt. Ltd., Raipur in 2012. It is a small long fruited hybrid, resistant to bacterial wilt. Plants are vigorous, stems and leaves are green. It is small long fruited hybrid with an average fruit wt. of 80 - 100 g. Light pink fruit colour.Can be grown in rainy season. Good for distant transportation. Resistant to bacterial wilt. Recommended at National level for cultivation in West Bengal and Assam. |  |
| **PBHL-52** | Developed by PAU, Ludhiana in 2014.It is an early maturing of long group of brinjal hybrid. Its plants are medium in height, compact, thornless with green foliage. Flowers are purple, borne in cluster and solitary. Fruits are long, medium sized, shining-purple with green calyx. Its average yield is 675 q/ha. Recommended at National level for cultivation in Punjab, U.P., Bihar and Jharkhand |  |

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| **Nishant** | Developed by Advanta seeds Pvt. Ltd in 2015. The plants are about 85cm tall, spreading type with 2-3 primary branches. Fruits are 12-15cm long, violet fruits with green calyx in clusters. It bears 20-30 fruits per plantand has yield 300- 350 q/ha. Recommended at National level for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |

**Promising varieties of Chilli and their attributes**

| Varieties | Description | Photograph |
|---|---|---|
| **Pant Chilli-3** | Developed by GBPUAT, Pantnagar in 2009. It has average plant height 85 cm and erects plants with dark green foliage. Fruit long, tolerant to LCV and anthracnose diseases. It has green fruit yield 150-175 q/ha. Recommended for cultivation in Chhattisgarh, Orissa and A.P. |  |
| **HS-HP-154** | Developed by SKUA&T, Srinagar in 2009. The plants are tall, about 75 cm of height. Fruits are 6 – 7 cm long. The average green fruit yield ranges from 150 – 200 q/ha. Recommended for cultivation in Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **Kashi Anmol (KA-2)** | Developed by ICAR-IIVR, Varanasi in 2005. Plants are determinate, bushy with nodal pigmentation on stems. Fruits pendant, attractive green, first picking can be taken 50 days after transplanting. It is suitable for green fruit production under chilli-wheat, chilli-potato cropping system. It has yield (green chilli) potential of 200-225 q/ha in a crop duration of 130-145 days. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |
| **Kashisindhuri** | Developed at ICAR-IIVR, Varanasi in 2009. It is a non-pungent type and has high oleoresin content.Fruit shape- long and pendent, dull shaped | |

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| | wrinkled, green fruit colour. It gives first picking of green chilli in about 94 days after seed sowing. It has average green fruit yield 150q/ha. Recommended for cultivation in Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **Kashi Gaurav** | Developed at ICAR-IIVR, Varanasi in 2011. Plant type-intermediate, strait and smooth dark green fruit. Fruits are 9-12cm long with 1.2-1.3cm of diameter and average fruit weight ranges 10-11g. It gives first picking of green chilli in about 85 to 90 days after seed sowing. Tolerant to anthracnose, thrips & mites. It has average green fruit yield of 150 q/ha. Recommended for cultivation in West Bengal and Assam |  |
| **Kashi Abha (VR-339)** | Developed by ICAR-IIVR, Varanasi in 2019. Fruits of this variety are short stout with blunt apex and highly pungent. Tolerant to biotic (anthracnose, CLCV, thrips and mites) and abiotic stress (low and high temperature). It has average yield 150 q/ha (green fruits) |  |
| **ACS-06-2** | Developed at AAU, Anand in 2011. It has intermediate plant growth habit. Fruits are pungent, elongated straight and compact, surface is semi wrinkle with light green colour. Fruiting starts 75-80 days after transplanting. It has green fruit yield of 110-130 q/ha. Recommended for cultivation in Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **LCA-620** | It is developed at Dr. YSRHU, RS, Lam in 2014. Plants are tall, erect and has bold and medium long (8-9 cm) fruits with medium pungency. Excellent dry fruit colour and has fruit (red ripe) yield 138 q/ha. Recommended for cultivation in Chhattisgarh, Orissa and A.P. |  |

## Promising hybrids of Chilli and their attributes

| Hybrids | Description | Photograph |
|---|---|---|
| **Rani** | Developed by VNR Seeds Pvt. Ltd., Raipur in 2010. Hybrid is tolerant to Fusarium wilt and LCV under field condition.Plants are determinate, medium tall and light green immature fruits. Fruiting starts 50-55 days after transplanting. It has fresh fruit yield of 175-200 q/ha. Recommended for cultivation in Punjab, U.P., Bihar, Jharkhand, Karnataka, Tamil Nadu, Kerala and Pondicherry. |  |
| **HH-41786** | Developed by Syngenta Seeds Pvt, Ltd in 2011. This hybrid has vigorous plant growth and attractive long fruits (about 10 cm). It has green fruit yield of 100-130 q/ha. Recommended for cultivation in M.P., Maharashtra and Goa. |  |
| **Vidya** | Evolved by VNR Seeds Ltd., Raipur in 2013. It has has medium plant height (70 cm), green leaf colour, and intermediate branching habit. Fruits are long (12 – 14 cm), light green in colour with very strong calyx attachment, wrinkled surface and mild pungent. It is tolerant to Fusarium wilt. Hybrid has green fruits yield potential of 200-220 q/ha. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand. |  |
| **CH-27** | Developed by PAU, Ludhiana in 2019. Plants spreading, tall, Fruits length 7.5 cm; pungent (0.8% capsaicin), rich in colouring matter (242 ASTA units); resistant to leaf curl virus, fruit rot and root knot nematodes; 145 q/ha yield. Recommended for cultivation in Punjab, U.P., Bihar and Jharkhand |  |
| **Kashi Ratna (CCH-12)** | This hybrid developed at ICAR-IIVR, Varanasi in 2018.It is a CMS based hybridsuitable for green chilly purpose.Tolerant to anthracnose and thrips. Hybrid has fresh fruit yield potential of 200-220q/ha. Semi erect, early maturing variety, fruit contains 0.62% (93450 SHU) capsaicin and 175.6 mg/100g Vitamin C (ascorbic acid). |  |

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| **Arka Sweta:** | This hybrid developed at ICAR-IIHR, Bengaluru in 2005. It has indeterminate plant growth habit with green foliage. It is a CGMS based high yielding hybrid with 280-300q/ha green yield and 45q/ha dry yield. Fruits are long (11-12cm), smooth, light green and turn to red colour on maturity. Field tolerant to CMV & susceptible to powdery mildew. Suitable for cultivation in Punjab, UP, Bihar & Jharkhand, Rajasthan, Gujarat, Haryana, Delhi, Karnataka, Tamil Nadu, Kerala and Pondicherry). |  |

**Promising varieties of Capsicum and their attributes**

| Varieties | Description | Photograph |
|---|---|---|
| **DARL-70** | Developed at DIBER, Pithoragadh in 2013. Fruits are uniform, green in colour with smooth, thin and bright skin. Pendent fruit bearing with 3-4 lobed per fruit. Tolerant to Fusarium wilt and powdery mildew.It has fruit yield of 200-220 q/ha yield. Recommended for cultivation in J&K, H.P. and Uttarakhand. |  |
| **KTC-1** | Developed at IARI, RS,Katrain in 2019.It is a high yielding variety with vigorous plant growth. Plant bears 6-7 fruits/plant. Average fruit weight is 70 g. It has fruit yieldof 200q/ha. Recommended for cultivation in J&K, H.P. and Uttarakhand. |  |
| **Arka Mohini** | Improvement over IIHR 312-1-2 (Titan variety) followed by mass selection. Determinate plant habit with dark green foliage, thick fleshed, 3-4 lobed dark green, blocky fruits, average fruit weight 180-200g, fruits pendent, turn red on ripening, yields 20t/ ha in 160 days . Recommended for |  |

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| | release in 1984 by SVRC and 1n 1986 by AICRP (VC) at national level. | |

**Promising hybrids of Capsicum and their attributes**

| Hybrids | Description | Photograph |
|---|---|---|
| **PRCH-101** | Developed at UUHF, Ranichauri in 2013. It is intermediate with branching habit, on an average 4 primary branches/plant are observed. Produces 9-10 fruits per plants with average fruit weight of 80 g.This hybrid has fruit yield of 300-320 q/ha. Recommended for cultivation in J&K, H.P. and Uttarakhand. |  |
| **ArkaAthulya** | High yielding F1 hybrid with powdery mildew tolerance. Plants are continuous in growth habit with dark green foliage. Suitable for fresh green market and yields 45-50t/ ha in 140-150 days. Fruits are firm, blocky with 3-4 lobes and medium large (100-120g). Suitable for *kharif* & *rabi* season cultivation under open field conditions. |  |
| **DARL-202** | Developed at DIBER, Pithoragadh in 2003. Plants are early maturing with vigorous growth. Fruits are three to four lobed. Each plant bears 18-20 fruits. Recommended for cultivation in J&K,H.P. and Uttarakhand, Punjab, U.P., Bihar and Jharkhand. Hybrid has yield potential of 340-370 q/ha. |  |

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| **KTCPH-3** | This hybrid developed at IARI, RS, Katrain in 2005. It has been identified for release and notification through AICRP-VC in 2005. Plants erect, medium and bushy. First picking starts at 60-70 days after transplanting. Fruits are green, conical, turns dark red at maturity and 9-11 cm long.Recommended for cultivation in J&K, H.P. and Uttarakhand, Rajasthan, Gujarat, Haryana, Delhi, M.P., Maharashtra and Goa. Hybrid has yield potential of 225-250 q/ha. |  |

**Cauliflower**

Cauliflower is a thermo sensitive crop. Varieties differ in their temperature requirement for curd formation and development. They have been classified into different maturity groups according to their temperature requirement. The sowing and transplanting time have to be adjusted so that the varieties are ready for harvest at specified period in the north Indian plains (Table 1.1).

**Table 1.1: Maturity groups in Cauliflower**

| **Maturity** | | **Sowing Time** | **Transplanting Time** | **Temperature for curd development** | **Varieties** |
|---|---|---|---|---|---|
| **Early** | September maturity (mid Sep.-mid Oct.) | Mid-May | July beginning | 22°C -27 °C | Pusa Early Synthetic, Pusa Meghna , Pusa Kartik Shankar, Pusa Deepali, Pant Gobhi 2, Pant Gobhi-3, PusaKatki |
| | October maturity (mid Oct.- mid Nov.) | May end mid-June | Mid July | 20°C - 25 °C | |
| **Mid early** | November maturity (mid Nov.-mid Dec.) | July end | September beginning | 16 °C - 20 °C | Pusa Sharad, , Improved Japanese, Pusa Hybrid-2 Pant Gobhi-4, |
| **Mid late** | December maturity mid Dec.-mid Jan.) | (August end | September end | 12 °C - 16 °C | Pusa Himjyoti, Pusa Shubhra, Pusa Paushija (DC-76), Pusa Moti (DC-5) |
| **Late** | Snowball | Sept. end mid Oct. | Oct. end – mid Nov | 10 °C - 16 °C | Pusa Snowball-1, Pusa Snowball-2, Pusa Snowball K-1, Pusa Snowball K-25 |

**Source:** Dey and Bhatia (2017)

**Description of Important Varieties**

**Early Varieties:**

1. **Pant Gobhi 3:** A synthetic variety combining inbred lines. Plants with long stem, semi-erect leaves and hemispherical creamy white, medium compact non ricey curds. Yield 12 t/ha. Curds are ready for harvest in September.
2. **PusaMeghna:** Belongs to early maturity group, suitable for growing under hot and humid climate. Curds compact, creamish white and medium in size, weighing about 350-400g.
3. **PusaKartikSankar:** It is hybrid of Indian cauliflower which belongs to early maturity group. It is resistant to downey mildew and can tolerate high temperature and high rainfall during its vegetative growth. Curds are medium sized, semi dome shaped, compact, retentive white with fine texture, weighing about 475g. It is free from bracts and riceyness.
4. **PusaDeepali:** Plants medium tall, erect, bluish green and waxi leaves, curds compact, retentive white and medium in size with an average yield 10-12 t/ha.
5. **Pant Gobhi 2:** Recommended for cultivation in northern plains of the country. Curds are medium compact and yellowish. Yield potential is 10t/ha. It is available in October in the plains.
6. **SBECF - 102 (Sabour Agrim):** It is an early variety, developed at BAU, Sabour, Bihar in 2014. It is an early variety forms curd at average temperature of 22°C -27 °C, plants are erect to semi spreading with light green leaves. It takes 48 - 54 days for 50% curd initiation and 65-68 days for 50% curd maturity from the day of transplanting. It has round, white and compact curds with average curd weights ranges from 450 - 482 g. It has yield potential of 150-200q/ha. It is recommended for cultivation in M.P., Maharashtra and Goa.
7. **DC 31:** This is an early group cauliflower variety developed at ICAR-IARI, Pusa, New Delhi in 2014. It is suitable for transplanting during July and reaches marketable maturity during October. Its curd initiation and development takes place at an average temperature range of 22°C -27 °C. Its curds are compact with retentive white colour. The average curd weight is 500-600g with yield potential of 160-180q/ha and recommended for cultivation in Punjab, U.P., Bihar and Jharkhand.
8. **Kashi Gobhi-25** (VRCF-50): Developed through selection from the germplasm at ICAR-IIVR, Varanasi in 2018. It is a November maturity (first fortnight of November around 25 °C temperature). White compact and hemispherical curd free from riceyness,

leafiness and fuzziness. Marketable curd weight 600-700 g and has yield potential of 250-280 q/ha.

**Mid-early Varieties:**

1. **Improve Japanese:** An introduction from Israel. Plants erect, leaves bluish green; curds compact and creamish-white. Average yield is 16-18 t/ha.
2. **Pusa Hybrid 2:** First $F_1$hybrid released by a public sector organization. Plants semi-erect with bluish green upright leaves, resistant to downey mildew. Curds are creamy white, very compact, with an average yield of about 23 t/ha.
3. **PusaSharad:** Foliage bluish-green, leaf with narrow apex and prominent mid rib. Semi-dome shaped white and very compact curds. Average yield is around 24 t/ha.
4. **Pant Gobhi 4:** A variety released for November maturity. It has medium long stem, semi-erect leaves; hemispherical creamy white, medium compact, non ricey curds. Average yield is 14 t/ha.

**Mid Late Varieties:**

1. **Pant Shubhra:** Released for cultivation in Bengal Assam basin and Sutlej Ganga Alluvial plains. Curds compact, slightly conical, retentive, creamish -white in colour, non ricey and non leafy. The yield potential is 25 t/ha.
2. **Pusa Himjyoti:** Erect bluish-green leaves and waxy coating; curds retentive white, self blanched, solid and 500-600g in weight. This is the only variety which can be grown from April-July in the hills. It is also suitable for growing in December maturity group in north Indian plains.
3. **Pusa Moti (DC-5):** High yielding variety of mid late maturity group (December-January) and is recommended for growing in north Indian plains and hills. This variety produces attractive compact white curds compact, full of flavour, suitable for use as cooked vegetable or in combination with other vegetables and for pickling. It is tolerant to major pest and diseases and can even tolerant to low frosting temperature. Average curd yield is about 30-33 t/ha.
4. **Pusa Paushija (DC-76):** Developed through recurrent breeding at ICAR-IARI, New Delhi in 2008. It has distinguished bluish green, narrow conical leaf top. This is high yielding variety for mid late maturity group i.e. maturing during 2nd fortnight of December to first fortnight of January. Forms curds at 12-160C temperature. It has medium bluish green leaves narrow elliptic with pointed tip. Compact curd with retentive white colour weighing about 900 g and takes 90-100 days from transplanting

to first harvest. It is tolerant to downy mildew. Recommended for cultivation in J&K, H.P. and Uttarakhand, Rajasthan, Gujarat, Haryana and Delhi, North Indian Hills plains and has yield potential of 350-400 q/ha.

**Late Varieties:**

1. **Pusa Snowball 1:** A late variety suitable for cool season. Leaves are straight and imnner leaves cover the curd. Curds are compact, medium and snow white in colour. Ready for harvest in January- February in north Indian plains and during march- April in the hills. Yield potential is about 22-25 t/ha.
2. **Pusa Snowball K 1:** Among the snowball types grown in the country, it has best quality curds which are snow white and retain it even if harvesting is delayed. The leaves are puckered, serrated and light green in colour. It is late in maturity by about a week than Snowball 1. It is tolerant to black rot disease. Average yield is 25-30 t/ha.

**Treatment of Cauliflower Seedlings with PGR**

Treatment of cauliflower seedlings with NAA (10 ppm) as starter solution has been found effective in respect of plant stand in the field and vegetative growth. Application of GA4 + GA7 at the rate of 80mg/l of water shortened the period from transplanting to harvest. The quality of the curd was not affected by this treatment (Booij, 1990). Dipping of cauliflower seedling roots at transplanting in IBA (1 mg/l) + starter solution of ammonium sulphate and superphosphate (1:2) also induces earliness and increase curd yield. Synergistic effect of mineral nutrition and growth regulators has been noticed for plant growth and curd yield of cauliflower. Combined spraying of GA (100mg/l), NAA (120 mg/l) and Mo (2g/l) enhances the total yield. Similar increase in yield may obtained by spraying of GA (50 mg/l) and urea (1g/l). Spraying of 150 ppm Ethrel at the time of emergence of flowering stalks increase seed yield.

**Grafting for Quality Transplant Production**

Vegetable production with grafted seedlings was originated in Japan and Korea to avoid the serious crop loss caused by infection of soil-borne diseases aggravated by successive cropping. This practice is now rapidly spreading and expanding over the world. Vegetable grafting has been safely adapted for the production of organic as well as environmental friendly produce and minimize uptake of undesirable agrochemical residues (Lee *et al*., 2010). Grafting of watermelon onto bottle gourd enhances its tolerance to soil-borne diseases (Heidari*et al*., 2010) and reduces Fusarium wilt (Rivard and Louws, 2006). The major vegetable crops being

grafted are: tomato, cucumber, eggplant, melon, pepper and watermelon (Nichols, 2007). Grafting is also very much useful for increasing yield for example as much as 106 per cent with the use of certain rootstocks for watermelon production in Australia. Some rootstock varieties have been bred specifically to be used as rootstocks, such as the Maxifort rootstock used in greenhouse tomato production systems. Use of vigorous rootstock varieties can increase water and nutrient uptake in grafted plants. Many growers worldwide are utilizing these rootstocks to increase fruit yields, even where little disease pressure is evident.

Grafting in-brinjal

**Benefits of Grafting**

**Imparting Disease and Pest Resistance**

The main objective of grafting is to avoid soil borne diseases such as Fusarium wilt in cucurbitaceae (cucumber, melon etc.) and bacterial wilt in solanaceae (tomato, eggplant and pepper etc.). Expanding the use of resistant rootstocks in grafting in combination with Integrated Pest Management (IPM) practice, may help to reduce the need for soil fumigation with methyl bromide for many crops. This may prove boon in organic farming of vegetables. Further, continuous cropping is in vogue in greenhouse which results reduced yield and quality of the produce. An estimated loss of 68 per cent in vegetable yield caused by soil born diseases under continuous cropping was reported by Takahashi (1984).

In brinjal yield is very low due to numerous diseases and parasites, in particular to *Ralstonia solanacearum*, Fusarium wilt, Verticellium wilt and Bacterial wilt, nematodes and several insect pests (Collonnier *et al*., 2001).Among all, bacterial wilt is extreme disease expressed rapid wilting by yellowing of foliage followed by collapse of entire plant. Soil treatment with chemicals and resistant sources were used so far but due to residual nature of chemicals only alternative left is resistant sources. The number of wild relatives of *Solanum* species was resistant and graft compatible to eggplant. Grafting of vegetable crops is a simple method of propagation in which preferred rootstocks are used to improve vigour, precocity, enhanced yield and quality, better survival under abiotic and biotic stress conditions (Pandey

and Rai, 2003). Ashok Kumar *et al.* (2017) reported that among all rootstocks used in grafting, *Solanum torvum* was found best rootstock followed by *Solanum khasianum* and promising for resistance towards bacterial wilt, whereas *Solanum surathense* and *Solanum xanthocarpum* showed maximum susceptible reaction against bacterial wilt infection among all grafted plants. The non-grafted control plants showed highly susceptible compare to grafted ones. The results recommended that eggplant could be grafted on *Solanumtorvum* and *Solanum khasianum* for graft compatibility controlling bacterial wilt in north eastern region of the country.

**Table 1.2: Effect of wild brinjal used as root stock to manage bacterial wilt**

| **Grafting combinations** | **Bacterial wilt infection (%)** |
|---|---|
| *Solanumtorvum* × PusaShyamala | 12.225 |
| *Solanumtorvum* × Pusa Hybrid-6 | 13.475 |
| *Solanumxanthocarpum* × PusaShyamala | 45.500 |
| *Solanumxanthocarpum* × Pusa Hybrid-6 | 48.175 |
| *Solanumkhasianum* × PusaShyamala | 29.600 |
| *Solanumkhasianum* × Pusa Hybrid-6 | 31.475 |
| *Solanumsurathense* × PusaShyamala | 58.525 |
| *Solanumsurathense* × Pusa Hybrid-6 | 55.300 |
| Control plants | 71.350 |
| C.D. | 2.361 |
| SE(m) | 0.809 |
| SE(d) | 1.145 |
| C.V. | 3.985 |

**Source:** Ashok Kumar *et al.*(2017).

## Promising Root Stock for Tomato and Brinjal

### Tomato

The most common genetic rootstock sources for tomato are tomato hybrids and interspecific tomato hybrids (*S. lycopersicon*× *S. habrochaites* S. Knapp & D.M. Spooner), but eggplant rootstocks are also recommended for specific conditions, such as flooding or waterlogged soil (Black *et al.*, 2003). It appears from currently available commercial sources that most rootstock cultivars originated from screening multiple *S. habrochaites* lines and crossing selections with tomato to create hybrids to use as rootstocks. There are a few open pollinated tomato rootstocks available, which appear to result from direct selection in the intended environment. While the potential genetic base for rootstocks of tomato would appear

to be very large considering the vast array of closely related species that could be used, the actual genetic base appears to be limited. All currently available commercial rootstocks are limited to specific tomato genotypes with resistance to soil-borne disease and to *S. lycopersicon*× *S. habrochaites* hybrids. It would appear that the genetic potential of other *Solanum* spp. has not yet been fully exploited for rootstock development. Even the brinjal rootstocks that are sometimes recommended for a specific purpose are limited to few genotypes.

**Brinjal**

The primary purpose for grafting eggplant has been for the control of soil-borne diseases, namely Verticillium wilt, bacterial wilt, Fusarium wilt, and root-knot nematodes (Goth *et al.*, 1991; Kalloo, 1993; Yamakawa, 1982). The first rootstocks used for grafting eggplant were selections from *S. integrifolium* (Yamakawa, 1982), which are reported to remain the most popular rootstock in Japan (Iwamoto *et al*., 2007). *S. integrifolium* is highly resistant to Fusarium wilt, is more resistant to bacterial wilt than most eggplant cultivars, and is reported to be highly compatible with eggplant and allows prolonged harvest (Tachibana, 1994). However, the level of bacterial wilt resistance is not enough to protect the scion when conditions favor the disease (Iwamoto *et al*., 2007). Creating interspecific hybrids between *S. integrifolium* selections and eggplant genotypes with some resistance to bacterial wilt has been successfully used to control bacterial wilt (Daunay*et al.*, 2001), but the level of resistance is still less than that found in some other *Solanum* spp. (Yamakawa, 1982). More recently, somatic fertile hybrids were created between *S. integrifolium* and *S. sanitwongsei*; both parents have resistance to bacterial wilt, although the disease resistance of the progeny was not reported (Iwamoto *et al*., 2007).

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# Chapter -2

## Rooting Media for Raising Hi-Tech Nursery in Vegetable Crops

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The cultivation of plants in systems without soil *in situ* is defined in literature as "soil-less culture" (Gruda, 2009). Many such systems are based on the use of *solid rooting media* for growing plants. They are usually called growing media or substrates or potting media. With reference to plant propagation, growing media are defined as all those solid materials, other than soil, which alone or in mixtures can guarantee better conditions than agricultural soil (for one or more aspects). Hence, media of different origin take on the role of soil and provide anchorage for the root system, supply water and nutrients for the plant, and guarantee adequate aeration in the root area (Gruda *et al.*, 2006).Therefore, growing medium may be explained as the materialsor (rooting) mediumconsisting of mixtures of components that provide water, air, nutrients and support to plants which enables proper rooting or growth of plant, hence also called as 'rooting media'. All media provide plant support, while the nutrients are provided by added fertilizers. Water and air are provided in the pore spaces in the media. The main functions of rooting media are:

- Supply of nutrients, air, and water
- Allow maximum root growth
- Physically support to the plant.

Characteristics of a good rooting media:

- It should be sufficiently porous so that it is well drained and has proper salinity level
- It should have good water holding capacity and proper aeration
- Optimum weight – not too heavy to lift, not so light as to blow away easily
- Medium should be slightly acidic to neutral. Suitable pH between 5.0 and 6.5 is satisfactory in most of cases
- It should be pest free (weed, insect and fungal free)
- Readily available

- It should be not very expensive.

Growing media have favoured the development of specialized nurseries for large-scale production of seedlings/plantlets, to satisfy the growing demand coming from vegetable market, due to both technical and economic reasons. Rooting media plays an important role in hi-tech nurseries for healthy vegetable seedling production. Usually pro-trays and plug-tray nurseries are used for raising seedlings in hi-tech nurseries in which rooting media are used particularly for (Das *et al.*, 2018):

a) Raising seedlings of transplanted vegetables such as capsicum, cauliflower, cabbage, broccoli, Brussels sprouts, tomato, brinjal and chill.

b) Raising seedlings of directly sown vegetables such as cucumber, bottle gourd, pumpkin, ridge gourds and hyacinth bean etc.,

c) Suckers of vegetables such as spine gourd and pointed gourd.

d) Crops viz., ginger and turmeric micro-rhizomes can be sown in the plug trays.

**Soil**: One of the most commonly used media in the nurseries from time immemorial has been the garden soil. Garden soil is the basic natural medium for growing plants and is a very common easily available and the cheapest source. The soil contains both organic and inorganic matters. Loamy and porous soil, rich in organic matter with neutral pH (around 7) is good for the growth of plants while loamy silty or clayey soils are not preferred due to poor aeration and stickiness. Light and sandy soils should be used as growing media. Soil is mixed with sand and farmyard manure (2:1:1) for better aeration, water-holding capacity and nutrient supply to the plants. Soils hold water and nutrients very well in a container but disease and weed seeds can be a problem.

**Problems of soil as a rooting medium**

1) The soil-borne pathogens pose a serious threat to the plants, resulting in lower production.
2) Presence of weed seeds
3) It is difficult to maintain the nutritive status, pH and water-holding capacity of soil as per the requirements of a particular crop for long duration.
4) Some types of soil such as saline or ill-drained soil create problems in soil aeration, porosity, nutrient uptake, etc., which in turn affect the crop productivity.

Therefore, the role of growing media has increased in the present times as growing media

as mentioned earlier are solid substrate that replace the natural soil for plant development on which roots grow regularly by extracting water and nutrients (Douglass *et al.*, 2009). These are also called as soil-less media and have the following advantages:

**Advantages of Soil-less (growing) media**

1) Soil-less media, whether liquid or solid, facilitates precise nutritional requirement of the plant.
2) It helps pathogen-free cultivation.
3) More economical use of fertiliser is possible.
4) Labour saving in weeding and fertiliser applications.
5) Seedling raising under problematic soil conditions is possible.

**Types of growing media**

Rooting media used in hi-tech nurseries are highly modified mixtures of organic and inorganic materials. Growing media are primarily divided into organic and inorganic materials. The organic materials include synthetic (like phenolic resin and polyurethane) and natural organic matters (peat, coconut based and composted organic wastes). Inorganic substrates can be classified as natural unmodified sources (sand, tuff and pumice), processed materials (expanded clay, perlite and vermiculite) and mineral wool (rockwool, glasswool). Based on the surface charge activity of materials, these can be distinguished in active (peat, tuff) or inert (rockwool and sand).

**The inorganic growing media**

**Sand**: The usual size of sand is from 0.05 to 2.0 mm. Sand increases porosity because of the large particles. It improves aeration and drainage and needs minimum cost incurrence. Quart sand is most useful. However, it has no mineral nutrients. It is relatively inexpensive but heavy. While sand is vulnerable to diseases and pests, however once sterilised, it can prove to be a good medium for propagation media.In fact, the general recommendation is to wash sand (flushing out salt content if present) and sterilize or pasteurize it before incorporating it in the growing medium (Miller and Jones, 1995). the more serious drawback of using sand in growing media is its weight, which causes problems with handling and increases the cost of shipping (Gordon, 2004).

**Tuff:** Tuff is produced from ash and rock fragments ejected during volcanic eruptions. Some

particles melt together in the heat. The material is very porous and consists of mostly silicon dioxide and aluminum oxide with small amounts of iron, calcium, magnesium and sodium. After mining, it is screened to different sizes but is not heat treated. It increases aeration and drainage in growing media. Tuffs possess a buffering capacity and may absorb or release nutrients, especially P, during the growth period (Raviv *et al.*, 2002).

**Pumice:** Pumice is a natural product, a light silicate mineral of volcanic origin. It is used as substrate for vegetables like tomato, cucumber, pepper. There is increased interest in growing plants in pumice, because it requires relatively low investments and is easily applicable in existing growing systems. Pumice can be used for many years, so it produces relatively little substrate waste. In addition, pumice is friendly to the environment, because no harmful production processes are involved (Boertje, 1995). Pumice has a low volume weight of 0.4–0.8 g $cm^{-3}$ and a TPS of 70–85 percent (Boertje, 1995). Pumice has a neutral pH; it contributes little to plant nutrition, but does not decrease the availability of fertilizer nutrients (Handreck and Black, 2005).

**Expanded clay granules:** Expanded clay is a granular product with a cellular structure. It is produced by heating dry, heavy clay to 1100 °C: water is released, causing the clay to expand. The raw material must have a low content of soluble salts to avoid having to add substances, such as lime, during the process. Expanded clays are light with a low volume weight of 0.28–0.63 g $cm^{-3}$; chemically, they are neutral, with a pH of about 7.0 (Raviv *et al*., 2002).

**Rockwool:** It is a fibrous material made from a mixture of basaltic rock and limestone gravel that are converted at high temperature to mineral wool. The fibers are then fixed with a special binder and compresses to form blocks of various shapes and dimensions, exhibiting a fairly uniform pore size distribution and high porosity. It has a low volume weight of (approximately 0.07–0.1 g $cm^{-3}$) and a TPS of 92–97 percent. The main chemical characteristic of rockwool is that it is totally inert, except for some minor effects on pH. It has pH>7 (Jorgensen, 1975; Papadopaulos, 1994). One problem is that rock wool is difficult to dispose after use (Robertson, 1993).

**Perlite:** Perlite is a natural mineral of volcanic origin which is light weight. The pH is usually neutral to slightly alkaline. Perlite is not a trade name but the term used for naturally occurring siliceous volcanic mineral sieved and heated to 1000 °C. At these temperatures perlite expands to 4–20 times its original volume, due to the presence of 2–6% combined water in the perlite rock, producing a lightweight material with high porosity. Perlite can be used alone or mixed

with other substrates for greenhouse plant production. The high porosity helps to control the water-holding capacity and aeration of the substrate.

**Vermiculite**: Vermiculite is produced by heat treatment of mica. It is porous and light and has a water-holding capacity of three to four times its weight. Chemically it is hydrated magnesium, aluminium, iron, silicate. Similar to perlite, vermiculite is produced by heating the ground and sieved material to 700 to 1000°C. Vermiculite is sterile and light in weight. It is used as a sowing medium, covering germinating seeds, and as a component of potting soil mixtures. Media containing vermiculite should be mixed dry. When mixed wet, the desirable physical properties deteriorate because particles tend to collapse flat (Handreck and Black, 2005). While perlite is mainly used to improve the drainage properties in a mix, vermiculite is used to increase the water-holding capacity of a growing medium. It can hold 3–4 times its weight of water. Furthermore, vermiculite can hold positive-charged nutrients such as K, Mg and Ca.

**Organic growing media**

**Compost**: Compost is the product of organic matter decomposition. Leaves, grass clippings, wood waste, and farm animal manures are some of the common ingredients that are used for compost preparation. Compost contains major and minor nutrients that plants need for good growth. The physical and biochemical properties of compost used as rooting media vary greatly, depending on the materials used, the method adopted and the stage of maturity. The most beneficial effect of compost inclusion in a growth medium is its nutritional contribution. Non-mature compost can immobilize a significant amount of N, but once stabilized, compost acts, to a large extent, as a slow-release fertilizer.The use of compost in horticulture is limited by the high electrical conductivity, neutral or slightly alkaline pH, and the excessively high amount of certain ions causing phytotoxicity (Verdonck, 1988) and a low water-holding capacity(Abad et al., 2001).

**Sphagnum** Moss: Commercial sphagnum moss is the dehydrated remains of acid-bog plants of the genus Sphagnum such as S. *papilliosum, S. capillacem* and *S. palustre*. It is generally collected from the tree trunks of the forest species in south Indian hills above 1500 m above MSL during rainy period. It is light in weight, acidic, sterile and has good water-holding capacity. It differs from peat moss in that it is the young residue or live portion of the plant. It is the commonly used medium in air layering.

**Peat**: Peat is the main component of soil-less media mixes. It consists of the residues from a marsh swamp. It contains some organic nitrogen and is favourable for newly rooted cuttings or germinated seeds. It is produced by partial decomposition of plant material under low-oxygen conditions.It consists of at least 30% (dry mass) of dead organic material accumulated on such water-dominated terrestrial surfaces as swamps, fens and bogs (Joosten and Clarke 2002). One of the most common components of peat is *Sphagnum* moss, although many other plants can contribute. The physical and chemical characteristics of *Sphagnum* peat (Bures,1997, Aendererk *et al.*, 1982; Perelli *et al.*, 2004), mostly used for growing media preparation is summarized in the following table (Table 2.1).

**Table (2.1)Main properties of *Sphagnum* peat**

| **Characteristic** | **value** |
|---|---|
| Bulk density (Kg/l) | 0.07-0.30 |
| Porosity (% vol.) | > 9 |
| Air capacity (% vol.) | 15-40 |
| Water availability (% vol.) | 25-30 |
| pH | 3-5 |
| Electrical conductivity (mS/cm) | 0.20-0.60 |
| Ashes (%) | 1-6 |
| Cationic Exchange capacity (meq/100 gr.) | 100-170 |
| Carbon/Nitrogen ratio | 30-80 |

**Advantages of peat as a rooting medium are:**

- Relative consistency
- Low nutrient content and pH
- Light weight
- High volume of pores
- Good air capacity
- High water-holding capacity
- High CEC
- General freedom from pollutants, pathogens and seeds of weeds
- Stable structure
- Ease of storage
- Possibilities for reuse or recycling

**Coco peat (Coir pith):** The processed coir pith resembles peat and has got many characteristics as that of sphagnum peat, the most common potting media used in horticulture and hence it is commercially known as coco peat. With the development of commercial horticulture and reduction in the availability of sphagnum peat and also advantage over it (Table 2.1), coco peat has become internationally recognized as an ideal soil amendment and component of soilless container media for horticultural plants. It is a by-product of the coconut industry, and is used widely as a substrate due to its low cost, aeration, drainage and long life. It is derived from coir

fibre dust (Fig. 2.1). It is supplied in loose form as well as in compressed brick forms. It is usually marketed in compressed bales to which water is added. The compressed bricks are easy to transport at low costs. The bricks weigh about 4–5 kg and can expand to 4–5 times of their volume once water is added after loosening them. It is advisable to use coco peat after treatment with steam or other means of disinfestation. It has a pH of about 5.0 making and contains low levels of micronutrients, but higher levels of phosphorus & potassium.


(http://www.svcoirexports.com/about-cocopeat.html)

Fig. 2.1. By-products of coconut as growing media

**Table (2.2). Advantages of Coir pith over Sphagnum peat** (Ravindranath and Radhakrishnan, 2016)

| Coir pith | Sphagnum peat |
|---|---|
| 1) Requires lesser amount of lime due to high pH | 1) Requires large amount of lime to maintain pH for growing plants |
| 2) Quick and easy rewetting after drying | 2) Becomes hydrophobic once dried |
| 3) Requires short time for irrigation to replace loss of water and drainage from pot, saving fertilizer due to non leaching of nutrients | 3) Requires longer time for irrigation due to hydrophobicity resulting in leaching of nutrients |
| 4) High capillary wetting property | 4) Comparatively low capillarity |
| 5) Distributes moisture evenly in pot mix | 5) Distributes moisture evenly in pot mix |
| 6) Able to provide aeration in base of mix | 6) Under influence of gravity water collects in bottom to fill pore spaces and reduce availability of air to roots |
| 7) Very resilient and exceptional physical stability when wet or dried | 7) Collapses when wet retarding availability of air and water to plant roots, shrinks when dried allowing to run water between roots and pot wall increasing the time to rewetting |

**The major properties of coco peat are:**

- High water holding capacity, i.e., 6-8 times than itsweight.
- Excellent moisture retention even afterdrying.
- Slow degradation due to high lignocellulosic bonding.
- High porosity, stores and releases nutrients over extended periods oftime.
- Greater physical resiliency that withstands compression better.
- Excellent aeration / oxygenation providing enhanced root penetration.
- Acceptable Electrical Conductivity (EC), pH and Cation Exchange Capacity(CEC).
- 100% degradable, organic and a renewable resource.
- Contains natural substances beneficial for plant growth

**Bark:** Bark is a by-product of the wood and paper/saw-mill industry. It is usually stripped from trees, milled and screened into various sizes. The air and water-holding capacity of bark can be adjusted by varying the percentage of fine material (< 1–2 mm) (Prasad and Chualáin, 2004). As bark can be produced in different particle sizes, it is possible to make different mixes with different physical properties. Composting is recommended to eliminate phytotoxins. N may be added during composting to overcome N immobilization(Solbraa, 1979).

**Saw dust:** These materials are readily available as they are the by - products of saw mills. It is used as a water holding agent but has a very little nutrient value. As with hardwood bark, plant growth is restricted in uncomposted sawdust. However, the carbon to nitrogen ratio is much higher in sawdust than in bark and N must be added: an estimated 2–3 percent N by weight is required to compost sawdust. Therefore, it is used as growing media after addition of nitrogen. The volume weight of sawdust is slightly less than sphagnum peat moss; it has similar water retention to pine bark but greater air space after drainage (Aendererk *et al.*1982).

**Biochar (upcoming new substitutes):** Biochar, a carbon-rich, recalcitrant charred organic co-product of the bioenergy pyrolysis process has emerged as a promising potential replacement for peat and perlite in nursery seedling propagation (Gruda, 2019). Biochar and hydrothermal carbonization (HTC) might play a more important role as constituents of growing media.

**Chemical Properties of Growing Media**

The capacity of the rooting media to hold and make available nutrients is affected by the cation exchange capacity (CEC) and the media pH.Cation exchange capacity (CEC) refers to the media's ability to hold nutrients having a positive charge, such as $NH^4$, Ca, Mg and K. The term "buffering capacity" is often used interchangeably with CEC. It refers to the ability of the

media, as a result of its CEC, to resist changes in pH and nutrient levels. Compared to soil, soilless media have low nutrient-holding capacities when considered on the basis of the volume of media. Because of this, nutrients for plant growth should be supplied constantly by fertigation. Cation exchange capacity of soilless media should be in the range of 6 to 15 meq/100 cc of media. From a practical point of view, considering the small volumes of growing media used for vegetable production, high CEC growing media also lead to limited nutrient-buffering capacity, however, frequent fertigation can mitigate the negative effects.The initial pH of the growing media should be between 5.8 and 6.2. Gianquinto and Pimpini (2001) reported pH of commonly used organic and inorganic growing media (Table 2.3). Similarly, Carlile *et al*. (2015) reported pH, electrical conductivity (EC) and nutrient status (Table 2.4) of organic constituents of some organic growing media.Since most components of media are acidic, dolomitic limestone (calcium and magnesium carbonates) is added to start at an acceptable pH range and provide Ca and Mg for plant growth. The smaller the particle size of the ground limestone, the quicker is the increase in media pH. Commercially blended media typically have limestone already incorporated. The pH of the media should be measured and adjusted before use.

**Table (2.3) pH value of different growing media**

| Growing media | pH value |
|---|---|
| Expanded clay | 4.5–9.0 |
| Sand | 6.4–7.9 |
| Peat | 3.0–7.3 |
| Perlite | 6.5–7.5 |
| Vermiculite | 6.0–7.2 |
| Pumice | 6.7–9.3 |
| Tuff | 7.0–8.0 |

**Table (2.4).pH, electrical conductivity (EC) and nutrient status of organic constituents of growing media**

| Growing Media | pH | EC (dS $m^{-1}$ ) | $(NH_4 + NO_3)$-N (mg $L^{-1}$) | P (mg $L^{-1}$) | K(mg $L^{-1}$) |
|---|---|---|---|---|---|
| Peat | 3.9 | 0.2 | 48 | 1.6 | 4 |
| Coir dust | 6.2 | 0.9 | 31 | 3 | 55 |
| Coir chips | 5.7 | 0.5 | 3 | 5 | 57 |
| Pine bark (composted) | 4.0–4.3 (USA) 5.0–5.2 (Europe) | 0.30 | 2 (no added N) 50–100 (urea added at 1 kg $m^{-3}$) | 13 | 290 |
| Wood fiber | 4.8 | 0.2 | 3 | 3 | 35 |
| Green compost | 7.5–8 | 1.0 | 100 | 28 | 900 |

**Physical properties of the growing media**

Physical properties of the growing media include distribution of air, water, and solid in a container medium depends on several factors including pore space, bulk density, particle size distribution, container height, and media settling. Kalaivani and Jawaharlal (2019) studied the physical properties of some growing media and reported the results of the bulk density, particle density and porosity of different Medias (Table 2.5). Miller and Jones (1995) also reported important chemical and physical properties of few important growing media (Table 2.6).

**Table (2.5). Physical properties of some organic growing media**

| Media components | Bulk Density (g/cc) | Particle Density (g/cc) | Porosity (%) | Moisture Content (%) | Water holding Capacity (%) |
|---|---|---|---|---|---|
| Coco peat | 0.09 | 0.23 | 60.91 | 37.36 | 65.49 |
| Vermi compost | 0.52 | 1.05 | 50.78 | 34.05 | 44.53 |
| Press mud | 0.70 | 1.37 | 48.77 | 31.06 | 39.01 |
| Bio compost | 0.75 | 1.42 | 46.79 | 30.38 | 31.29 |

**Total pore space:** One of the most important criteria for any substrate is the percentage of pore space and the proportion and amount of water and air that is presented in the pore space. Desirable total porosity values which maintain oxygen levels above 12% are around 50–80% by volume (Wilson, 1983). The total pore space is calculated as follows:

$$TPS = (100 \times (1 - BD/RD)$$

Where BD is bulk density ($g.cm^{-3}$) and RD is the real density ($g.cm^{-3}$).

**Table (2.6). Characteristics of various components of growing media**

| Medium | Bulk Density ($g\ cm^{-3}$) | pH ranges | Mineral Nutrients | Sterility | CEC (wt) (meq/100 g) | CEC (Vol) (meq/100 $ml^{-3}$) |
|---|---|---|---|---|---|---|
| Peat | 96.1 - 128.2 | 3.5-4.0 | Minimal | Variable | 180 | 16.6 |
| Vermiculite | 64.1 - 120.2 | 6.0-7.6 | K-Mg-Ca | yes | 82 | 11.4 |
| Perlite | 72.1 - 112.1 | 6.0-8.0 | None | yes | 3.5 | 0.6 |
| pine bark | 128.2 -448.6 | 3.3-6.0 | Minimal | variable | 52.6 | 15.3 |

**Bulk Density:** For outdoor container nurseries, dry bulk density of media might range between 12 to 24 $g/cm^3$ (wet bulk density of 70 and 90 $g/cm^3$). A nursery media that uses a significant percentage of mineral soil will have a dry bulk density of 40 to 50 $g/cm^3$. For a greenhouse media, the dry bulk density will be lower and in the range of 8 to 18$g/cm^3$.

Water retention capacity: It can be defined as the water amount, retained by the media, to be available for the plants.

**Media for greenhouses**

Growing/rooting media in greenhouses are used in containers (organic substrates, perlite etc.). However, sometimes they are used in the form of prepared cubes (rockwool cubes for seedling and transplant production), bags and slabs (peat-based substrates and rockwool, respectively), mats (polyurethane foam) and troughs (rockwool). The last three are also used generally for vegetable production in soil-less culture systems. Some of the desirable properties of rooting media to be used are as follows:

- The medium should be well drained.
- A desirable medium should be a good balance between physical properties like water holding capacity and porosity.
- Highly porous medium will have low water and nutrient holding capacity, affects the plant growth and development.
- Medium which is too compact creates problems of drainage and aeration which will lead to poor root growth and may harbour disease causing organisms.
- The media reaction (pH of 5.0 to 7.0 and the soluble salt (EC) level of 0.4 to 1.4 dS/m is optimum for most of the greenhouse crops).
- A low media pH (<5.0) leads to toxicity of micronutrients such as iron, zinc, manganese and copper and deficiency of major and secondary nutrients while a high pH (>7.5) causes deficiency of micronutrients including boron.
- A low pH of the growth media can be raised to a desired level by using amendments like lime (calcium carbonate) and dolomite (Ca-Mg carbonate) and basic, fertilizers like calcium nitrate, calcium cyanamide, sodium nitrate and potassium nitrate.
- A high pH of the media can be reduced by amendments like sulphur, gypsum and Epsom salts, acidic fertilizers like urea, ammonium sulphate, ammonium nitrate, mono ammonium phosphate and aqua ammonia and acids like phosphoric and sulphuric acids.
- The pH of water and mix should be monitored regularly.

**Preparing growing media for hi-tech nursery**

Generally, in hi-tech nursery, rooting media should be soil-less media, light and porous which retains moisture and allows proper drainage and free from weed seeds and any soil borne

pathogens or insects.

Different types of media combination for plug trays hi-tech nursery (Das *et al.*, 2018):

i) Cocopeat: Sand: FYM: vermicompost (2:1:0.5:0.5) or Cocopeat: Vermiculite: Perlite (3:1:1)
ii) Fine soil: Sphagnum Peat Moss: Perlite (2:1:2)
iii) Sand: Soil: FYM: Rice Husk Ash (1:1:1:1)
iv) Coco peat (70 Kg) and neem cake (1kg) + *Azospirillum* and *Phosphobacteria* (each @ 1 kg).
v) Fine Sand for induction of rooting of stem cuttings

Some of the examples of combinations of growing media (Thomas *et al*., 2014).for use are as follows (Table 2.7). However, growing medium will vary among nurseries, environments, and plant species.

**Media ingredients for commercial formulations**

When choosing commercial rooting medium, knowledge of its characteristics (physical, chemical and biological) is very important, because they affect plant response and production cost. Absence of pests and pathogens is essential. Commercially available materials like peat, sphagnum moss, vermiculite, perlite and locally available materials like sand, red soil, common manure/ compost and rice husk can be used in different proportions to grow greenhouse crops. These ingredients should be of high quality to prepare a good mix. They should be free from undesirable toxic elementslike nickel, chromium, cadmium, lead etc. The most common media used in greenhouse production today are mixtures of peat, vermiculite and perlite. The media are designed to achieve high porosity and water retention while providing adequate aeration. A nutrient charge is added and the pH adjusted to approximately 6.0. A non-ionic wetting agent is generally added to peat media to improve initial wetting. Formulations without wetting agents are available for growing sensitive plants, such as seedlings.

**Treating the Rooting Media**

Solarisation by exposing the soil under sun and airtight covering the soil with polyethylene for 5-6weeks is commonly done. So that temperature inside increases and organism gets killed without oxygen. Drenching the soil mix with formalin 2-5% solution (200-250ml/10L) upto a depth of 15-20 cm @ 4-5 L/$m^2$ soil surface and immediately covered with black polyethylene sheet for 6-7 days. The mix is raked after removing the polyethylene cover

and is left exposed for at least 4-5 days. Soil may be drenched with solution of carbendazim or captan (3-4g/L) @ 1-2L/$m^2$ soil surface. Now-a-days drenching with hydrogen peroxide with silver @ 20ml/L is used for media treatment as it takes less time in the process and is less dangerous as compared to formalin.

**Table (2.7). Growing media for different nursery uses**

| Media type | Properties | Examples of media (by volume) |
|---|---|---|
| Seed propagation | Maintains uniform moisture around germinating seeds (not too wet or too dry); no fertilizer; free from pests and diseases. | • 3 partsperliteto1partcoarsevermiculite (for beachplants)<br>• 4 parts per liteto1partpeat<br>• 3 partssmallrinsedcindersto1partpeatand1partperlite |
| | | • Fine, washed quartzs and [0.02to0.04in (0.5to1mm)](100%) and will need frequent watering) |
| Rooting cuttings | Porous to prevent water-logging and to allow good aeration for root formation; provide support for cuttings; free from diseases and weed seeds. | • 3 partsperliteto1partvermiculite<br>• 3 partssmallrinsedcindersto1partpeatand1partperlite<br>• 100%rinsed small cinder (but needs frequent misting) |
| | | • 100%washedquartzsand(2mm) |
| | | • 1partgritorfinegravelto1partwashe d sandto1partagedsawdust<br>• 1partgritorfinegravelto1partagedsawdust |
| Transplant | Coarser; heavy enough to keep plants upright; may contain some nutrients; free from diseases and weed seeds. | • 1partpeatand1partvermiculite<br>• 2partscinderorperliteto1part well-decayed compost and 1 part peat |
| | | • 1partcoarsesand,2partscoconutcoir,1parttopsoil/duff<br>• 2partsbagasseto1partricehullsand1partalluvialsoil<br>• 1partwell-composedgrassesto1partricehullsorpumice<br>• 3partscomposedbarkto1partsandand1partshale |
| | | • 2partswell-decayedcompostto2partssandand1part claysoil |
| | | • 3partscoirtoonepartcompost<br>• 30%compostedricehulls,50%pinebark,and20%sand |

**Manures and fertilizers in nurseries:** Manures and fertilizers are important component in seedling raising in a nursery. Usually if nursery is being raised in portrays, then one portray of 96 cells will require about 1.2 kg of cocopeat. But, as discussed earlier additional fertilizer will be required to supply to the rooting media. Therefore, it is suggested to spray at 12$^{th}$ and 21$^{st}$ day 19:19:19 @ 3g/L for best results.


Cocopeat


Sphagnum moss


Vermiculite Perlite

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# Chapter -3

## Enhancing Vegetable Seed Health through Coating and Priming

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The crisis of food is everywhere because of the growing world population and climate change. So, there is a rise in interest of growing crops with high yield. Simultaneously, the practice should be environment friendly which will ensure agricultural sustainability, cost effectiveness and food security (Ma, 2019). The interest of coating the seeds of vegetables and crops is rising in today's horticultural and agricultural practices as it is highly cost effective and less time consuming but it is very advantageous. In order to maintain the yield of crops, maintaining quality seeds throughout the cultivation is a must, to ensure this, one must go for various test like seed germination test, seed vigour test, seed moisture test etc.Present day farmers are shifting from growing agricultural crops to vegetable crops as these vegetable crops fetch high premium prices. In addition to this, increasing awareness of balanced diet and changing food habits are some of the reason for shifting of traditional agriculture to commercial vegetable production (Sarkar and Rakshit,2017; Schreinemachers *et al*., 2018). Medicinal properties like antioxidants, antimicrobial, anti-inflammatory etc. are also attracting vegetable grower (Sarkar *et al.*, 2018). All these bioactive compounds help in preventing diseases in human (Dias, 2012). Differences in seed quality within and between seed lots arise from the presence of different proportion of immature, mature and over-mature seeds. Occasionally these differences are associated with colour or some other physiological characteristics such as size, which allow physical techniques like seed processing to separate seed into different viability classes.

Seed is the unique organ of a plant. The potential plant of next generation is stored in a juvenile (embryonic) state along with a reserve of food and energy molecules in inactive state but prepared for function only under favourable environment condition. Until favourable

condition is available the mature seed remains physiologically inactive except maintaining the lowest rate of respiration. Such a quiescent state can be sustained for a longer period through the mechanism of dormancy. On the other hand, with the availability of favourable conditions of moisture, temperature and light physiologically inactive seed bursts into the regime of full activation of its reserve molecules conductive to the growth and development of embryo. In fact, therefore, the complete domain of development and maturation of seed towards germination depends on specific physiological events.

**Influence of temperature on growth and development**

Temperature both of soil and environment, influence all the aspects of growth and development of crops, *viz.*seed germination, survivability and growth, development of economic plant parts, flowering and seed production, pollination, fruit set, quality of the produce, seed storage and occurrence of diseases and pests.Soil temperature mainly influences seed germination and water uptake by the plants. Plants extract water from warm soils more quickly and easily than from cold soils. Root growth is also inhibited in cold soil. On the other hand, atmospheric temperature influences most of the other aspects of growth and development of the plants.

**Seed germination**

Minimum soil temperature for seed germination in majority of vegetable crops ranges between 2°C and 15°C. Seeds of some cool season vegetable crops, like onion, parsnip, spinach, beet, cabbage, carrot, cauliflower, Swiss chard, parsley, pea, radish, turnip, etc., can germinate at the minimum temperature range of 1.7°C to 4.4°C. On the other hand, for most of the warm season vegetable crops, like cucurbits, beans, brinjal, chilli, etc., a minimum of 15°C soil temperature is required for seed germination. Seeds of some vegetable crops, like tomato, asparagus, etc., require a minimum of 10°C for seed germination. However, optimum soil temperature for seed germination in most of the vegetable crops lies between 20ºC and 30°C. Maximum temperature range for seed germination in the warm season vegetable crops is 35º to 40°C.

**Seed enhancements:** Seed enhancements include several methods that can be used to accelerate the rate of germination and increase the germination percentage or seedling growth.

**Moisturization**: It improves field emergence of legume and other vegetable crops like cowpea, French bean, pea, hyacinth bean, okra, palak, beet, etc. especially if the soil is wetted immediately after sowing.

**Seed treatments:** It refers to the application of fungicide, insecticide or a combination of both to the seeds so as to disinfect and disinfest them from seed-borne and soil-borne pathogens and storage insects. In most of the vegetable crops, captan or thiram 75% dust at 2-3g/kg of seed proves to be the best. Seeds may also be treated with non-toxic materials of plant origin like turmeric powder, neem powder, tobacco powder, etc. against storage pests.

**Table (3.1): Soil temperature requirement for seed germination**

| Crops | Soil temperature (°C ) | | | |
|---|---|---|---|---|
| | Minimum | Optimum range | Optimum | Maximum |
| Tomato | 10.0 | 15.5-25.0 | 25.0 | 30.0 |
| Brinjal | 15.5 | 24.0-32.0 | 28.0 | 35.0 |
| Chilli | 15.5 | 18.0-35.0 | 29.0 | 35.0 |
| Cabbage | 4.4 | 10.0-30.0 | 20.0 | 37.8 |
| Cauliflower | 4.4 | 10.0-30.0 | 20.0 | 37.8 |
| Radish | 4.4 | 7.0-32.0 | 28.0 | 35.0 |
| Carrot | 4.4 | 7.0-26.0 | 24.0 | 35.0 |
| Beet | 4.4 | 10.0-29.0 | 26.0 | 35.0 |
| Turnip | 4.4 | 15.0-35.0 | 29.0 | 40.0 |
| Parsnip | 1.6 | 10.0-21.0 | 18.0 | 29.0 |
| Asparagus | 10.0 | 25.0-30.0 | 30.0 | 35.0 |
| Muskmelon | 15.5 | 24.0-35.0 | 30.0 | 37.8 |
| Cucumber | 15.5 | 15.5-35.0 | 30.0 | 40.5 |
| Watermelon | 15.5 | 21.0-35.0 | 30.0 | 40.5 |
| Summer squash | 15.5 | 21.0-35.0 | 30.0 | 37.8 |
| Pumpkin | 15.5 | 21.0-32.0 | 30.0 | 37.8 |
| Bitter gourd | 15.5 | 20.0-35.5 | 32.0 | 37.8 |
| Ridge gourd | 15.5 | 21.0-35.0 | 30.0 | 40.5 |
| Okra | 17.0 | 21.0-35.0 | 29.0 | 40.5 |
| Pea | 4.4 | 4.4-24.5 | 22.0 | 29.4 |
| French bean | 15.5 | 15.5-29.0 | 26.0 | 35.0 |
| Lima bean | 15.5 | 18.0-29.0 | 26.0 | 29.0 |
| Cowpea | 15.5 | 15.5-29.0 | 28.5 | 40.5 |
| Hyacinth bean | 15.5 | 15.5-29.0 | 28.0 | 35.0 |
| Cluster bean | 15.5 | 15.5-35.0 | 29.0 | 35.0 |
| Palak | 10.0 | 15.0-30.0 | 25.0 | 35.0 |
| Amaranth | 10.0 | 15.0-35.0 | 32.0 | 35.0 |
| Spinach | 1.6 | 7.2-23.9 | 21.1 | 29.4 |
| Celery | 4.4 | 15.5-21.1 | 21.1 | 29.4 |
| Swiss chard | 4.4 | 10.0-29.4 | 29.4 | 35.0 |
| Lettuce | 1.6 | 4.4-26.6 | 23.9 | 29.4 |
| Parsley | 4.4 | 10.0-29.4 | 23.9 | 32.2 |
| Onion | 1.6 | 10.0-35.0 | 23.9 | 35.0 |

**Methods of testing seed viability**

**Germination test:** It is the most commonly used test to determine the viability of non-dormant seed. This test is widely used in vegetable crops. In this test, germination is taken as the

emergence and development of the seedling to a stage where the presence, absence and formation of essential structures can be assessed thus, indicating whether or not the seedling is able to develop further into a satisfactory plant under favourable conditions on soil. So, any abnormality in the seedling is not counted as germinated. Only the normal seedlings are counted. For most of the vegetable crops, temperature requirement for germination test ranges between 20° and 30°C Duration of germination test for vegetable seeds varies from 7-15 days depending on the crop.

**Table (3.2): Germination test in vegetables**

| Crops | Substrate | Temperature (°C) | First count (days) | Final count (days) | Additional recommendation to break dormancy |
|---|---|---|---|---|---|
| Okra | TP;BP | 20-30 | 4 | 21 | - |
| Onion | BP; TP | 20 | 6 | 12 | Pre-chill at 5°C |
| Beet | TP;BP | 20-30 | 4 | 14 | Pre-wash 2-4 hours in running water |
| Cabbage | TP | 20-30 | 5 | 10 | Pre-chill, soaking the paper in 0.2% $KNO_3$ solution |
| Cauliflower | TP | 20-30 | 5 | 10 | Do |
| Chilli | TP;BP | 20-30 | 7 | 14 | Soaking paper in 0.2% $KNO_3$ solution |
| Muskmelon | BP | 20-30 | 4 | 8 | - |
| Cucumber | TP;BP | 20-30 | 4 | 8 | - |
| Winter squash | BP | 20-30 | 4 | 8 | - |
| Pumpkin | BP | 20-30 | 4 | 8 | - |
| Summer squash | BP | 20-30 | 4 | 8 | - |
| Carrot | TP;BP | 20-30 | 7 | 14 | - |
| Lettuce | TP;BP | 20 | 4 | 7 | Pre-chill at 5°c |
| Tomato | TP;BP | 20-30 | 5 | 14 | Soaking the paper in 0.2% $KNO_3$ solution |
| Brinjal | TP;BP | 20-30 | 7 | 14 | - |
| Broad bean | BP | 20 | 4 | 14 | - |
| Cowpea | BP | 20-30 | 5 | 8 | - |

**BP :** Between two or more layers or germination or filter paper.

**TP :** Top of the one or more layer of filter or germination paper.

**[Note:** Potassium nitrate ($KNO_3$) solution at 0.2% concentration is to be applied to papers (substrate) at the point of saturation only at the beginning of the test. Subsequent moistening is to be done normally with water.]

Generally, seeds are germinated on wet filter paper in petridish or germination box kept in

incubator or culture room for temperature control. The filter paper must be soaked in water for 2-4 hours to remove water soluble toxic materials, if any. Seed may be placed on top of the one or two layers of paper or in between two filter papers or sheets of paper. When seeds are placed between two filter papers or sheets of paper towel, the sheet or roll along with the seeds are kept in the incubator in upright position. Sufficient moisture is ensured in the paper on petridish or in the paper roll and at the same time moisture loss is restricted.

**Tetrazoliun test:** It is widely recognised and quick method of predicting seed viability. This test is based on the principle that all living cells which respire in the hydrate state can reduce the colourless solution of 2,3,5, triphenyltetrazolium chloride (TZ) in a red coloured compound called formazan thus impart red colouration to the living and respiring cells. Tissues of the viable embryo of the seed are living and respire on hydration and thus become red coloured upon contact with TZ solution. In this method, the seeds are soaked overnight at room temperature for complete hydration of all tissues. Then the hydrated seeds are cut longitudinally so that a portion of embryo is attached to each half of seed. One half of each seed is placed in a petridish and covered with 1% aqueous solution of tetrazolium chloride and kept preferably in dark for 3-4 hours. No controlled environment is required for this test. However, staining of the seeds will be better at the temperature range of 25-30°C. After development of colour the TZ solution is drained and the seeds are rinsed 2-3 times with water and coloration is then evaluated.

**Excised embryo test:** This test provides a unique way of assessing viability of dormant seed. In this method, embryos of the dormant seeds are carefully removed and placed on a moist germination paper or filter paper in a petridish and kept at 20-22°C under normal light intensity. The viable embryo shows growth activities like greening, spreading of cotyledons and extension of embryonic axis, while non-viable embryo remains soft and shows no sign of growth.

**Mobilization efficiency test:** This test is based on the principle that efficiency of food matter mobilization from cotyledon to embryonic axis can be related to subsequent seedling growth and development. In this meth, two seed lots are drawn from the sample. Seeds of one lot are washed with distilled water, surface sterilized with 0.1% mercuric chloride solution for 1 minute, again thoroughly washed and then soaked for 4 hours. The embryonic axis and cotyledons are dried separately, maintained at 65°C for 24 hours, cooled in desiccators and weighed. Seeds of the other lots are put for germination in an incubator (same as germination test). After 4-7 days, depending on the crop, the growing embryonic axis and cotyledons are

dried separately at 65°C for 24 hours and then weighed. Mobilization efficiency according to Srivastava and Sareen(1974), can be determined as

$$\text{Mobilization efficiency (\%)} = \frac{Increaseindryweightofembryonicaxes}{Decreaseindryweightofcotyledon} X\ 100$$

In this calculation, difference in dry weight of cotyledons and embryonic axes before and after germination is mentioned as decrease in dry weight of cotyledon and increase in dry weight of embryonic axes. Seeds having higher viability potential possess enhanced, mobilization efficiency, because mobilization efficiency is positively correlated with germination percentage.

**X-ray test:** It is not a direct viability test but this test can indicate structural potential for seed viability by revealing morphological deficiencies of the seeds like emptiness, insect infestation, and mechanical damage through x-ray photographs. Usual procedure of this is to soak the seeds for 12-16 hours and then the soaked seeds are kept in concentrated barium chloride solution for 1-2 hours. After washing, x-ray photograph of the seeds are taken using soft x-ray films.

**Testing of seed quality**

**Physical purity test**: Physical purity denotes the percentage (by weight) of seeds belonging to the variety under certification. The working sample from the seed lot is classified into the components like (a) pure seed *i.e.*, seeds of the variety under certification, (b) seeds of other varieties of the same crops, (c) seeds of other crops, (d) seeds of weeds and (e) inert matters like sand, straw, stone, pebbles, soil particles, etc.

So, by purity analysis, the composition of the sample is ascertained and the results are expressed as weight percentage.

$$\text{Purity (\%)} = \frac{Weightofpureseed}{Totalweightofworkingsample} X\ 100$$

Similarly, weight percentage of the impurities can be determined separately.

**Viability or germination test**: This test determine the percentage of seeds of the representative sample of the seed lot that produce or likely to produce normal seedling under suitable environment.

**Determination of seed moisture content**: Two methods are employed namely, air-oven method and moisture meter method.

**Air-oven method**: Small quantity of working sample is required for this test. Most of the vegetable seeds are required to be oven dried for one hour at 130°C. Seeds containing oils (*e.g.* onion, cabbage, cauliflower, radish, chilli, sweet pepper, etc.) and some other small seeds (e.g., brinjal, amaranth) are required to be dried for 17 hours at 103°C. The cover of the seed container must be kept open during drying. After oven drying, the containers are closed and allowed to cool in a desiccators for 30 minutes and then weighed.

$$\text{Seed moisture } (\%) = \frac{M2 - M3}{M2 - M1} X\ 100$$

Where, M1 = weight of empty container with its cover

M2 = weight of container, cover and seed sample before oven drying

M3 = weight of container, cover and seed sample after oven drying

**Moisture meter method**: Moisture meter is an electric instrument by which moisture content of the seed sample is determined directly by their electrical conductivity since moisture content is directly proportional to resistance. Computerised moisture meter is also available. Simply seeds are kept on the moisture metre and readings are taken by pressing the button. The moisture is given in % unit.

Fig 3.1Moisture meter

**Seed coating and Seed priming**

**Coating:** Seed coating is a practice of applying external material such as fertilizers, polymers, colorants, microbes etc. vicinity to germinating seeds which improves seed quality and consequently yield by enhancing the seed performance (Adak *et al*., 2016). The coating helps in giving the seeds uniform in size making sowing comfortable, spacing and depth can be controlled as visibility is increased. Seed coating is a tool for establishing and stimulating seed quality (Hazra and Patanjali, 2016).

Two seed coating technologies, pelleting and film coating are applied in vegetable crops. Pelleting consists of application of solid particles that act as a filler with a binder to form a more or less spherical dispersal unit. Film costing consists of spraying a solution or suspension of film forming polymer onto a mass of seeds.

**Film coating:** Film coating is the technique of encapsulating seeds with a thin layer of synthetic slurry of polymers, pigments, and solvents, using rotating drum machines or simply by shaking.

The thin coating layer makes the size of the seed uniform, so enhances the handling features of the seeds while minimizing the loss of coating material during handling (Taylor *et al.*, 2001).

Fig 3.2 Normal seeds

Fig 3.2 Coated seeds

**Encrusting:** Encrusting is simply the process of covering the seeds with adhesives and coating material to enhance coating process. It gives smoother surface and more uniform shape and size so it can be used in greenhouse as its seed planting efficiency is more (Szemruch and Ferrari, 2013).

**Seed coating agents**

**Protectants:** The chemicals like insecticides, bactericides, fungicides, nematicides, and herbicides protect the seeds from various insects and pests (Ehsanfar and Modarres-Sanavy, 2005; Elzein*et al.,* 2010). The application of protectants can also improve germination rate, growth establishment and increase yield (Yang *et al*., 2014; Ryu*et al.*, 2006).

**Micronutrients:** Micronutrients are nowadays gaining importance as its essentiality is plant growth is confirmed but most of the soil is deprived of it. Seed coating with micronutrients likeiron (Fe), copper (Cu), manganese (Mn) and zinc (Zn)] can improve nutritional status of plants and thus improving yield (Williams *et al*., 2016). *Triticumaestivum* seeds coated with polymer mixture of Cu, Mn and Zn enhanced the nutrient uptake and yield (Wiatrak, 2013).

**Growth stimulants:** Coating the seeds with growth stimulants like auxin, gibberellic acid etc. hasa remarkable effect on plant growth and its development. It has also been found to improve physiological functions of the plant (Madsen *et al*., 2016).

**Microorganisms:** Plant growth promoting microbes and mycorrhizal fungi can be coated with seeds as biofertilizerinocula and is considered an efficient and convenient tool for introducing beneficial microbes in the rhizosphere zone of the plants to compete with the harmful microbes present in soil (Bennett *et al*., 2009). Due to poor microbial survival and sensitive to varying

soil environment, commercialization and large scale use of these biofertilizers are limited (Ma *et al.*, 2016). Different seeds are having some concentration of minerals like zinc and phytic acid and it has been found that after coating the seeds, these minerals have been increased in its concentration in the seed.

**Table (3.3): Zinc and phytic concentration of selected common vegetables** (Gibson and Ferguson, 2008)

| **Common Vegetables** | **Zinc mg/100g** | **Phytic acid mg/100g** |
|---|---|---|
| Pigeon peas Dry (*Cajanuscajan* L.) | 2.2 | 727 |
| Cowpea (*Vignaunguiculata* L.) | 3.8 | 420 |
| Common beans (*Phaseolus vulgaris* L.) | 1.5 | 557 |
| Lima beans (*Phaseoluslunatus* L.) | 1.5 | 238 |
| Pumpkin leaf (*Cucurbita maxima*) | 0.7 | 34 |
| Chinese cabbage (*Brassica chinensis* L.) | 0.7 | 5 |
| Okra leaf (*Abelmoschusesculentus* L.) | 1.8 | 97 |


Fig 3.3 Pictorial depiction of seed coating process

**Advantages of Seed Coating**

1. It is useful for uniform growth and establishment of the crop.
2. It enhances the seed germination process.
3. It gives protection against soil borne diseases and insects.
4. It helps plant to withstand even in the adverse conditions.
5. Increased visibility of seed in the soil

**Priming**: Another approach is to try to improve seed quality of the poorer seeds in the seed lot by physiological treatments. In the mid- 1970's, Walter Heydecker in U.K invented a technique

called priming. Heydecker (1973) defined seed priming as a presowing treatment in which seeds are soaked in an osmotic solution that allows them to imbibe water and go through the first stage of germination, but does not permit radicle protrusion through the seed coat. The seeds then can be dried to their original moisture contents and stored or planted by conventional techniques. Priming has the ability to improve the mean performance of a seedlot and also

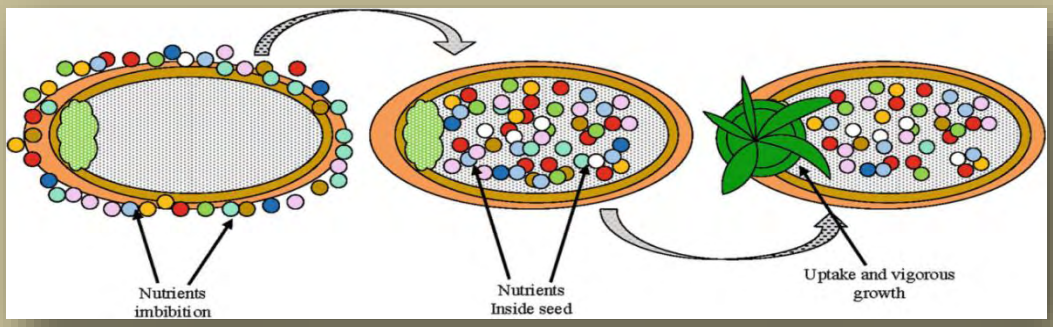



Fig 3.4 Effect of priming on seeds (Waqas *et al.,* 2019)

reduces variation within a seed-lot for a wide range of species.

Priming refers to hydrate seeds under controlled conditions but preventing from the completion of germination. During priming, seeds are soaked for 2-3 hours and kept in this condition for a day or less under 15 to 20°C. Since seeds have not completed germination, they remain desiccation tolerant and can be dried again for long-term storage. Many inorganic salts like NaCl, $KNO_3$, $K_3PO_4$ and $MgSO_4$ and organic compounds, like glycerol, mannitol and polyethylene glycol are used to prepare priming solution.

Seed priming is broadly defined as it is a pre-sowing seed treatment in which seeds are soaked in an osmotic solution that allows them to imbibe water, which go through the first stages of germination but does not permit the radicle protrusion through the seed coat, respectively. Seed priming isanorganized hydration technique, which allows germination metabolism without actual germination (Farooq *et al.*, 2006). It is used to increase speed of the germination rate, consistency and overcome its seed dormancy. In priming, seeds are hydrated in a controlled manner to provide enough water to initiate the metabolic processes of germination, but not enough to allow germination to be completed. The performance of seed priming in wheat to improve salt tolerance was effective (Jafar*et al.*, 2012). Stored proteins are solubilized during priming and lipid peroxidation is reduced while the activities of antioxidants are enhanced (Afzal *et al.*, 2008; Jafar*et al.*, 2012). Seed priming also boostsup osmolyte accumulation by altering metabolic processes (Delavari*et al.*, 2010) and also seed transition we are wetting the seed and drying it (Chen and Arora, 2013). Many inorganic salts, organic

substances and plant growth stimulators are used to control the hydration process during seed priming (Farooq *et al.*,2006; Afzal *et al*., 2008; Jafar*et al*.,2012). Use of chemical salts has been found to be more effective and economical in improving overall crop performance in adverse climatic conditions (Farooq et al., 2006; Jafar*et al.*, 2012).

The process of seed priming involves, first, exposure to an eliciting factor which makes plants more tolerant to stress exposure in future (Beckers and Conrath, 2007; Tanou*et al*., 2012). Priming is a process that hydrates the seed followed by drying the seed so that the germination processes begins inside the seed but radicle emergence does not occur (Giri and Schillinger, 2003). Priming the seeds enhances the germination mechanisms like defence to counter environmental stress during germination (Farooq *et al*., 2006, 2009).

**Table (3.4): Nutritional and environmental benefits by primed vegetable seeds** (Modified from Sarkar *et al.* 2018)

| Family | Host crop | Bio-inoculants or primers | Nutritional parameters (Minerals) | Physiological benefits | Environmental benefits | References |
|---|---|---|---|---|---|---|
| Brassicaceae | Cabbage | *Bacillus megaterium* | Increased N (18.0%) and P (10.2%) contents | Increased fresh shoot (32.9%) and root (22.6%) weight, dry shoot (16.0%) and root (35.6%) weight, stem diameter (47.5%), seedling height (27.2%) in seedlings | Reduction in environmental pollution | Turan*et al.* (2014) |
| | Radish | *Burkholderiagladii, Pseudomonas putida, Bacillus subtilis, Agrobacterium rubi* | | Improved germination percentage and rate under high saline condition | Plant growth promotion under stress condition | Kayma k*et al.* (2009) |
| | | *Bacillus subtilis, Pseudomonas fluorescens* | Increased N, P, K, Ca, and Mg contents in roots and leaves | Increased fresh and dry masses of roots and leaves, Chl a, Chl b, Chl a/b ratio, carotenoid, and total photosynthetic pigment contents in leaves | Reduction in environmental contamination and plant production under stress condition | Mohamed and Gomaa (2012) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Asteraceae | Lettuce | *Glomusintraradices Glomusmosseae* | Higher Cu and Fe contents | Increased levels of Chl | Maintenance of resilience of ecosystem services | Baslam*et al.* (2011) |
| Fabaceae | Pea | *Glomusmosseae* | Enhanced N (10%), P (26%), K (7%), Ca (4%), Fe (7%), Mn (4%), Zn (20%), Cu (38%), B (7%), and Mo (13%) uptake | Increased pod (12%) and stover (5%) yield | Improved soil fertility | Kumar *et al.* (2017) |
| | | *Glomusmosseae* | Enhanced N (16.3%), P (18.2%), and K (6%) uptake | Increase in root dry weight (14.9%), root weight density (13.7%), rooting depth (21.4%), and root volume (23.5%) | Improved soil-available P status | Yadav *et al.* (2018) |
| Solanaceae | Tomato | *Rhizobium* spp. | Increased N, P, K, and Mg contents | Increased numbers of flowers and fruits | Promotion of beneficial microorganisms | García-Frailee*t al.* (2012) |
| | | AMF | Higher nutrient uptake | Higher photosynthetic rate and stomatal conductance and increased fruit yield (~25%) | Increased crop water use efficiency | Bowles *et al.* (2016) |
| | | AMF and *Pseudomonads* | - | Increased flower and fruit production | Reduction of chemical inputs | Bona *et al.* (2017) |
| Malvaceae | Okra | *Glomusmosseae* | Enhanced N (5%), P (19%), K (3%), Ca (13%), B (4%), and Mo (15%) uptake | Increased fruit (10%) and stover (3%) yield | Improved soil fertility | Kumar *et al.* (2017) |
| Cucurbitaceae | Cucumber | *Glomusmosseae, G. etunicatum, G. clarum, G. caledonium* | Increased P and Zn shoot contents | Increased cucumber seedling survival and fruit yield | Reduction of fertilizer requirement and sustainable | Ortas (2010) |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | crop production | |
| Solanaceae | Pepper | *Rhizobium* spp. | - | 20 to 30% increase in the fresh weight | Promotion of beneficial microorganisms | García-Fraile*et al.* (2012) |
| | | *Glomus* spp. | Improvement in N, P, K, Ca, Fe, Mn, Zn, and Cu contents | Enhancement of photosynthetic pigments and rate, growth, and biomass | Improved plant and soil health | Pereira *et al.* (2016) |
| Convolvulaceae | Sweet potato | *Bacillus cereus*, *Achromobacterxylosoxidans* | Increased N, P, and K contents | Increased vegetative parameters (shoot length, root length, shoot fresh and dry weight, and root fresh and dry weight) and photosynthetic pigments | Promotion of sustainable agriculture | Dawwam*et al.* (2013) |
| Poaceae | Sweet corn | AMF | Increased N, P, K, Zn, and Mn contents | Enhanced yield | Improved soil fertility | Ortaş and Sari N(2003) |

**Technique of seed priming**

Seed physiologists recognize three main stages during germination (triphasic uptake of water).

**Stage 1:** This stage is recognized with a rapid initial uptake of water that is usually completed in 6- 24hr depending on the species. All seeds, even dead ones, take up water rapidly during this stage.

**Stage 2:** This is the plateau phase of water uptake during which there is initiation of nucleic acid and protein synthesis in preparation for the emergence of the radicle. This stage may last two or three times as long as stage one.

**Stage 3:** This is a stage characterized by the rapid uptake of water, cell expansion and the protrusion of radicle through the seed coat. The stage 3 is relatively short and the differences in the times of germination between the seeds of a population are associated with differences in the duration of stage2. Thus ‘good’seeds germinate earlier than the ‘poorer’ seeds. Regulating the availability of water to the seed and preventing it from entering stage 3 can reduce this variation. This enables ‘good’ seed to be held back, allowing ‘poor’ seeds in the lot to catch up the development. The

hydration of the seeds can be regulated using osmotica (osmopriming), salt (halopriming) and inorganic or organic carriers (solid matrix priming). Primed seeds emerge faster and grow vigorously. In this process controlled hydration of seed is done to a level that permits pre-germinative metabolic activity to proceed, but prevents actual emergence of the radicle. Different methods are adopted for priming seeds.

**Hydropriming:** Prior to sowing, seed is soaked in water for a specified duration depending upon crop and variety. After completion of soaking period, surface dry them either by drying them with cloth or placing in sun. Farmers can hydroprime their own seed if they know the safe limits. These safe limits are calculated for advances in quality seed production of vegetable crops so that germination will not continue once seeds are removed from water.

**Osmopriming:** Seeds are osmotically primed by soaking in -0.5 to -1.0MPa Polyethylene glycol 6000 solutions in a test tube or cylinder. Aeration during the priming is provided through a glass tube connected by a rubber pipe to an aquarium pump. Priming is done at a constant temperature (20 to 250 C) for a period ranging from 2 to 7 days. Distilled water is added to test tube as needed to maintain constant volume and thus constant water potential of the solution. After the completion of priming period, seeds are removed from the solution and rinsed with water and surface- dried immediately.

**Halopriming:** Seeds are haloprimed by soaking them in salt solution for a specified duration at constant temperature. Salts like potassium nitrate, calcium nitrate and magnesium nitrate at 10 to 30mM concentration are generally used. After the completion of soaking period, seeds are removed from solution and surface- dried.

**Solid matrix priming:** For solid matrix priming 100g seed is mixed with 200g vermiculite to which 250ml of water is added. The vermiculite and seeds are mixed thoroughly, sealed in a plastic bag and incubated at constant temperature for a specified period. After completion of incubation period, seeds are sieved out and dried to original moisture content. After drying seed to original moisture content, the primed seed can be used for sowing. Occasionally in case sowing is delayed, the primed seed can be stored in dry place for several days.

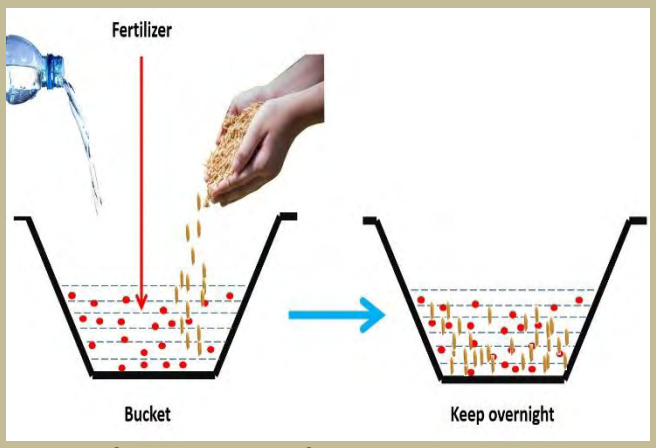
**Effect of Seed Priming on seedling growth and development**

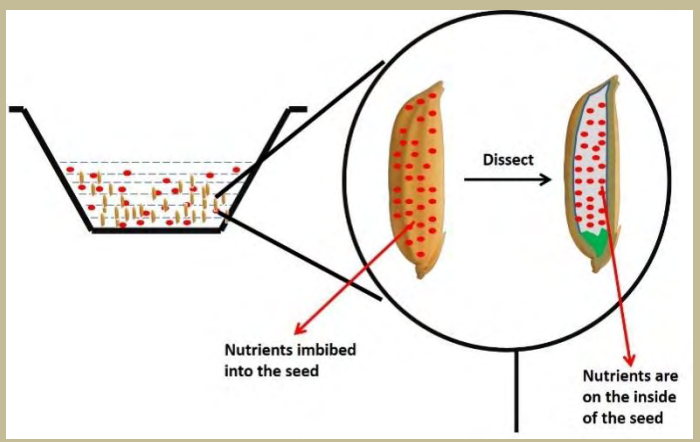
The benefits from priming treatments include increased germination, uniform emergence, germination under optimal and sub optimal environments and improved seedling vigor and growth (Pandita and Nagarajan, 2000; Khan *et al*., 1992; Penzola and Eira, 1993). Seed priming modify embryonic axis growth. The response varies according to the species and priming

conditions. Priming did not modify embryo volume and cell number of leek and onion but under similar conditions, carrot embryo volume increased almost 50% and the number of cells increased by two- fold. Generally, the major effects of seed priming on growth has been observed as early more uniform emergence and not accelerated growth, per se, of the species.

Fig 3.5 Pictorial depiction of seed coating process

Osmopriming of freshly harvested and aged seed of tomato seed improved germination,




speed of germination, field emergence and vigor of seedlings. Seed priming did not modify the number of basal and lateral roots and taproot length of 14 days old pepper seedlings (Stoffella*et al*., 1992). Root length of primed lettuce seeds germinated at 35˚C was greater than that of non-primed seeds (Wurr and Fellows, 1984). Pill (1989) reported that primed parsley seeds yielded 52% more fresh weight compared to non-primed seeds 24 days after sowing. Priming of carrot seeds resulted in 36% increase in dry weight of one- month old seedlings compared to non-primed seeds (Nagarajan*et al*., 2003). The differences in root and shoot growth between primed and nonprimed seeds are more evident under stressful conditions. Hydration of bittergourd seed in wet muslin cloth for 48h improved emergence, seedling length and dry weight significantly under low temperatures (Pandita and Nagarajan, 2004). Root growth from perennial rye grass seeds germinated at low temperature was greater in primed seeds than in nonprimed seeds, but no differences were observed at 25°C (Danneberger *et al*., 1992).

**Effect of Priming on yield and quality**

Seed priming promoted early growth of brinjal, pepper, cucumber, and muskmelon plants, but no differences were detected in early and final yield between primed and nonprimed seeds (Passam *et al.* 1989). However, Alvarado *et al*. (1987) reported that flowering was early in primed tomato seeds, but fruit maturation, yield or fruit soluble solid content were

unaffected. Under stressful conditions, priming increased early seedling growth and marketable yield (Odell *et al*., 1992). Beneficial effects of priming on yield and quality have been reported in crops growing under stressful conditions. Pandita *et al.*(2010) reported that solid matrix priming alone or in combination with *Trichodermaviride* significantly improved final marketable pod yield under sub-optimal temperature but there was no such improvement under optimal temperatures. Priming had no effect on the number of pods per plant and pod yield per plant under either environment. There is no doubt about the beneficial effects of priming on the rate and uniformity of seed germination. However, priming treatments are influenced by complex interaction of factors including plant species, osmoticum, duration, temperature, seed vigour and storage conditions following priming.

**Physiological and molecular basis of Priming**

It is important to understand physiological and molecular basis of seed priming for further refinement of this process to obtain better and more consistent benefits. A number of studies have reported on these effects but the biochemical mechanism of priming remains largely unelucidated. Lettuce seeds primed in PEG 6000 had increased activities of acid phosphatase and esterase and reduced time for RNA and protein synthesis than non-primed seeds (Khan *et al.*, 1977). Coolbear*et al.* (1990) reported large increase in nucleic acid content during priming process. The activities of peroxidase and dehydrogenase markedly increased in osmoprimed seed of carrot (Nagarajan*et al*., 2003). Solid matrix priming improved emergence in chilli seed under suboptimal temperatures were attributed to increased activity of glyoxylate cycle enzymes (Pandita*et al.*, 2007). Nascimento*et al.* (2000) found that during priming of a thermosensitive lettuce genotype endo-ß-mannanase activity was induced after 24 h. After drying and immediately upon reimbibition, endo-ß-mannanase levels were high, leading to rapid germination at $350^0$ C. A connection between priming, thermotolerance and endo-ß-mannanase activity has finally been established (Cantliffe*et al*., 2000). Membranes play an active role in seed hydration and dehydration mechanism, but their role during and after priming has not been studied extensively. Basra *et al.* (1989) reported changes in quantity and quantity of membrane phospholipids during and after priming. Parera and Cantliffe (1991) demonstrated that SMP primed sweet corn had less solutes leakage and reduced water uptake rates during early imbibition than non-primed seeds.

**Morphological Changes in Primed Seeds**

Morphological changes in primed seeds of ‘Minetto’ lettuce seeds were studied by Guedes*et al*. (1981) under electron microscope. They found that the outer layer of endosperm

cells were gradually loosened after 9 h of priming and this loosening weakening of cell wall, possibly is one of the mechanism of priming enhanced seed germination. Osmopriming of tomato seeds showed large free space between embryo and endosperm under X-ray radiography (Pandita*et al.*, 2007). The occurrence of free space in primed seeds has been suggested to play a role in accelerating germination rate by facilitating uptake of water (Argerich and Bradford, 1989). During priming the embryo expands and compresses endosperm tissue at a location opposite to radicle tip (Liptay and Zariffa, 1993). Both the compression forces of embryo and hydrolytic activities on the endosperm facilitates protrusion of roots upon rehydration (Liu *et al.*, 1996)

**Advantages of seed priming**

1. It improves rate of germination, seedling establishment in field
2. It imparts faster growth rate and drought tolerant in to the seedlings
3. It eliminate or greatly reduce the amount of seed-borne fungi and bacteria
4. The crops can compete more effectively with weeds.
5. It enables seed to germinate even under adverse agro-climatic conditions.
6. It improves uniformity to optimize harvesting efficiency.

These techniques can help the seeds to combat abiotic stress like drought, high temperature, salinity etc. Biotic stress given by pest from the soil can also be limited by these practices. Therefore, with some challenges, the seeds treated with coating and priming can improve overall quality of seed thus giving high yield.

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# Chapter -4

# Quality Transplant Production of Vegetables under Protected Condition

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Nursery under open field conditions with traditional method is a labour intensive and costly affairs and more over majority of the seedling affected by several biotic and abiotic stresses like, continuous rains, too low and too high temperatures, disease and insect-pest etc., resulting there is wastage of money, labour and time. Controlled conditions includes green house, poly house, low tunnel poly house, net house, shade net house etc. where we can raise as well as care the healthy seedlings. For the early establishment in the field and to reduce the cost of production now a day's vegetable seedlings are being raised in plug trays under controlled conditions round the year. Controlled conditions may be created fora small place and seedlings may be raised in plug trays in racks and if it require additional $CO_2$, light, humidity may be provided from outside to fulfill the requirements. Water may be given through micro sprinklers. Under this system, each transplant grows in an individual cell to avoid the competition among trans-plants and maintain the uniformity. Plug trays transplants establish better in the field because roots remain intact and are not damaged while pulling and transplants result tostands better and their growth can be controlled more easily through fertilizer and water management under protected condition. The growth can be stimulated by heating or cooling according to the specific needs of the seed. This technique reduces fluctuations in temperature and moisture that usually occur in open conditions.

**Protected structure**

A protected structure is a framed or an inflated structure covered with a transparent or translucent polythene sheet or shade net type material which separates the structure from outer

environment in which crops could be grown under the conditions of at least partiallycontrolled environment. Different types of protected structures are used for quality transplant production. On the basis of cladding material used these are given below.

**(i) Glass house:** Roof and all the four sides of glass house are covered with glass sheets. Green house effect increases temperature inside glass houses. Most of the glass houses are provided with heating systems. During summer, cooling devices are also provided. Temperature, humidity, light and carbon dioxide are also controlled through computerized micro processor system for providing ideal conditions. $CO_2$ enrichment is done inside the glass house to enhance its concentration. Vegetable cultivation and high quality seedling raising inglass house is generally popular in developed countries such as USA, UK, West Germany USSR, Japan, Spain, Italy, Rumania and Bulgaria. Plants are supplied with optimum amount of nutrients through drip irrigation and foliar spray.

Fig.4.1: Glasshouse

**(ii) Poly-house:** Recent advancements in petrochemicals and plastics led to replacement of costly glass houses to less costlier poly-houses. Poly-houses are large structures made of aluminium or galvanized iron or locally available wooden materials using ultraviolet stabilized low density polythene or transparent plastic film as cladding materials for growing plants under controlled or partially controlled environment. Based on climate control devices and materials used, poly-houses are classified into low cost, medium cost and high cost poly-houses.

Fig. 4.2: Polyhouse structure

**(a) Low cost polyhouse:** The cost of establishment of low cost polyhouse is around`500-1000 per $m^2$. Low cost polyhouses are not provided with any climate control device. This is a structure made of 700 gauge polythene sheet supported on bamboo or locally available materials. During winter of mild sub-tropics poly-houses are completely closed at night and as a result temperature inside would be 5-10ºC more than outside. During daytime, polyhouse side walls are kept open

Fig.4.3: Low cost polyhouse

to allow natural ventilation. During hot summer, temperature inside the poly-houses are reduced by providing shade nets, frequent watering and by opening the side walls.

Fig.4.4: Medium cost polyhouse

**(b) Medium cost polyhouse:** The cost of establishment of medium cost polyhouse is around`1000-2000 per $m^2$. In medium cost polyhouse the covering material used is UV stabilized polyethylene sheets, frame is made up of aluminium rods and the temperature inside polyhouseis controlled by providing "fan and pad cooling system", shade nets and micro-sprinklers. During winter, hot air blowers are necessary to maintain higher temperature. It has a single layer covering of ultraviolet stabilized polythene of 800 gauge thickness on GI pipes of 15 mm bore.

**(c) High cost polyhouse:** The cost of establishment of high cost polyhouseis around`2000 and above per $m^2$. It is provided with fibreglass covering along with full climate control devices. Temperature, humidity, light, day length and winds are automatically controlled using computers. Sensors and data loggers are provided in glass house to detect variation and to record climatic factors (Gopalakrishnan, 2007). High-tech structures are also provided with fully automatic fertigation system, sprinklers, misting system and fumigation devices.

Fig.4.5: High cost polyhouse

**(iii) Rain shelters:** This is naturally ventilated low cost shelter to protect plants from direct rain. Rain shelters are the most suited protection structures in high rainfall states like Assam and Kerala. It is provided with roof claddings of UV stabilized low density polyethylene film and sides are fully open. Mostly even span structure is used for construction of rain shelters.

Fig.4.6: Rain Shelter

**(iv) Tunnels:** Tunnel is used for initiating early germination of different summer crops like cucurbits. During rainy season also, a plastic tunnel can be provided to protect mid-season varieties of cucumber raised in nursery against rains. Plastic tunnels are extensively used in cold desert of Ladakh for raising vegetable nursery and to obtain early crops. In tunnels, environment is made congenial for growth of plants when atmosphere is unfavourable. Plastic tunnels are made using UV stabilized corrugated or plain fibre reinforced plastic sheets using metallic or plastic frames to provide support to film in tunnel shape (Venkatachalam and Ilamurugu, 2009).

Fig. 4.7: Polytunnel

**(v) Net house:** These simple framed structures are of two types, namely shade nets and insect proof nets. Shade nets are perforated plastic materials used to cut the solar radiation so as to protect leaves from wilting/scorching sunlight. These nets are available in three colours i.e. black, green and white and in different shading intensities ranging from 25 to 75%.Insect proof nylon nets are also available in different intensities of perforations, ranging from 25 to 60 meshes. Nets of 40 and higher mesh are effective means to control entry of most flying insects and save the plant from viral diseases.

Fig. 4.8: Net house

**Containers**

The production of containerized vegetable transplants has changed dramatically in the past several years. Most container-grown vegetable transplants were produced in peat-based containers, but now the vast majority is grown in hardened plastic or polystyrene (styrofoam) containers. Generally, peat containers, clay pots, peat pellets, fiber blocks and plastic pots are not used for mass production. Since both plastic and polystyrene containers are considered

Fig.4.9: Plastic trays

best and most are reused many times. Because of reuse, containers must be properly sanitized after each use otherwise disease problems are likely to occur. For this purpose containers are sterilized with 10 percent chlorine bleach solution after every use. Generally, smaller cells are used for plants such as cabbage, broccoli, cauliflower, collard, kale and lettuce. Trays with 1 to 1½-inch cells are well suited for producing transplants of these crops. These trays generally have 200 to 338 cells per tray. Boyhan and Granberry (2017)suggested the use of larger cell sizes, 1½ to 2½ inches, for production of tomato, pepper, watermelon, muskmelon, cucumber and squash transplants. These trays generally have from 72 to 200 cells per tray.

**Sowing of seeds:** Seeds are usually sown at a shallow depth after pressing the media with finger in gentle way into the potting plugs. The actual depth of sowing depends on the crop and the size of the seeds. After sowing of seeds a thick layer of vermiculite is given to cover the seeds. The plug trays then kept in the germination room at the optimum required temperature. Depth of seed sowing in some vegetable is given in table 4.1.

Fig.4.10: Sowing of seeds in plastic trays

**Table 4.1: Depth of seed sowing in some vegetable crops.**

| Crops | Depth of seed sowing ( in inches) |
|---|---|
| Tomato, Egg plant, Sweet Pepper, Chilli and Cole crops | 0.5 |
| Cucumber, Muskmelon and Watermelon | 0.5-0.7 |
| Summer Squash | 0.6-0.7 |

**Germination chambers**

Most vegetable crops benefit from the use of a germination chamber. This is usually an insulated room in which temperature and relative humidity can be maintained at a precise level. The goal is to facilitate the germination process in a confined area to minimize the cost of heating a large greenhouse to obtain a congenial germination temperature. Garton *et al.* (2020) states that the air circulation is

Fig.4.11: Seed germination chamber

important to ensure uniform temperature and humidity throughout the chamber. There should be a thermostat to maintain the temperature regime. If the temperature goes too high, the variability between the seeds is accentuated, resulting in both uneven germination and transplant development.

Optimum temperature and time for germination vary for different vegetable crops. Germination conditions for the major transplanted vegetables are listed in Table 4.2. Germination time will vary between seed lots, so growers should check the trays regularly while they are in the germination chamber. The trays should be moved to the greenhouse after the seed coat has cracked and the shoot just starts to emerge. This will prevent excessive elongation. The time taken for germination in the germination chambers may only be 2 or 3 days. If possible, warm water should be used when watering plants during early growth-stages. Water should be heated to about 21°C.

**Table 4.2: Optimum temperature ranges for germination of seeds**

| Crops | Germination temperature ($^{o}$c) | Approximate days for emergence |
|---|---|---|
| Tomato | 21-24 | 3-4 |
| Egg plant | 21-24 | 3-4 |
| Sweet pepper | 26-28 | 4-6 |
| Cole crops | 18-24 | 2-3 |
| Cucurbits | 24-30 | 2-3 |
| Onion | 18-24 | 3-4 |

**Transfer in protected structure**

After emergence of seed, plug trays should be transferred in protected structure. Vegetable seedling growers should use a rack system for benching in the greenhouse and for moving seedlings to the field. Plug trays are usually handled on racks made of either angle-iron or wood with wire-mesh tops. During the growing-on stage, environmental conditions (temperature, light, ventilation), water and nutrients, all affect the growth and quality of the transplants. The optimum day and night growing temperature requirements differ for

Fig. 4.12: Transfer of plastic trays in polyhouse

every crop and are listed in Table 4.3. Warm-season vegetable crops (tomatoes, peppers, egg plant and cucurbits) are susceptible to low temperature. Chilling occurs when transplants are exposed to temperatures below 10°C but above freezing point for an extended period. Chilling causes stunting of growth and can have a long lasting effect on field establishment. For susceptible crops, maintain a minimum greenhouse temperature of 10°C. The DIF (difference) Method is a method of managing greenhouse day/night temperatures to control plant height. The DIF is determined by subtracting the night-time from the daytime temperature. A higher day temperature gives a positive DIF and promotes growth while a lower day temperature gives a negative DIF which retards growth. High temperatures during the first three to four hours after sunrise can cause considerable elongation in vegetable transplants. This elongation can be reduced by keeping the greenhouse temperature cooler during the morning hours compared to the night-time temperature (negative DIF). According to Omafra, (2020) when cooling the greenhouse to a negative DIF, be careful to avoid chilling temperatures. Usually, 4-5°C negative DIF will give good height control.

**Table 4.3: Optimum temperature ranges for growth of various vegetable transplants.**

| Crops | Growing Temperature in Day (°C) | Growing Temperature in Night (°C) |
|---|---|---|
| Tomato | 18-21 | 10-18 |
| Egg plant | 18-21 | 10-18 |
| Sweet pepper | 18-21 | 12-18 |
| Cucurbits | 21-24 | 12-18 |
| Cole crops | 12-18 | 8-15 |
| Onion | 16-18 | 8-15 |

**Quality of irrigation water:** The greenhouse fertilizer program may have to be adjusted according to the pH, bicarbonate level and nutrient content of the water supply. Complete water analysis should be done every year since water can vary considerably over time. This will be especially true where water is taken from shallow wells or high water-table areas. The pH of the water used for watering plug transplants should be 5.5 to 6.5. At these levels, micronutrients are more available. A water sample containing 90 ppm bicarbonates is considered soft, while 350 ppm is considered to be very hard. Both of these samples may have the same pH. The bicarbonate level of the irrigation water is best in the 60-100 ppm range in order to avoid big

changes in pH when some types of fertilizers (ammonium) are added. The electric conductivity levels of irrigation water between 1.0 and 2.0 are considered to be most ideal.

**Watering of transplants:** The amount and frequency of watering will vary depending on cell type, growing media, greenhouse ventilation and weather conditions. It is important to water thoroughly and moisten the entire plug, which will promote root growth to the bottom of the plug. If the plug is not watered thoroughly, root growth will be confined to the top of the plug. Allow the plug to dry down before watering, but do not let the plant wilt severely, as this will damage roots. Plug transplants should be watered thoroughly in the morning, but should not be watered late in the afternoon. If the plants remain wet overnight, disease problems increase. If an overhead watering boom is used, it is advisable to remove and rearrange the nozzles occasionally to avoid the "streaking" that results from variations in output from different nozzles.

**Fertigation:** Water and nutrients are the two most critical inputs in vegetable production and its efficient management is not only important for higher productivity but also for maintaining environmental quality as it provide higher nutrient use efficiency, less water pollution, efficient application of micronutrients, better weed management, reduce soil compaction and effective use of undulated land. Among the various irrigation methods used for water application, the most efficient and increasingly adopted worldwide is micro irrigation systems particularly, drip and sprinkler methods. Vegetable transplants are usually fertilized with a soluble fertilizer which is applied in the irrigation water. Fertilizes material vary in percent nitrogen (N), phosphate ($P_2O_5$), and potash ($K_2O$); and in the micronutrient content. Growers should use fertilizers that have most of the nitrogen in nitrate form. In general, concentration of nitrogen 100 ppm, phosphorous 20-45 ppm and potassium 80-85 ppm are ideal for fertigation of vegetable transplants. The water soluble fertilizer mixtures (N:P:K) like 18:18:18, 19:19:19, 20:20:20, and 0:0:50 are mostly used along with urea which is also water soluble fertilizer and compatible with the above fertilizers, hence used for preparing the fertilizer stock solution and applied either through overhead tank system or through venture system. Fertigation dose and duration varies depending on the stage of crop and recommended dose of fertilizers.


Fig.4.13 Water soluble fertilizers

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# Chapter -5

## Scientific Nursery Raising Practices for Solanaceous Vegetable Crops

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"A vegetable nursery is a place or an establishment for raising or handling of young vegetable seedlings until they are ready for more permanent planting." The production of good quality seedlings is essential for getting higher yields and improving crop quality. In the past, the farmers themselves produced the seedlings required for transplanting at a lower cost, as most of the vegetable varieties were open pollinated types. Now, most commercial farmers are going for intensive vegetable cultivation using high yielding F1 hybrids to augment productivity. As these hybrid seeds are expensive, converting every individual seed into a healthy seedling becomes essential and this requires intensive nursery management. Vegetable seedling production is taken up by specialized farmers/companies or as a specialized activity in most advanced countries. In India too, the production of vegetable seedlings is gradually changing from open field nurseries to protected raised bed or seedling tray production in some of the intensive vegetable growing areas. Seedling production as a specialized practice is also rapidly catching up; however quality establishment of a hi-tech nursery by every individual farmer is not practically feasible and economically viable. Such farmers have to depend on commercial nurseries for vegetable seedlings to meet their requirements.

**Demerit in traditional method of nurseries raising**

- Higher pest and disease incidence (such as damping off)
- Poor germination due to improper management
- Missing the right growing season due to non viability of seedlings/ planting material at the time of planting
- Lack of application of advance scientific practices such as raised beds, seed treatment, protection against improved weather conditions, etc.

- Non-availability of seedlings throughout the year

Even today some of the growers are not familiar to scientific methods of raising and they grow seedling in open. Such seedlings suffer from soil-borne diseases or transplant shock when they are moved into the open field. Many nursery growers do not use proven seedling raising technologies such as proper media preparation, using seedling trays, maintaining hygienic conditions, using quality insect mesh, shade net materials, or a double door system. Production of quality transplant requires different skills and equipment than traditional seedling production, but resulting in higher net return.

Fig.5.1 Protected condition

Fig. 5.1 Open field condition

**Advantages of Nursery Raising:** It is very easy and convenient to look after the young tender seedlings growing in a small but compact area of a nursery. Favorable conditions of growth can be provided easily to the growing seedlings in a nursery. It eliminates the problem of seed emergence in heavy soils. It provides temporary protection from extreme weather conditions and facilitates in timely and easy management of pests and diseases in short growing period of 4-5 weeks. Weed control is easy in a small compact area. There is economy of land and more time is available for the preparation of land where transplanting is to be done. Uniform crop can be harvested if the crop is raised through nursery sown seedlings. Optimal use of expensive hybrid seeds and economization of the seed by sowing in nursery beds is another advantage. Sowing seeds in the nursery bed and then transplanting into the main field help in eliminating a part of the unfavorable weather conditions and also helps in getting early crop by adjusting suitable date of planting and there by securing a higher price for the produce.

**Factors to be taken into consideration for raising nursery**

**1. Selection of site:** Area selected should be well drained, and free from water logging. There should be proper sun light. The nursery should be near the water supply so that irrigation can be easy. The area should be well protected from pet and wild animals. Soil should have good organic matter. Soil texture should be neither too coarse nor too fine. Soil should be sufficiently

porous and adequately aerated. It should have a fair degree of water holding capacity. Soil pH of nursery bed should be in the range of 6 to 7. Acidic and alkaline soils are not suitable for raising nursery rather, neutral soils are suitable. Soil should normally be rich in all essential nutrient elements. Preferably soil testing of nursery area should be done so as to mix additional nutrients accordingly for improving its soil fertility status.

**Be close to high quality water:** There should be a good water source near to the nursery as a reliable supply of good quality water is necessary. It may be useful to construct rainwater harvesting storage tanks next to the nursery. The volume of water to be harvested and the size of the catchment needed can be calculated based on average rainfalls in the location.

**1.2 Ensure good access but minimize road dust:** Good accessibility is a requirement for a nursery area to ensure safe and easy transportation of nursery materials and seedlings to the planting sites.

**Treatment of soil against pathogens:**

**Bio Treatment of soil:** Soil drench with Trichoderma viride solution @ 50g/l water is an eco friendly method of soil treatment to manage many fungal diseases.

**Soil solarization:** May-June as temperature rises up to 45oC at this time. Wet the soil with water, or saturate it with water. Spread white polythene of 200 gauges on the whole nursery area for about 5-6 weeks. The margin of the polythene should be covered by wet soil (compressed mud) to check the entry of air. After 5-6 weeks, remove the polythene sheet. Prepare the beds for seed sowing.

**Table 5.1. Comparison of the effect of different colors of plastic mulch on light and weed control**

| Plastic Color | Soil Temp. (2- 4'' depth) | Light Reflectivity | Light Absorptivity | Light Transmission | Weed Suppression | Comments |
|---|---|---|---|---|---|---|
| Black | Increase 3 to $5^0$F | Low | High | Low | Excellent | Most common dose well in temperate |
| Clear | Increase 6to $14^0$F | Low | Low | Very High | Poor | Best in cool region and for fall crops |
| White/ silver | Decreases (-2 to $0.7^0$F ) | High | Low | Low | Excellent | Reflection interferes with movement of aphids. Best for tropical climates |
| Inrared Transmitting (IRT) | Increase 5 to $8^0$F | Low | High | High | Excellent | Selective light transmission. Transmits the sun warming wavelengths (like clear), but not |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | those that allow weeds to grow (like black) |

Source: (Angima 2009; Penn State Extension 2015; Sanders,2001)

**Chemical treatment:** The chemical treatment is also done with formalin (1:1000) solution water applied at 5 lit/m2 area saturated to be depth of 15 cm and covered thereafter with polythene sheet/ gunny bags or tarpaulin for 48 to 72 hours to kill harmful fungi and insect. The beds are uncovered and tilled to allow the formalin to evaporate. Mix chloropyriphos dust and carbofuran/ phorate granule @ 5g /$M^2$ in soil. Drench the soil with bavistin @ 1g/l water or Dithane M-45 @ 2g/ l water or with Blitox or Phytolon @ 3 g/l water as a prophylactic treatment against soil borne pathogens.

**Formalin Solution treatment:** This treatment should be done 15-20 days before seed sowing. Prepare formalin solution (1.5 to 2%) in one container and drench the soil @ 4-5 litre of water per square meter soil surface to saturate it up to a depth of 15-20 cm. Cover the drench area with polythene sheet of 200 gauge. Put the wet soil on the margin of the covered polythene sheet so as it does not allow the polythene film blown away by the wind and air from the covered area to outside. Remove the cover (polythene) after 15 days and prepare the beds for seed sowing.

**Table 5.2. Optimum temperature for seed germination, seed sprouting and seedling ready for transplanting**

| Crop | Temperature required for germination | Days required for seed sprouting | Seedling ready for transplanting (week) | Optimum depth for seed sowing (cm) | Month of Nursery Sowing |
|---|---|---|---|---|---|
| **Brinjal** | 20-35$^0$C | 5-7 | 4-5 | 0.5-1.0 | May-June |
| **Tomato** | 21-27 $^0$C | 5-6 | 4-5 | 0.5-1.0 | May-June, September-October |
| **Chilli** | 27-32 $^0$C | 7-8 | 6-7 | 05-1.0 | June-July<br>Sep-October |

**Nursery bed preparation**

The soil of the nursery area should be fine and fertile with good water holding capacity. For the preparation of beds, the field should be ploughed and leveled well. Soil should be worked thoroughly to obtain a fine textured soil free of clods and debris. Prepare raised beds to facilitate proper drainage of excess water. The level of the bed surface should be made little slanting on the two sides. The length of nursery bed should be 3-5 m but it can be increased or

decreased according to the availability of land and requirement of plants but the breadth of the beds should not be more than 1.00 -1.2 m and the beds should be 15-20 cm raised from the ground surface. The standard size of nursery bed is 3m × 1m × 15 cm. A space of 30-45 cm should be left between two beds. This space can be utilized to perform intercultural operations such as weeding, disease and insect-pest management and also for draining out the excess rain water from the nursery beds. Add 20-25 kg well rotten farmyard manure in each standard size nursery bed along with 200g single super phosphate and 15-20 g each of fungicides and insecticides such as mancozeb and dusts like methyl parathion. The number of nursery beds depends on the particular crop, season and growing area of crop for transplanting. The beds should be prepared in the east and west direction and lines/ rows for sowing of seeds should be made from north to south direction on the beds. Seed sowing in nursery bed should be treated with fungicides like bavistin or thiram or captan @ 3g/kg of seed to check the infection of soil borne diseases. Make rows at a spacing of 5 cm. Sow the seeds at 1 cm depth. The general rule for sowing depth is 2-3 times of the thickness of seed. Mix a little of sand in the seed for uniform distribution in the rows and cover it with soil or farmyard manure. Avoid broadcasting seeds in the nursery-bed. Thick sowing or sowing with broad casting also leads to increase in an incidence of damping off disease. If seeds are sown too deep, nutrient reserves will be exhausted before the plant emerges or emerging plants will be weak or liable to die. If sown too shallow, then it is likely to be eaten by birds or washed away by the splash of rains or irrigation water.

Fig.5.3 Nursery bed preparation

Fig.5.4 Nursery

**Table 5.3. Seed rate and nursery area required for raising seedlings for one hectare area Crop**

| Crop | Seed rate (g/ha) | Nursery area required (m2) |
|---|---|---|
| Tomato (Hybrid) | 150-200 | 75-100 |
| Tomato (OP) | 250-300 | 100-125 |
| Brinjal | 300 | 150 |

| | | |
|---|---|---|
| Chilli | 500-600 | 75-100 |
| Cpsicum | 400-500 | 100-150 |

**Table (5.4) Promising varieties and hybrids of Solanaceous vegetables**

| Crop | Hybrid/Varity | |
|---|---|---|
| **Tomato** | **Hybrid** | **(Arka Samrath) IIHR-H-240** Source: ICAR-IIHR Banglore , Yield 800-850q/ha<br>**Kashi Abhiman** Source: ICAR-IIVR Varanasi, Yield 850-900 q/ha<br>**Tai-01458(TO-01458)** Source: Syngenta seed company, Yield 450 q/ha<br>**BCTH-4** Source: BCKV ,Kalayni, Semi determinate Yield 550-600 q/ha |
| | **Variety** | **Kashi Chayan** Source: ICAR-IIVR Varanasi, Yield 600-700 q/ha<br>**Pujnjab Ratta** Source: PAU ,Ludhiana, Yield 560 q/ha<br>**Kashi Aman** Source: ICAR-IIVR Varanasi, Yield 500-600 q/ha |
| **Chilli** | **Hybrid** | **NCH-587** Source: Nirmal Seed Pvt.Ltd., Jalgaon, Yield 120-135 q/ha<br>**VNR-332 (Rani**) Sourse :VNR Seed Pvt. Ltd. Raipur, Yield 175-200q/h<br>**Vidya** Sourse :VNR Seed Pvt.Ltd. Raipur , Yield 200-220 q/ha |
| | **Variety** | **PC-56** Sourse: GBPAUT Pantnagar, Yield 150-170q /ha<br>**Kashi Gaurav** Sourse: ICAR-IIVR Varanasi, Yield 150q/ha<br>**LCA-620** Sourse : Dr. YSRHU RS, Lam, Yield 138 q/ha |
| **Brinjal** | **Hybrid** | **PB-70** Sourse: GBPUA&T, Panthnagar, Yield 400q/ha<br>**DBL-02** Sourse: ICAR-IARI, New Delhi, Yield 370-390 q/ha<br>**PHBL-51** Sourse: PAU Ludhiana, Yield 550-650 q/ha<br>**Nishant** Sourse: Advance Seed Pvt. Ltd. Yield 300-350q/ha |
| | **Variety** | **PB-67** Sourse: GBAU&T, Pantnagar , Yield 410q/ha<br>**Rasika** Sourse: Bejo sheetal seeds Pvt. Ltd. Jalana ,Yield400-580 q/ha<br>**VNR-51C** Sourse: VNR Seeds Pvt. Ltd Raipur, Yield 450-500 q/ha<br>**PHBL-51** Sourse: PAU Ludhiana, Yield 550-650 q/ha<br>**IVBL-23** Sourse: ICAR-IIVR Varanasi, Yield 400 q/ha<br>**Pusa Vaibhav(Rounde)** Sourse: IARI, New Delhi, Yield 410q/ha |

**Use of Mulch:** A thin layer of mulching of paddy straw or sugarcane trash or sarkanda or any organic mulch during hot weather and by plastic mulch in cool weather is done to maintain the soil moisture for proper seed germination.

**The advantages of mulching are:**

- It maintains the soil moisture and temperature for the better seed germination
- It suppresses the weeds.
- Protect from direct sunlight and raindrops.
- Protects against bud damage.

**Removal of Mulch:** Due attention is given to remove the covered mulch from the seedbed. After three days of sowing, observe the seed beds daily. As and when the white thread like

structure is seen above the ground, remove the mulch carefully to avoid any damage to emerging plumules.

Use of shading nets or polysheets: After seed germination or during the seedling growth, if there is very high temperature (> 30° C), cover the nursery bed with 50% or 60% shading nets (green or green + black coloured) about 60 - 90 cm above ground by providing suitable support. During winter season, cover the nursery bed over night with polythene sheet about 60-90 cm above ground by providing suitable support. Remove the sheet in the morning before the temperature rises. This technique protects young seedlings from severe winter frost or low temperature injury. Also during rains, cover the nursery bed with polysheet by providing proper support.

Fig 5.5 Shade Net

**Watering:**

Provide light irrigation to the nursery beds with rose can till the seeds germinate. During summers, irrigate the beds twice in a day i.e. both morning and evening. During winters, irrigation once in a day is sufficient. Keep beds moist but not wet otherwise “damping-off of seedling” may appear. Excess rainwater or irrigated water should be drained out from the nursery bed otherwise plants may die due to excess of water. Watering in the beds depends upon the weather condition. If temperature is high, irrigation is applied whereas irrigation is not needed during rainy days.

Fig-5.6 Watering of seedbed

**Thinning**: It is an important operation to remove weak, unhealthy, diseased, insect-pest damaged and densely growing plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant. The thinning facilitates balanced light and air to each and every plant. It also helps in monitoring the disease and insect pest infestation.

**Weeding of nursery bed:** Timely weeding in nursery is very important to get healthy seedlings. If there are some weeds in the seed bed, remove them manually either by hand or by hand hoe (thin forked Khurpi). Pre emergence herbicides can also be sprayed soon after the seed is sown to control the weeds. Stomp @ 3 ml/litre of water should be sprayed on the nursery beds after the seed sowing and covering with mixture of farmyard manure, soil and sand. For

good quality seedlings, spray urea @ 0.3 per cent when the plants are 8-10 cm tall.

**Plant protection:** Adaptation of plant protection measures in the nursery against the incidence of insect pest and diseases is very important task to get the healthy seedlings. Damping off seedlings, leaf curl, leaf blight diseases and leaf miner and borer infect the seedling in the nursery. The care for controlling them time to time is essential.

Common pests and their managements: The most commonly observed insect pests in nurseries are whiteflies, leaf miners, thrips and aphids.

Fig 5.7 Whiteflies

Fig.5.8 Leaf miner

**Using sticky traps for monitoring and trapping insects:**

Sticky traps are an important part of an Integrated Pest Management (IPM) program. They are easy to implement and inexpensive. Sticky cards will trap the adult stages of flying insects such as thrips, whiteflies, leaf miners and winged aphids. Remember, immature stages of thrips and white flies will not be caught on the cards.

**Types of sticky traps:** Most commonly, 3 by 5 inch sticky cards/traps are used in the polyhouse. Larger sticky cards are also available. Small cards are an excellent tool for monitoring while larger cards are good for mass trapping.

**Commercially available cards**

| | |
|---|---|
| YELLOW<br>Best for general pest monitoring Attract whiteies, leaf miners and winged aphids | BLUE<br>More attractive to thrips Used to detect thrips population |

**Recommended chemicals for the control of sucking insects and diseases**

**Precautions:** The fungicide Bavistin should be avoided as it has an antagonistic effect on the bio-pesticides incorporated into the growing medium.

**Table (5.5). Nursery pests and their control measures**

| | |
|---|---|
| Whitefly | Diafenthiuron @2g/L or Acetomaprid @0.2 g/L or Thiomethaxam @0.3 g/L or Flunicamid @150 ml /ha or Pyriproxifen @625 ml/ha |

| | |
|---|---|
| Leaf miner | Chloropyrifos -2 ml /L or Thiamethoxam -0.3 g/L Sprinkling of diatomaceous earth (powder form natural) |
| Thrips | Fipronil 5% @ 2 ml/L or Diafenthiuron @2g/L or Thiomethaxam @0.3 g/L or Spinosad @ 175 ml /ha |
| Blight | Mancozeb + Carbendazim@ 2.5- 3 g/L of water or Cymoxanil + Mancozeb@ 2-3 ml /L of water with sticker |
| Damping of | Drenching with COC after germination @3 g/L of water or Copper Hydroxide 2 g / L of Water or Cymoxanil + Mancozeb @ 2-3 ml/L of water |

**Damping off:** This is very serious disease of nursery. Pre-emergence death of seeds is seen. In first instance girdling takes place on the stem near base of the stem and seedlings bent down near the ground and die. The causal organisms are *Pythium, Phytopthora, Rhizoctonia* and *Fusarium* fungi. Treat the nursery bed either by soil solarization, formalin solution or formalin dust or fungicides like thiram or captan. Treat the seeds as discussed in seed treatment. If the disease appears after the seed emergence drench the nursery beds with 0.1% solution of brassicol or 0.7% captan or thiram after germination. It will be better to remove and burried the affected seedlings from the beds otherwise spread will be more. The disease can be controlled to some extent by applying treated sand, soil and FYM mixture up to the level from where the seedlings are falling.

**Raising of virus free seedlings:** Leaf curl is a white fly transmitted viral disease, infestation starts from seedling stage and continue till harvest of the crop. The disease is specially seen in the tomato and sometime in chilli too and causes great loss of the crop. The leaves of affected plants show curling, mottling, rolling puckering etc. It can be controlled by the following ways:

- Treat the soil of the nursery by carbofuran 3-5 g/sqm.
- Seed treatment with Imidachloprid @ 2.5 g/kg seed
- Cover the seed bed after seed sowing by Agronet making a tunnel like structure.
- Spray the nursery beds 15 days after seed germination at 7 days interval with Metasytox or Monocrotophos @ 1.5 ml/litre of water. Last spray is done 2 days before transplanting.
- Remove the infected plants if any in the field and burried in with soil or burn.
- In this way the raised seedlings will be healthy and free from viral diseases.

**Hardening of the plants in the nursery:** Hardening improves the quality and modifies the nature of colloids ion the plant cell enabling them to resist the loss of water. Hardening improves the presence of dry matter but decrease the percentage of feasible water and transpiration per unit area of leaf. Decrease the rate of growth in the plant. Harden plants

withstand better against unfavorable weather condition like hot day, wind and low temperature. Hardening of plants increases the waxy covering the leaves of cabbage. For hardening withhold irrigation in the nursery beds 4-5 days before the date of transplanting but on the day of transplanting, first apply water to the nursery beds and then take out the plants for transplanting. Hardening should be gradual to prevent or check the growth. Warm season crops like tomato, brinjal and chili cannot withstand severe hardening. Hardened plants withstand unfavorable weather conditions like hot day winds or low temperature more efficiently than non-hardened seedlings.

**Selection of seedlings for transplanting:** After attaining proper growth, seedlings are transplanted in main field. At the time of transplanting, seedling should be:

- Stocky and sturdy
- Should have good root system
- Should be free from any insect pests and diseases

Grafting in solanaceous vegetables: Soil-borne diseases and nematodes pose serious problems in vegetable cultivation. In acidic soils and under humid conditions, bacterial wilt is a serious threat to tomato production. Under such conditions, grafting commercial F1 hybrids or varieties onto resistant rootstocks is a viable option to improve yields. Tomato seedlings can be grafted onto *Solanum torvum* or wilt-resistant brinjal varieties. For raising the rootstock, seeds of Solanum torvum are sown into seedling trays in a soilless medium containing three parts of washed coco peat and one part each of vermiculite and perlite. *Solanum torvum* takes at least 15 to 20 days to germinate. Normally 8-10 seeds are sown in a single cell and when the seedlings reach the 3-4 leaf stage, excess seedlings are transplanted into a new tray at one seedling per cell. The rootstock seedlings require daily irrigation and fertigation once every 5-7 days. There are three common types of grafting in solanaceous crops: tube grafting, wedge grafting and slant/side grafting.

**Tube grafting:** For tube grafting 1 cm long hollow silicon tubes with a hole diameter of 2.0 – 3.0 mm are used. The rootstock seedlings are de-topped at a height of 5.0 – 6.0 cm above the base of the plant. The silicon tube is slowly slipped over the rootstock. Using a razor blade the seedling is then split longitudinally through the centre to a length of 1.0 – 1.5 cm. The scion seedling is then detached from the pro-tray by giving a horizontal cut 4.0-5.0 cm above the base. A small tapering cut is then made on each side of the detached scion to make a wedge 1.0 – 1.5 cm long. The prepared scion is then inserted into the split made in the rootstock and the

silicon tube is pulled up over the joint to ensure that the scion and stock are aligned properly. The scion can be any desired commercial hybrid or variety. Scion seeds are raised in seedling trays with 25 mm x 25 mm cells, at one seed per cell. The scion seedling will be ready for grafting in 15- 20 days after sowing.

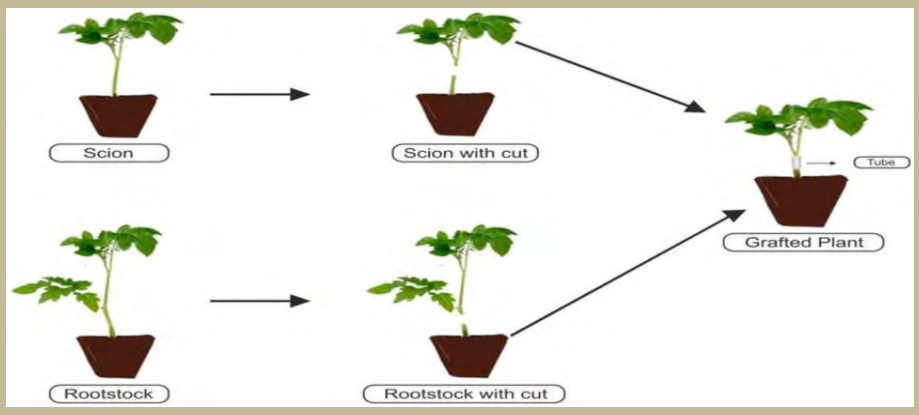


Fig. 5.9. Tube grafting in tomato

**Wedge (clip) grafting:** The same procedure is followed but the stock and scion are held together using a grafting clip made of plastic. This method is comparatively easier than using the silicon tube, which needs to be removed when the joint is established. Grafting clips can be easily detached from the graft joint and reused again.

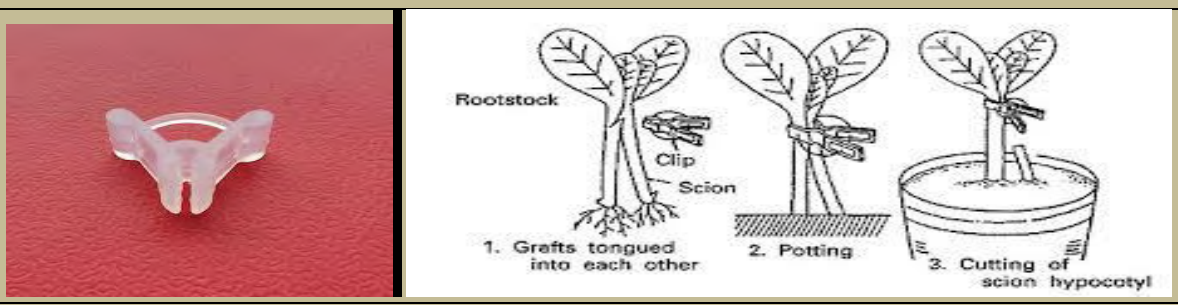


Fig.5.10 Wedge (clip) grafting

**Slant/side grafting:** Side grafting is also used for vegetable seedlings. The stock is de-topped using a slanting cut 5.0 – 6.0 cm above the base. A small polyethylene sleeve (1.0 cm long) is then fixed on the rootstock where the slanting cut has been made. A matching slanting cut is made on the scion seedling and it is then inserted into the polyethylene sleeve attached to the rootstock so that both the cuts are aligned with each other.

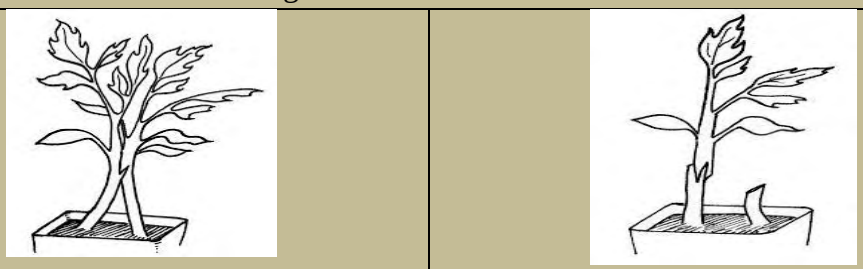

Fig.5.11. Slant/side grafting

The vegetable seedlings after grafting are immediately shifted to a healing chamber that can provide a hot (25 – 30°C), humid (90 - 95% RH) environment for the grafts to heal. High humidity is maintained inside the healing chamber by spraying water or fogging at periodic intervals depending upon the weather. The spraying intensity increases in dry weather. After 4 to 5 days, when the grafts heal, they are transferred to a polyhouse and kept for a week for further hardening. The hardened seedlings are then transplanted. It is important to harden seedlings before they are transplanted. Seedlings are grown in a controlled environment. The temperature is pretty much maintained, the light is not as strong as full sunlight outside, and they are protected from adverse environmental conditions such as wind and rain. As seedlings grown indoors have never been exposed to the harsher outdoor environment, they do not have any defences built up to help them deal with this growing environment. To prepare them, it is important to gradually expose them to the outside environment where they will have to establish and spend the rest of their lives. The best way to help strengthen seedlings for the outside environment is to harden them off. It is an easy process and will enable the plants grow better and stronger when transplanted out into the main field.

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# Chapter -6

## Quality Seedling Production of Cole Crops

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India is the world's second largest producer of vegetables after China. Cole crops group is an important cool season vegetable groups which are mostly cultivated in rabi season which is widely grown and popular in almost all the regions of the country. Among the vegetables, cole crops play a vital role both in production and nutritive value. The word 'Cole' is abbreviated from `Caulis' which means stem. Probably, the stem being quite prominent, the term 'Cole' was used to refer the group of these plants originating from a single wild form, namely *Brassica oleracea* var. *sylvestris*. Cole crops is a general term used to describe many vegetables that belong to Brassicaceae family, including cabbage (*Brassica oleraceae* var. capitata), cauliflower (*Brassica oleraceae* var. botrytis), broccoli (*Brassica oleraceae*var. italika), knolkhol (*Brassica oleraceae* var. gongylodes), Brussels sprout (*Brassica oleraceae* var. gemmifera) etc. Cabbage and cauliflower are the major cole crops but broccoli and knolkhol are also being cultivated in limited scale. The regular crop is grown during pre rabi season at lower altitude while off season (summer crop) is grown at higher altitude (>2000msl) (Denzongpa and Sharma, 2013).

**Nutritive value:**

Cole crops are known as the "Crown jewel of Nutrition" for their vitamin rich, high fibre, low fat and low calorie properties. They are rich in vitamin C, beta carotene, fibre, antioxidants, and phytochemicals which help in preventing cancer and heart diseases. Nutritional profile of different cole crops id given in table (6.1).

**Why do we need Nursery?**

*Some vegetables require special cares during their early growth period.* There are some vegetables with very small sized seeds. These are first sown in the nursery for better care and to combat with the time for field preparation and after about one month of seed sowing,

seedling is transplanted in the main field.

**Table 6.1. Cole crops nutrition profile, fresh/raw** (per 100 g of edible portion)

| **Principle** | **Cauliflower** | **Cabbage** | **Broccoli** | **Brussels sprouts** | **Knol-knol** | **Kale** |
|---|---|---|---|---|---|---|
| | **Nutrient value** | | | | | |
| Energy | 25 Kcal | 25 kcal | 34 Kcal | 43 Kcal | 27 Kcal | 35 Kcal |
| Carbohydrates | 4.97 g | 5.8 g | 6.64 g | 8.95 g | 6.20 g | 4.42 g |
| Protein | 1.92 g | 1.3 g | 2.82 g | 3.38 g | 1.70 g | 2.92 g |
| Total Fat | 0.28 g | 0.1 g | 0.37 g | 0.30 g | 0.10 g | 1.49 g |
| Cholesterol | 0 mg | 0 mg | 0 mg | 0 mg | 0 mg | 0 mg |
| Dietary Fiber | 2.0 g | 2.50 mg | 2.60 g | 3.80 g | 3.6 g | 4.1 g |
| **Vitamins** | | | | | | |
| Folates | 57 µg | 53 µg | 63 µg | 61 µg | 16 µg | 62 µg |
| Niacin | 0.507 mg | 0.234 mg | 0.639 mg | 0.745 mg | 0.400 mg | 1.180 mg |
| Pantothenic acid | 0.667 mg | 0.212 mg | 0.573 mg | 0.309 mg | 0.165 mg | 0.370 mg |
| Pyridoxine | 0.184 mg | 0.124 mg | 0.175 mg | 0.219 mg | 0.150 mg | 0.147 mg |
| Riboflavin | 0.060 mg | 0.040 mg | 0.117 mg | 0.90 mg | 0.020 mg | 0.347 mg |
| Thiamin | 0.050 mg | 0.061 mg | 0.071 mg | 0.139 mg | 0.050 mg | 0.113 mg |
| Vitamin A | 0 IU | 98 IU | 623 IU | 754 IU | 36 IU | 4812 IU |
| Vitamin C | 48.2 mg | 36.6 mg | 89.2 mg | 85 mg | 62 mg | 93.4 mg |
| Vitamin E | 0.08 mg | - | 0.17 mg | - | - | - |
| Vitamin K | 15.5 µg | 76 µg | 101.6 µg | 177 µg | 0.1 µg | 389.6 µg |
| **Electrolutes** | | | | | | |
| Sodium | 30 mg | 18 mg | 33 mg | 25 mg | 20 mg | 53 mg |
| Potassium | 299 mg | 170 mg | 316 mg | 389 mg | 350 mg | 348 mg |
| **Minerals** | | | | | | |
| Calcium | 22 mg | 40 mg | 47 mg | 42 mg | 24 mg | 254 mg |
| Iron | 0.42 mg | 0.47 mg | 0.73 mg | 1.40 mg | 0.40 mg | 1.60 mg |
| Magnesium | 15 mg | 12 mg | 21 mg | 23 mg | 19 mg | 33 mg |
| Manganese | 0.155 mg | 0.160 mg | 0.210 mg | 0.337 mg | 0.139 mg | 0.920 mg |
| Phosphorus | - | 26 mg | - | 69 mg | 46 mg | 55 mg |
| Zinc | 0.27 mg | 0.18 mg | 0.41 mg | 0.42 mg | 0.03 mg | 0.39 mg |
| Copper | 0.039 mg | - | 0.049 mg | 0.70 mg | 0.129 mg | 0.053 mg |
| Selenium | - | - | 2.5 µg | 1.6 µg | 0.7 µg | 0.9 µg |
| **Phyto-Nutrient** | | | | | | |
| Carotene-α | - | 33 µg | - | 6 µg | - | - |
| Carotene-ß | 0 µg | 42 µg | 361 µg | 450 µg | 22 µg | - |
| Lutein-zeaxanthin | 1 µg | 30 µg | 1403 µg | 1590 µg | - | - |
| Isorhamnetin | - | - | - | - | - | 23.6 mg |
| Kaempferol | - | - | - | - | - | 46.8 mg |
| Quercetin | - | - | - | - | - | 22.6 mg |

**Source**: https://www.nutrition-and-you.com/vegetable-nutrition.html.

**Advantages of nursery raising for cole crops production**

Fig. 6.1 Soil solarization

Nursery is a place or an establishment for raising or handling of young seedlings until they are ready for more permanent planting. It is possible to provide favorable growth conditions i.e. germination as well as growth. Better care of younger plants as it is easy to look after nursery in small area against pathogenic infection, pests and weeds. Crop grown by nursery raising is quite early and fetch higher price in the market, so economically more profitable. There is saving of land and labour as main fields will be occupied by the crops after a month. More intensive crop rotations can be followed. More time is available for the preparation of main field becau separately. As vegetable seeds are very expensive particularly hybrids, so we can economize the seed by sowing them in the nursery (Reddy, 2020).

**Selection of site**

- Area selected should be well drained, and free from water logging.
- There should be proper sunlight.
- The nursery should be near the water supply so that irrigation can be easy.
- The area should be well protected from pet and wild animals.
- Soil and Soil preparation

Raising of cole crop seedlings requires deep, fertile and healthy soil with good water holding capacity. Preferably, the soil for nursery should be loam to sandy loam, loose and friable, rich in organic matter and well drained. The soil pH should be close to the neutral i.e. about 7.0. It needs a deep cultivation of the nursery land either by soil turning plough or by spade and subsequent 2-3 hoeing with cultivator. After that all the clots, stones and weeds from the field should be removed and land should be leveled. Mix 2 kg well rotten and fine farm yard manure/compost or leaf compost or 500 g vermicompost per square meter and mix in the soil. If the soil is heavy, mix 2-3 kg sand per square meter so that the seed emergence may not be hampered.

**Soil treatment: Soil is treated by following methods:**

**A. Soil solarization:** Soil solarization is an important practice. The suitable time period for soil solarization is May-June as temperature rises up to 45oC at this time. In this process, wet the soil surface with water, or saturate it with water. Then white polythene of 200 gauges is spread on the whole nursery area for about 5-7 weeks. The margin of the polythene should be covered

through wet soil (compressed mud) to check the entry of air. After 5-7 weeks the polythene sheet should be removed. Prepare the beds for seed sowing. **B. Biological soil treatment:** In this type of soil treatment, apply 10-25 g of trichoderma powder per 100m$^2$ of nursery bed. Application of neem cake and FYM before treatment increases the efficacy. The *trichoderma* may suppress the growth of the pathogen population in the rhizosphere through competition and thus reduce disease development. It produces antibiotics and toxins such as trichothecin and a sesquiterpine, Trichodermin, which have a direct effect on other organisms. The antagonist (*Trichoderma*) hyphae either grow along the host hyphae or coil around it and secrete different lytic enzymes such as chitinase, glucanase and pectinase that are involved in the process of mycoparasitism. Examples of such interactions are *T. harzianum* acting against *Fusarium oxyporum, F. roseum, F. solani, Phytophthora colocaciae* and *Sclerotium rolfsii*. In addition, *trichoderma* enhances yield along with quality of produce, boosts germination rate, increases in shoot & root length, solubilizing various insoluble forms of phosphates augment nitrogen fixing. Promote healthy growth in early stages of crop. Increase dry matter productions substantially provide natural long term immunity to crops and soil.

Fig 6.2. Stream treatment

**C. Formalin Solution treatment:** This type of soil treatment should be done 15-20 days before seed sowing. Firstly prepare the formalin solution (1.5 to 2%) in one container and drench the soil @ 4-5 liter of water per square meter soil surface to saturate it up to a depth of 15-20 cm then the drench area should be covered with polythene sheet of 200 gauge. Put the wet soil on the margin of the covered polythene sheet so as it does not allow the polythene film blown away by the wind and air from the covered area to outside. 15 days after the cover (polythene) should be removed. Finally prepare the beds for seed sowing.

**E. Steam treatment:** Hot steam can be used to treat the soil against harmful insect pest. For this, cover the required area with the help of polythene sheet and stop the movement of air in the covered area. Supply the hot steam for at least 4-6 hours continuously. This way all the harmful pathogen and insect pest will be killed.

**Application of fungicides**

Captan, Thiram which kill the soil borne pathogens. Use 2-3 g of any of the fungicides dissolve in per liter of water and drench the soil @ 4-5 liter of water per square meter soil surface to

saturate it up to a depth of 15-20 cm.

**Insect Control:** Presence of certain insect pest and their egg or secondary stage insects present in the soil which can infect the seedlings in the later stage. To save the seedlings against them, some insecticides are also used as soil treatment. Recommended insecticide is Chlorpyriphos @ 2 ml/ liter of water. The depth of 15 to 20 cm in the nursery soil and then prepared the beds for seed sowing.

**Nursery bed preparation**

The length of the bed may be kept 3 to 5 meter, however, width is restricted to 1.0 meter only which facilitates intercultural operations. The beds are raised 15 to 20 cm high from the ground level. A space of 30 - 40 cm is left in between two beds. The space between two beds helps in weeding, nursery care against diseases and insect pest and also for draining out the excess rain water from the nursery beds. The number of beds depends on the particular crop, season and growing area of crop. The beds should be prepared in the east and west direction and line should be made from north to south direction on the beds (Tiwari, 2009).

**Table 6.2. Quantity of seed and nursery area required for raising seedling of one hectare area**

| **Crop** | **Seed rate (g/h)** | **Nursery area required ($m^2$)** |
|---|---|---|
| Early cauliflower | 700 | 150-200 |
| Mid and late Cauliflower | 400-500 | 150-200 |
| Cabbage | 400-500 | 150-200 |
| Sprouting Broccoli | 400-500 | 250 |
| Brussels Sprout | 500 | 250 |
| Knol-khol | 1000-1500 | 250 |
| | **Time of Nursery sowing** | **Time of transplanting** |
| Early | July | August |
| Mid | Aug-September | September-October |
| Late | October | November |

**Use of mulch**

To maintain the soil moisture for seed germination cover the seed bed with a thin layer of mulch of paddy straw or sugar cane trash, or sarkanda or any organic mulch during hot weather and by plastic mulch (plastic sheet) in cool weather. It has following advantages:

**Table (6.3) Optimum temperature for seed germination and duration for ready seedlings**

| Crop name | Optimum temperature for seed germination | Optimum depth for seed sowing (cm) | Days taken for seed germination | Seedling ready for transplanting (Week) |
|---|---|---|---|---|
| Sprouting Broccoli | 29.4 | 0.5-1.0 | 4 | 4-6 |
| Cabbage | 26.67 | 0.5-1.0 | 4 | 4-6 |
| Cauliflower | 26.67 | 0.5-1.0 | 5 | 4-6 |
| Brussels Sprout | 26.67 | 0.5-1.0 | 4 | 4-6 |
| Knol-khol | 29.4 | 0.5-1.0 | 5 | 4-6 |

**Table (6.4) Varieties of cole crops**

| Crop name | Varieties |
|---|---|
| Cabbage | **Early**-Pusa Mukta, Golden Acer, Pride of India,<br>**Mid-** All Green, September, All Head Early<br>**Late**-Pusa Drum Head, Danish Ballhead |
| Cauliflower | **Early**-Pusa Deepali, Pusa Sarad, Early Kunwari, Pant Gobhi-3, Pusa Early Synthetic, Kashi Kunwari, Pusa Katiki<br>**Mid**-Pusa Shubhra, Pant Shubhra, Pusa Synthetic, Hisar-1<br>**Late-** Snowball-16, Pusa Snowball-1, Pusa Snowball-K-1, Pusa Himjyoti |
| Knol-khol | Early White Vienna, Early Purple Vienna, Large Green, Purple Vienna, King of North |
| Sprouting Broccoli | Pusa Broccoli KTS-1, Palam Samradhi, Palam Kanchan, Punjab Broccoli No-1 |
| Brussels Sprout | Hilds Ideal, Jade Cross, Rubine |

**Source**: Thamburaj and Singh (2019)

- Maintains the soil moisture and temperature for better seed germination.
- Suppresses the weeds.
- Protects from direct sunlight and raindrops.

- Protects against bird damage.

**Removal of mulch:** Due attention is given to remove the covered mulch from the seedbed. After three days, observe the seed beds daily. As and when the white thread like structure is seen above the ground, remove the mulch carefully to avoid any damage to emerging plumules. Always remove mulch in the evening hours to avoid harmful effect of bright sun on newly emerging seedlings.

**Use of shading net:** After seed germination during the seedling growth, if there is very high temperature (> 30$^{o}$ C) then beds should be covered by 50% or 60% shading nets of green/green + black coloured, about 60 - 90 cm above ground by the use of suitable support.

**Watering:** The first watering should be done just after seed sowing. Thereafter light irrigation should be given with the help of rose can till the seeds get germinated. Excess rainwater or irrigated water should be drained out from the field as and when it is required otherwise plants may die due to excess of water. Watering in the beds depends upon the weather condition. If temperature is high, open irrigation is applied. Need not to irrigate the beds during rainy days.

**Thinning**: It is an important operation to remove weak, unhealthy, diseased, insect pests damaged and dense plants from the nursery beds keeping distance of about 0.5 to 1.0 cm from plant to plant. The thinning facilitates balance light and air to each and every plant. It also helps in watching the disease and insect pest attack on plants while moving around the nursery.

**Weed control**: Timely weeding in nursery is very important to get healthy seedlings. If there are some weeds in the seed bed, remove them manually either by hand or by hand hoe (thin forked khurpi). Pre emergence herbicides can also be sprayed soon after seed sowing to control the weeds. Stomp @ 3 ml/liter of water should be sprayed on the nursery beds after the seed sowing and seed covering with mixture of FYM, soil and sand.

**Plant protection**: Adaptation of plant protection measures in the nursery against the incidence of insect pest and diseases is very important task to get the healthy seedlings. Damping off seedlings, leaf curl, leaf blight diseases and leaf miner and borer infect the seedling in the nursery. These insects- pests should be managed timely.

**Damping off:** This is very serious disease of nursery. Pre-emergence death of seeds is seen. In first instance girdling takes place on the stem near base of the stem and seedlings bent down near the ground and die. The causal organisms are *Pythium, Phytopthora, Rhizoctonia* and *Fusarium* fungi. Treat the nursery bed either by soil solarization, formalin solution or

formalin dust or fungicides like thiram or captan. Treat the seeds also.

**Control**: If the disease appears after the seed emergence drench the nursery beds with 0.1% solution of brassicol or 0.7% captan or thiram after germination. It will be better to remove and burried the affected seedlings from the beds otherwise spread will be more. The disease can be controlled to some extent by applying treated sand, soil and FYM mixture up to the level from where the seedlings are falling.

**Hardening of the plants in the nursery**

The term hardening includes "Any treatment that makes the tissues firm to withstand unfavourable environment like low temperature, high temperature and hot dry wind "Hardening is physiological process. Plants accumulate more carbohydrates reserves and produce additional quiticle on the leaves. In this process seedlings are given some artificial shocks at least 7-10 days before uprooting and transplanting. These shocks include exposure to the full sunlight, removal of all the shading nets, polythene sheets and irrigation is stopped slowly and slowly.

**Techniques of hardening:** The hardening is done by the following ways-

Withhold the watering to the plant by 4-5 days before transplanting. Lowering the temperature also retards the growth and adds to the hardening processes. Application of 4000 ppm NaCl with irrigation water or by spraying of 2000 ppm of cycocel are also recommended for hardening.

**Duration and degrees of hardening:** It is very necessary that plants should be hardened according to their kind so that there is an assurance of high percentage of survival and slow growth under the condition to be expected at the time of transplanting. Hardening should be gradual to prevent or check the growth. In Indian condition allowing the soil to become dry for 5-6 days does the hardening.

Effect of hardening: Hardening improves the quality and modifies the nature of colloids in the plant cell enabling them to resist the loss of water. Hardening increases the presence of dry matter and decreases the percentage of freezable water and transpiration per unit area of leaf. Hardened plants can withstand better against unfavourable weather conditions like hot day winds or low temperature. Hardening of the plants increases the waxy covering on the leaves of cabbage (Tiwari, 2009).

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# Chapter -7

## Quality Transplant Production in Dioecious Cucurbits

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Food security, nutritional security, profitability, and sustainability are the main principles of present and future agriculture strategies with special reference to vegetable development. In India vegetables are grown from sea shore to snow line with great diversity. Most of them are short duration, quick growing and produces high yield per unit area. Today, approximately annual world production is 1080.33 MT and India‘s production is 191.11 million tones with different groups of vegetables. The family Cucurbitaceae contributes most of the popular vegetables viz., cucumber, muskmelon, watermelon, gherkin, bottle gourd, bitter gourd, pumpkin which are widely grown whereas there is a long list of perennial cucurbits which have very sparse area. The term 'cucurbits' was coined by Liberty Hyde Bailey for cultivated species of the family Cucurbitaceae. Presently this term is not in vogue for cultivated forms, but for all species of the Cucurbitaceae (Robinson and Decker-Walters, 1997). In family Cucurbitaceae, numbers of vegetables are dioecious in nature. Apart from dioecy, they are in perennial in nature having significant advantages over annual cucurbits. The list of dioecious cucurbits which are commonly grown in India is given ass under:

**Table 7.1: List of dioecious cucurbits grown in India**

| Sl. No. | Common Name | Botanical Name | Chromosome Number (2n) |
|---|---|---|---|
| 1. | Pointed gourd | *Trichosanthes dioica*Roxb. | 24 |
| 2. | Ivy gourd | *Coccinia grandis* (L.) Voigt | 24 |
| 3. | Sweet gourd | *Momordica cochinchinensis* Spreng. | 28 |
| 4. | Spine gourd | *Momordica dioica* Roxb. | 28 |
| 5. | Bankunari (Melothria) | *Solena amplexicaulis* (Lamk) Gandhi Syn.*Melothria heterophylla* (Lour) Cogn. | 48 |

**Source:** Pandey (2019)

**1 . Pointed gourd (*Trichosanthes dioica* Roxb.)**

Fig.7.1. Pointed gourd

Among the perennial cucurbits, pointed gourd (*Trichosanthes dioica* Roxb) occupies an important place. Its immature fruits are used as a vegetable. They are also pickled and used in confectionery. Pointed gourd possesses several medicinal properties and it is recommended as food for convalescents. It is easily digestible and has diuretic and laxative properties. Sharma and Pant (1988) reported that feeding pointed gourd seeds in rabbits lowered the blood sugar, total cholesterol and serum triglycerides and increased the level of phospholipids and HDL-cholesterol. Ethanol extracts of plant cause significant lowering of blood sugar (Chandrasekar *et al.*, 1988). During the maturity of fruits, soluble solid increase and total mineral contents ranges between 1.20 and 2.05 per cent. Total sugar content ranges from 168.50 to 288.56 mg per 100 g, which increases during maturity. The crude fibre and ascorbic acid contents range from 2.73 to 3.06 per cent and from 29.50 to 33.35 mg per 100 g, respectively. During fruit maturity, the content of structural carbohydrate increases, while water and crude protein contents decrease. The total free amino acid content ranges from 3.99 to 4.09 per cent (Singh *et al.*, 2001). The nutritional composition of the fruit is given in table (7.2).

Fig 7.2 Kashi Alankar

Fig 7.3 Kashi Sufal

Iodine and fluorine contents of the fruits are 0.66 and 2.1 ppm in dry edible matter. A trace of 5-hydroxytryptamine has also been detected (Gopalan *et al.*, 2004). Pointed gourd is a native of India. It is found in natural state in the plains of north India from Punjab to Assam. It is extensively cultivated all over the Bihar, West Bengal and Assam.

**Botanical Description**

Pointed gourd belongs to the genus *Trichosanthes* and species *dioica* Roxb. It is a dioecious plant. The somatic chromosome number is 2n = 22. The karyotype of sex forms indicates high homogeneity. Guha *et al.* (2004) suggested that average packing ratio is a good parameter for the determination of distinction between 2 sets and therefore could be used for karyotype analysis of dioecious plant. The general morphological description of the plant is given as under:

It is perennial plant with well-developed roots, vine 2-3 m long, well branched; leaves cordate or ovate-along, stomata are present in both the leaf surfaces but the frequency is much higher in the lower surface; flowers dioecious, male peduncle paired, both 1-flowered; female solitary; fruits globose, oblong, smooth, 5-12 cm×2.6 cm striped, strips light green on the young fruit and red on the ripe ones; seeds globose.

**Table (7.2): The nutritive value of pointed of gourd** (per 100 g of edible portion)

| Constituent | Amount |
|---|---|
| Moisture | 92.0 g |
| Protein | 0.7 g |
| Fat | 0.2 g |
| Minerals | 0.5 g |
| Fibre | 3.0 g |
| Carbohydrates | 2.2 g |
| Energy | 20 k cal |
| Calcium | 30 mg |
| Phosphorus | 40 mg |
| Iron | 1.7 mg |
| Carotene | 153 g |
| Thiamine | 0.05 mg |
| Riboflavin | 0.06 mg |
| Niacin | 0.5 mg |
| Vitamin C | 29 mg |

Source: Gopalan *et al.* (2004)

**Table (7.3).Improved varieties of pointed gourd**

| | |
|---|---|
| Kashi Alnakar (VRPG-1) | A high yielding variety developed by ICAR-IIVR, Varanasi release through State Variety Release Committee and notified through Central Variety Release Committee which produces medium sized light green spindle shape and attractive fruits with some strips at distal end. Individual plants bear 100-130 fruits and gives an average yield of 30.0-38.0 t/ha. |
| Kashi Suphal (VRPG-2) | A high yielding variety developed and release by ICAR-IIVR, Varanasi (U.P.) It is an early maturing variety. Fruiting starts from 4$^{th}$ to 6$^{th}$ node onwards. Fruits are light green with soft flesh. It is a high yielding (28.0-30.0 t/ha). |
| Kashi Amulya | A high yielding variety developed and release by ICAR-IIVR, Varanasi (U.P.) It is less seeded varieties and fleshy. It is a high yielding (26.0-29.0 t/ha). |
| Swarna Alaukik | It is developed from Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi (Jharkhand). A high yielding variety produces light green fruits with blunt ends. The fruits are 5-8 cm long, solid, thin skinned and good for vegetable as well as preparation of sweets. Its average yield is 23.0-28.0 t/ha on vertical staking. It is recommended for uplands and plateau regions of Bihar, Diara lands of Genetic belts of Bihar and Uttar Pradesh and plains of Odisa and West Bengal. It has also been introduced in Telangana region of Andhra Pradesh. |

| | |
|---|---|
| Swarna Rekha | This variety has been developedthrough clonal selection at from Horticulture and Agro-Forestry Research Programme (HARP), Plandu, Ranchi (Jharkhand). A vigorously growing high yielding variety. Fruits are elongated, greenish-white, striped 8-10 cm long and tapering on both sides with soft seeds. Average yield is 20.0-23.0 t/ha on vertical bower system but on ground it yields 17.5-20.0 t/ha. Recommended for commercial cultivation in plains of Jharkhand, Odisa, plateau region of Bihar, diara lands and plains of Bihar, West Bengal, Eastern Uttar Pradesh, and Telangana region of Andhra Pradesh. |
| Swarna Suruchi | It is developed from Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi (Jharkhand). |
| Rajendra Parwal- 1 | This variety has been developed by clonal selection and released by RAU, Bihar. It produces very attractive long green fruits with white stripes and tapering at both ends. Average fruit weight is 40 g with good long distance transportation quality and tolerant to fruit fly. The average yield is 15.0-17.0 t/ha. It is recommended for commercial cultivation in Uttar Pradesh and adjoining parts of Bihar (including both *diara* land and upland areas). |
| Rajendra Parwal- 2 | This variety has been developed by clonal selection and released by by RAU, Bihar. Fruits are drum shaped, big, whitish green with very light self-stripes and soft. Average fruit weight is 30 g It is suitable for cultivation in Bihar and Uttar Pradesh, average yield is 15.0-17.0 t/ha. This variety is highly suitable for '*diara'* cultivation. It is tolerant to vine and fruit rot as well as fruit fly. |
| Faizabad Parwal-3 | This variety has been developed by clonal selection and released by NDUA&T, Faizabad (Uttar Pradesh). Its fruits are spindle shaped, green and less striped. They are excellent for culinary purpose. With an average yield of 12.5-15.0 t/ha, it is suitable for cultivation in eastern and western Uttar Pradesh. |
| Faizabad Parwal-4 | This variety has been developed by clonal selection and released by NDUA&T, Faizabad (Uttar Pradesh). A high yielding variety, it is recommended for reclaimed sodic soils. The fruits are light green, spindle-shaped with tapering ends. It is recommended for bower system of cultivation. |
| Narendra Parwal-260 | This variety is developed through clonal selection at NDUA&T, Faizabad. Fruits are light green, striped, 13.0-15.0 cm in length with thick flesh. It produces an average fruit yield of 22.5 t/ha, when trained on bamboo stakes. It is tolerant to wilt disease complex. |
| Narendra Parwal-307 | This variety has been developed by clonal selection and released by NDUA&T, Faizabad (Uttar Pradesh). Fruit size is small round shaped and colour is dark green with strips. It has very good self life and gives an average fruit yield of 22.5 t/ha. |
| Narendra Parwal-604 | This variety has been developed by clonal selection and released by NDUA&T, Faizabad (Uttar Pradesh). Fruits are medium sized, light green and without strips. It gives an average fruit yield of 22.5 t/ha. |
| CHES Hybrid-1 | It is developed from ICAR-Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi (Jharkhand). It is the first pointed gourd hybrid |

| | |
|---|---|
| | developed in the country. Its solid, green striped fruits weight 30-35 g each, the total yield being 28.0-32.0 t/ha. It is resistant to fruit fly. |
| CHES Hybrid-2 | It is developed from ICAR-Horticulture and Agro-Forestry Research Programme, Plandu, Ranchi (Jharkhand). It is high yielding hybrid, producing dark green striped fruits with an average fruit weight of 25-30 g, average yield is 30.0-40.0 t/ha. |
| Chotta Hilli | Fruits medium, long (5.71 cm x 3.37 cm), oval to spindle-shaped swollen in the middle, greenish with prominent white stripes, blunt end and bulged at the stalk. |
| Dandali | Fruits are medium-sized (6.84 cm x 3.89 cm), egg-shaped, light green, stock end dispersed, striped and slightly grooved towards distal end. |
| Hilli | Its fruits are oblong (9.65 cm x 3.08 cm), greenish white, white striped and tapering towards distal end with dispersed neck. |
| Shankolia | Fruits are medium long (7.56 cm x 2.94 cm), resembling to those of "shankh or shell". They taper towards ends, are greenish with white stripes, slightly beaked towards distal end and bulged towards stalk. |
| BCPG-3 | This early variety has been developed by BCKV, Kalyani (West Bengal) through selection from the local germplasm. Plants having good vigour and medium viny in nature. Stem shape angular, tendril branched and coiled. Leaves serrated riund and medium in size (6.5-7.0 cm), Pubescent, intermediate and sparse. Petiole length (3.5-5.0 cm), fruit spindle shaped, medium curved, fruit skin primary colour light green with white alternate stripe. Average fruit length 7.30 cm, girth 3.5 cm, and fruit weight 34 g. Average fruit yield is 62 t/ha. |
| BCPG-4 | This early variety has been developed by BCKV, Kalyani (West Bengal) through selection from the local germplas. Plants having good vigour and medium viny in nature. . Stem shape angular and pubescent, tendril branched and coiled. Leaves serrated oblong and medium in size (7.5-8.0 cm), Pubescent, intermediate and sparse. Petiole length (3.5-5.0 cm), fruit spindle shaped, medium curved, and fruit skin primary colour dark green with white alternate stripe. Average fruit length 8.78 cm, girth 3.52 cm, and fruit weight 44 g. Average fruit yield is 60 t/ha. |
| BCPG-5 | This early variety has been developed by BCKV, Kalyani (West Bengal) through selection from the local germplasm. Plants having good vigour and medium viny in nature. . Stem shape angular and pubescent, tendril branched and coiled. Leaves serrated oblong and medium in size (8-9 cm), Pubescent, intermediate and sparse. Petiole length (4-5 cm), fruit long shaped, and fruit skin primary colour dark green with prominent white alternate stripe having smooth skin. Average fruit length 9.5 cm, girth 3.75 cm, and fruit weight 46 g. Average fruit yield is 58 t/ha. |

**Source:** Bhardwaj (2020)

**Climate and Soil**

The pointed gourd prefers warm and humid climate. Frost or severe cold, especially below 5ºC, are un-favorable for the plant growth and development. During the winter season, crop remains dormant and vigorous growth starts only with the onset of spring. For raising the good crop of pointed gourd, a well-drained sandy to sandy loam soil is the best, as the plant does not withstand water logging. In the north Bihar, the areas usually flooded by overflowing riverbeds in the rainy season are utilized for cultivation during summer season. In West Bengal, it is commonly grown in dry river beds.

**Propagation**

The pointed gourd is commercially propagated by vegetative means through vine cuttings and root suckers. Seed propagation is avoided due to poor germination (50 per cent plants may be male); besides, the crop may be homogenous and homozygous (Singh, 1989). Mukhopadhyay and Chattopadhyay (1976) reported that seed treatment with 0.005 per cent GA or 0.5 per cent thiourea for 24 h before sowing enhanced the germination percentage and speed of germination.

- **Vine cuttings**

The defoliated vines are used for making cuttings to check the transpiration. The following methods are in vogue to plant the cuttings:

- **Lunda or Lachhi method :** In this method, the mature vines about 1-1.5 m long with 8-9 nodes per cutting are taken and folded into a figure of 8 commonly known as 'lunda' or 'lachhi'. The lachhi should be placed flat in the pit and pressed 3-5 cm deep in the middle in to the soil. Fresh cow dung may be applied over the central part of the pit to enhance the sprouting.
- **Moist lump method:** In this method, the vine 60-90 cm long is circled over a lump of moist soil leaving both ends 15 cm free. Such soil lumps are buried 10 cm deep into well prepared pits leaving the ends of vine above the ground. The under soil part sticks to the root and exposed ends sprout.
- **Straight vine method:** In this system, vines cuttings are planted end to end horizontally 15 cm deep into furrows. These furrows are spaced at 2 m apart are opened and filled in with a mixture of farmyard manure and soil.
- **Ring method:** The vine cutting is coiled into a spinal or ring shape and planted directly on the mound, covering one and half to two-thirds of the ring underground.

- **Small rooted cutting:** In the case of scarcity of planting material or popularizing the most desired type clone at a time, small cuttings with 3-4 nodes are prepared. These cuttings are treated with 100 ppm IBA and are planted in polythene bags filled with 1:1:1 in ratio of soil: sand: FYM to strike roots. These cuttings are then planted in eastern Uttar Pradesh in month of February- March. Pandey and Ram (2000) reported 61.13 per cent success of the rooted cuttings with the treatment of IBA @ 100 ppm table (3.7).
- **Root Suckers:** Pointed gourd possesses tuberous roots which are uprooted and planted on the mounds. The propagation through this method is easier and faster and gives assured success. Tripathy *et al.* (1994) obtained best planting roots in terms of highest fresh weight (58.53 g) and tuber size with the application of NPK @ 60:60:60 kg per hectare. They observed female plants more vigorous than male plants but there was no difference in tuber fresh weight between two sexes.

**Table (7.4) : Effect of IBA and NAA on the rooting of pointed gourd cuttings**

| **PGR concentrations** | **Sprouting (%)** | **Length of sprout (cm)** | **Shoot growth** | **Rooted cuttings (%)** | **Root number** | **Length (cm)** | **Survival (%)** |
|---|---|---|---|---|---|---|---|
| NAA | | | | | | | |
| 50 ppm | 57.89 | 2.40 | 4.06 | 52.17 | 4.74 | 15.48 | 50.33 |
| 100 ppm | 62.25 | 2.66 | 4.29 | 56.50 | 4.98 | 15.90 | 55.46 |
| 150 ppm | 57.68 | 2.52 | 3.65 | 51.17 | 4.87 | 15.99 | 51.84 |
| **IBA** | | | | | | | |
| 50 ppm | 60.19 | 2.55 | 4.33 | 56.58 | 4.96 | 17.18 | 55.64 |
| 100 ppm | 66.29 | 2.85 | 5.18 | 62.42 | 5.31 | 18.08 | 61.13 |
| 150 ppm | 62.31 | 2.59 | 4.15 | 55.50 | 5.15 | 18.23 | 55.16 |
| Control | 50.67 | 2.26 | 3.97 | 16.00 | 4.64 | 14.21 | 44.17 |
| CD ± at 5% | 4.81 | 0.20 | 0.82 | 4.36 | 0.41 | 2.31 | 9.83 |
| **Node number** | | | | | | | |
| One | 40.26 | 2.15 | 3.41 | 35.14 | 4.42 | 14.15 | 33.19 |
| Two | 49.91 | 2.49 | 3.88 | 45.71 | 4.82 | 15.13 | 44.19 |
| Three | 69.91 | 2.64 | 4.37 | 64.90 | 5.04 | 17.11 | 62.51 |
| Four | 79.09 | 2.91 | 5.27 | 71.57 | 5.52 | 19.36 | 73.56 |
| CD ± at 5% | 1.62 | 0.15 | 0.31 | 3.29 | 0.31 | 1.04 | 3.35 |

**Source:** Pandey and Ram (2000)


Fig.7.4 Different methods of planting of pointed gourd

Fig.7.5 Mother Block of pointed gourd

Fig7.6 Sprouted plants of pointed gourd

Fig7.7 Marketable bundles of pointed gourd stems

- ***In vitro* propagation:** Studies were conducted to standardize the protocol for large scale in vitro multiplication of pointed gourd at ICAR-IIVR, Varanasi (U.P.).Young vines of *T. dioica* –VRPG-101 (an advance breeding line) were collected from polyhouse grown plants. Shoot tips and nodal portions of vine were excised and after surface sterilization

inoculated onto hormone-free half strength MS medium. The established shoots served as mother stock. For further multiplication, shoot-tips and nodal portions were excised from mother stock and cultured onto MS medium supplemented with different concentrations of BAP. For root induction, *in vitro* raised shoots were cultured onto MS medium supplemented with different concentrations of IBA or NAA. Shoots with primary and secondary roots were transferred to pots containing soil and sand mixture. Plantlets were kept under controlled condition and irrigated with ¼th strength MS medium. Finally, they were transferred to field for evaluation. Shoot multiplication was achieved on medium supplemented with different concentrations of BA. Significant interaction between growth regulator level and explants was recorded for the number of shoots per explants, number of nodes per shoot and shoot length. The highest frequency of shoot regeneration (100%)was observed on MS medium supplemented with 8.8 µM BA. Root induction was also achieved with different concentrations of IBA and best response was obtained with medium containing 0.49µM IBA. Plants were acclimatized under controlled conditions and transferred to field, where they produced normal flower and fruit.

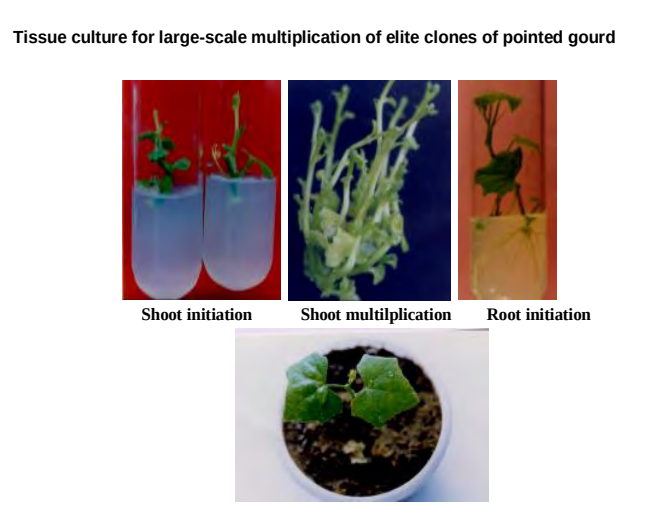


Fig 7.8. Tissue culture for large scale multiplication of elite clones of pointed gourd

**2. Ivy gourd (*Coccinia grandis* (L.) Voigt)**

Immature fruits of ivy gourd are used as a vegetable. Beside fruits, young shoots and leaves are consumed as fried, blanched or boiled. It is a very popular green in Thailand. The ripe fruits develop red colour and can be eaten raw. The main carotenoid of ripe fruit is lycopene (5.68 mg / 100 g) and beta carotene (2.24 mg / 100 g) (Baruah and Goswami, 1979). The flesh can be processed into fermented or dehydrated chips, which can be stored for a long period. The nutritive value of its fruit is given in table (7.5).

**Table (7.5): Nutritive value of ivy gourd**
(per 100 g of edible portion)

| Constituents | Amount |
|---|---|
| Moisture | 93.5 g |
| Protein | 1.2 g |
| Fat | 0.1 g |
| Minerals | 0.5 g |
| Fibre | 1.6 g |
| Carbohydrates | 3.1 g |
| Energy | 18 k cal |
| Calcium | 40 mg |
| Phosphorus | 30 mg |
| Iron | 0.38 mg |
| Carotene | 156 µg |
| Thiamine | 0.07 mg |
| Riboflavin | 0.08 mg |
| Niacine | 0.7 mg |
| Folic acid | 18 µ g |
| Vitamin C | 15 mg |

**Source:** Gopalan *et al.* (2004)

Fig 7.9 Ivy gourd

The leaves are a rich source of protein (3.3 - 4.9 g), minerals and vitamins, in particular vitamin A i.e. 8000-18000 IU (Boonkerd *et al.*, 1993). The plant possesses antioxidant property and administration of its leaf extract in streptozotocin diabetic rats caused a significant increase in plasma vitamin C and reduced glutothione (Venkateswaran and Pari, 2003). The roots and leaves of ivy gourd have been used in Ayurvedic and folk medicines to treat the diabetes, mellitus, skin eruption, tongue sores and earache. The Chclz extract of the root shows a hypoglyc-aemic effect in fasted albino rats (Vaishnav and Gupta, 1995 & 1996). Ivy gourd is a native of India. The plants are distributed in Myanmar, Pakistan and whole of the South East Asia. It is also distributed in tropical Africa.

**Botanical Description**

Ivy gourd belongs to the family Cucurbituceae and genus *Coccinia* Wght& Arnott with about 35 species. The cultivated species *Coccinia grandis* (L.) Voigt (Syn. *Bryonia grandis* L. (1767), *Coccinia indica* Wight and Arnott (1834), *C. cordifolia* (auct. non L.) Logn. (1881.) is a dioecious. Guha *et al.* (2004) reported the somatic chromosome number 2n = 24. In a cytogenetic studies in tetraploid Cruz *et al.* (1972) observed that the progeny from cross between 2x =2x female and 4x = 48 male had a high proportion of 3x male because of preferential pairing between the X and Y SAT chromosomes of the X male. The Y chromosomes appear to influence the expression of maleness.

**Taxonomic position of *Cocciniagrandis* (L.) Voigt is given as under:**

Boonkerd *et al.* (1993) have given following details of its morphological attributes. Plant a climbing or prostrate perennial herb with long tuberous roots, stem green and longitudinally ribbed when young, becoming white spotted when older and eventually wood and susterete; tendrits simple, usually one per node, in stipular position; leaves simple, alternate, with petiolate of 1.5 cm, lamina broadly ovate to subpentag-onal or orbicular in outline, 3-12 cm x 3-15 cm, shallowly to deeply palmately 3-5 lobed, cordate at base, margin entrie or sinuate and often with distinct reddish glandular teeth, glabrous, punctate; staminate flowers appear axillary, solitary or paired, rarely 3-4 in short racemes, pedicel 0.7-7.0 cm long; receptacle tubular, 3-7 mm long; sepals 5, linear, up to 6 mm long, corolla companu-late, yellow-orange, green veined, 5 lobed, lobes up to 2 cm × 1.5 cm; staminal column 6 mm long, pistillate flowers axillary, solitary, pedicel up to 2.5 cm long receptacle, calyx and corolla as in staminate flowers; ovary cylindrical, up to 1.5 cm long, style 3 mm long, stigma 3 lobed, each lobe divided in two; fruit 2.5-5.0 cm long and 1.5 to 2.5 cm in diameter. Fruits, smooth, bright green with white stripes when immature, become bright scarlet when ripe. Anthesis occurs early in the morning, pistillate flowers open earlier as compared to male. Stigma remains receptive 8-10 h before to 35-40 h after anthesis.

**Improved varieties**

Fig 7.10 Ivy gourd cultivation

In ivy gourd, so far no systematic work has been done on varietal improvement even though a large number of local varieties are popular among the growers in their respective areas of adaptability. Ivy gourd can be classified into two distinct types, i.e., bitter and sweet types. The sweet varieties, which are prolific bearer, producing very tender and soft fruits, are under common cultivation in Chengalepet district. Two varieties of ivy gourd, namely Allahabadi and Aligarhi that are resistant to powdery mildew (*Erysiphe cichoracearum*) are quite popular among growers). IGKVV, Raipur (Chhattishgarh) has evaluated and characterized 35 genotypes of ivy gourd. On the basis of yield performance, the Accession No. 59 that bears long pale yellow regular striping fruit was found excellent. A very useful strain with large and bold fruits has been detected in the Indo-Gangetic region of Bihar.

The fruits of this strain are very tender and could be kept safely for about 2 weeks under ambient room conditions without impairing cooking quality.

On the basis of fruit characters as recorded by Indian Institute of Vegetable Research, Varanasi (U.P.), ivy gourd can be categorized into two groups (Ram and Pandey, 1998):

**(a)** ***Round or oval fruited type****:* Basically the fruits are light green to light-yellow coloured striped and round to oval in shape.

**(b)** ***Long fruited type:*** The fruits are light green colour, long and striped.

Preliminary evaluations of few local collections were made at Indian Institute of Vegetable Research, Varanasi (U.P.) during the year 1996-99, and on the basis of fruiting ability and fruit quality, few desirable strains identified and recommended for commercial cultivation are VRK-05, VRK-10, VRK-20 and VRK-35. Accessions showing resistance against viruses(curled/mottled yellow colour) VRK-05, VRK-14, VRK-15, VRK-22, VRK-31, VRK-57, VRK-58, VRK-61, VRK-62, VRK-65 and VRK-67.Accessions showing resistance against leaf mine are VRK-01, VRK-06, VRK-22, VRK-04, VRK-31 VRK-33 and VRK-55 (Ram and Pandey, 1998 ).

**Table (7.6): Ivy gourd varieties developed by different research organization**

| | |
|---|---|
| Indira Kundru-5 | This variety has been released by State Sub-Seed Committee of Chhattisgarh State for cultivation in Chhattisgarh Plains. Vines are perennial in nature. First picking can be taken after 75-85 days of vine cutting. Fruiting is obtained round the year (9 months). It has average yield of 101.9 t/ha at spacing of 1.5 x 1.5 m. fruits are oblong in shape, green in colour with strips. Suitable for table purpose. Variety is tolerant to stem borer, powdery mildew, frost and drought. |
| Indira Kundru-35 | This variety has been released by State Sub-Seed Committee of Chhattisgarh State for cultivation in Chhattisgarh Plains. Vines are perennial in nature. First picking can be taken after 75-85 days of vine cutting. Fruiting is obtained round the year (9 months). It has average yield of 93.88 t/ha at spacing of 1.5 x 1.5 m. fruits are long in shape, light green in colour with strips. Suitable for table purpose. Variety is tolerant to stem borer, powdery mildew, frost and drought. |
| Sulabha (CG-23) | This variety has been developed by clonal selection from a germplasm (CG-23) at KAU, Vellanikkara. Fruits are long (9.25 cm), pale green, with average fruit weight is 18.5 g. it takes 37 days from planting to first flowering. The first harvest can be done in 45-50 days after planting.Average fruit length is 9.25 cm. fruits are cylindrical, slightly green with continuous striation. Leaves are typical trilobed. It produces 1050 fruits/year and has yield potential of 40.0-42.5 t/ha. |

| | |
|---|---|
| VRK 20 | It is clonal isolation at IIVR, Varanasi (Uttar Pradesh). It is very early bearing strain which bears light green striped fruits of 6.0 cm length and 2.7 cm diameter. The individual fruit weight is about 20 g. |
| VRK 31 | It is clonal isolation at IIVR, Varanasi (Uttar Pradesh). Fruit is somewhat swollen in the middle but pointed at the upper portion. The individual fruit weight is 25-30 g. |
| VRK 35 | It is clonal isolation at IIVR, Varanasi (Uttar Pradesh). A high yielding strain bears highly striped fruits of medium size with fruit weight 15-18 g. |
| VRK 37 | It is clonal isolation at IIVR, Varanasi (Uttar Pradesh). The oval shaped fruits of this strain are round 1.90 cm in diameter with individual fruit weight 16 g. |
| VRK 49 | It is clonal isolation at IIVR, Varanasi (Uttar Pradesh). Fruits are oval in shape. It is high yielding variety with fruit weight about 15 g. |
| Ac.Mo.51 | This variety was isolated at IGKV, Raipur. Fruits are light green and oval in shape. It is very high yielding variety (21.20 kg/plant). |
| Arka Neelanchal Sabuja | It is clonal isolation at ICAR-Central Horticultural Experiment Station, IIHR, Bengaluru, Aiginia, Bhubaneswar (Odisha). Fruits are dark green and nearly conical shaped with fragmented creamy stripes giving typical appearance of ivy gourd. Its yield ranges from 30-35 kg/plant. Fruits have excellent cooking quality and tolerate bruisinf during handling and transport. It can be grown in hot and humid agro-climatic condition of the Eastern and Southern States of India. |
| Arka Neelanchal Kunki | It is clonal isolation at ICAR-Central Horticultural Experiment Station,(IIHR, Bengaluru, Aiginia, Bhubaneswar (Odisha). This is an early fruiting variety which starts bearing in just after 40 days of transplanting. The variety produces light green, long slender, cylindrical fruits of 7.5-8.5 cm length with soft texture and has attractive stripes in skin. This variety has sequential fruiting habit and fruit develops by means of vegetative parthenocarpy hence, there is no need of male plants for pollination and more number of female plants can be accommodated per unit area. It has an excellent organoleptic quality as fried vegetable as well as vegetable curries. A single plant produces up to 20 kg fruits in one growing season. The fruits fetch good market price due to high consumer preference as they have good physical appearance and soft texture. |
| Ac.Mo.51 | This variety was isolated at IGKV, Raipur. Fruits are light green and oval in shape. It is very high yielding (21.20 kg/plant) variety. |
| IIVRK-1 | This variety was isolated at ICAR-IIVR, Varanasi (U.P.) through clonal selection. This is early maturing variety. Fruits are long striped and fruiting period is comparatively long. Average yield is 25-30 t/ha. |

**Source:** Bhardwaj (2020a)

**Climate and Soil**

Ivy gourd prefers warm and humid climate. Plants remain in dormant conditions during winter

season. Its plants can be spotted in grassland, brushwood, on road sides in hedges and sparse forests from the plains up to 1500 m altitudes. Plants does well in area where these is uniform distribution of rain and high humidity. Ivy gourd grows best in sandy loam and is not adapted to heavy soils. It needs fair drainage and is very susceptible to water logging.

**Propagation:** Ivy gourd can be propagated both by seed as well as by cuttings.

**(a) Seed propagation:** Seed propagation is not in vogue because of its dioecious nature (50 per cent male plants). A ratio of 1:10 male to female plant is considered ideal for pollination. Further, seed propagated plants come very late in bearing.

**Table (7.7): Effect of node number and plant growth regulators on regeneration of Ivy gourd cuttings**

| Treatments | Sprouting (%) | Days to sprouting (No) | Length of vine (cm) | Diameter of vine (cm) | Branches/ shoot (No) | Leaves/ cutting (no.) | Root length (cm) | Root diameter (cm) | Regeneration (%) |
|---|---|---|---|---|---|---|---|---|---|
| **Nodes /cutting** | | | | | | | | | |
| One | 64.56 | 10.9 | 13.1 | 0.40 | 4.0 | 34.5 | 15.2 | 0.08 | 55.06 |
| Two | 74.94 | 9.8 | 16.5 | 0.45 | 4.9 | 44.0 | 17.1 | 0.10 | 68.39 |
| Three | 82.89 | 9.1 | 19.3 | 0.46 | 5.0 | 52.4 | 17.9 | 0.13 | 75.97 |
| Four | 89.42 | 8.8 | 19.7 | 0.51 | 6.0 | 64.9 | 20.8 | 0.14 | 82.61 |
| **CD at 5%** | **1.99** | **0. 66** | **0.81** | **0.01** | **0.17** | **1.05** | **0.65** | **0.004** | **1.85** |
| **PGR concentration** | | | | | | | | | |
| **NAA** | | | | | | | | | |
| 25 ppm | 73.08 | 10.5 | 17.5 | 0.43 | 4.8 | 49.6 | 17.2 | 0.10 | 68.75 |
| 50 ppm | 73.08 | 9.7 | 17.3 | 0.45 | 4.7 | 49.5 | 17.2 | 0.11 | 66.83 |
| 75 ppm | 80.08 | 8.5 | 19.5 | 0.48 | 5.4 | 49.8 | 18.3 | 0.11 | 68.83 |
| 100 ppm | 77.17 | 9.0 | 15.0 | 0.43 | 5.0 | 48.4 | 17.8 | 0.11 | 69.08 |
| 125 ppm | 78.83 | 10.1 | 15.2 | 0.44 | 4.9 | 47.3 | 17.8 | 0.11 | 71.08 |
| 150 ppm | 77.00 | 9.6 | 15.2 | 0.47 | 4.7 | 47.5 | 16.8 | 0.11 | 69.42 |
| **IBA** | | | | | | | | | |
| 25 ppm | 75.75 | 10.7 | 15.7 | 0.45 | 4.5 | 48.6 | 17.8 | 0.12 | 71.42 |
| 50 ppm | 78.67 | 9.8 | 17.4 | 0.45 | 4.7 | 49.7 | 17.7 | 0.12 | 70.08 |
| 75 ppm | 85.17 | 8.7 | 20.3 | 0.50 | 5.7 | 50.6 | 18.6 | 0.12 | 74.67 |
| 100 ppm | 77.67 | 9.5 | 18.4 | 0.47 | 5.2 | 48.9 | 17.9 | 0.11 | 74.50 |
| 125 ppm | 80.00 | 10.0 | 17.1 | 0.46 | 5.3 | 49.2 | 17.8 | 0.12 | 70.58 |
| 150 ppm | 78.92 | 9.5 | 16.7 | 0.43 | 5.0 | 48.8 | 17.9 | 0.11 | 70.83 |
| **CD at 5%** | **3.45** | **1.20** | **1.40** | **0.02** | **0.29** | **1.81** | **NS** | **0.007** | **3.20** |

**Source:** Bhardwaj *et al*. (2017)

**(b) By cutting:** Four to five months old vines are selected for making cuttings. Cuttings of 12-

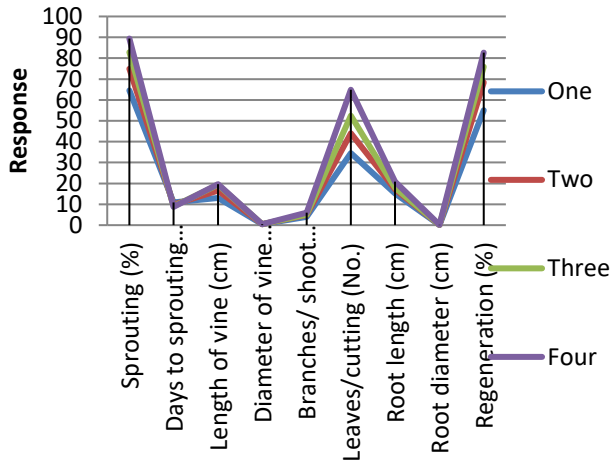


**Fig.1 Effict of node number per cutting**

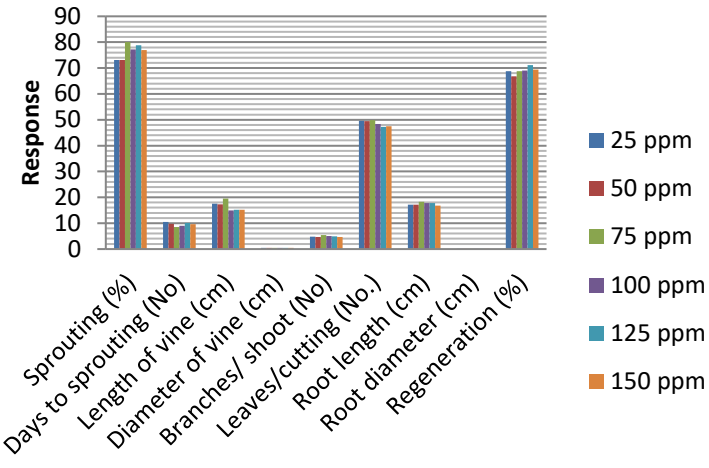


**Fig.2Effict of NAA**

15 cm length and pencil thickness having 5-6 leaves are taken and planted in basins of 60 cm diameter dug 175 apart. About 2-3 nodes bearing stem cuttings are transplanted at one place approximately at 3.0 cm depth in each basin. In an experiment cuttings with four nodes sprouted earliest (8.8 DAP) and enhanced the sprouting per cent, length and diameter of vine, number of branches per shoot, number of leaves per cutting, length and diameter of root and regeneration per cent than one, two and three nodes per cutting. Ivy gourd cuttings treated with 75 ppm IBA took minimum days to sprout and improved sprouting per cent, increased length and diameter of vine, number of branches per shoot, number of leaves per cutting, length and diameter of root and regeneration per cent than 75 ppm NAA and 25, 50, 100, 125 and 150 ppm IBA and NAA each (Bhardwaj *et al*., 2017). Sand and 1:1 sawdust: sand are suitablealternatives for propagation of *C. Africana* (Lam.) from branch cuttings (Ambebe *et al*., 2018).

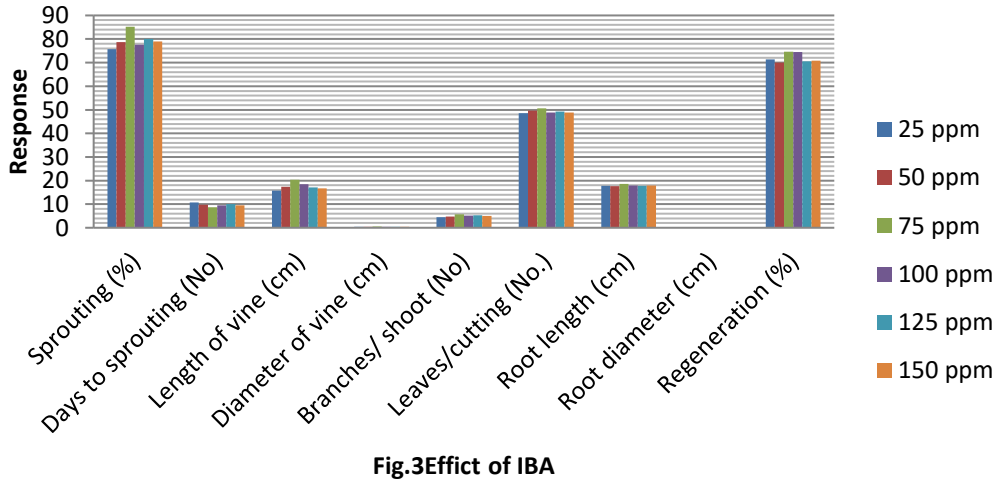


**Fig.3Effict of IBA**

**Nursery production**

Ivy gourd can be propagated through stem cuttings during July-August when vines are available and temperature is conducive for sprouting. Ivy gourd can be propagated directly in the field by using 30 cm long stem cuttings of pencil thickness (roughly 8-10 mm thickness) and planted at the rate of two cuttings per pit. In the plains, sometimes it becomes difficult to get the planting material in June-July due to flowering and fruiting season. So when fruiting stops in the month of October- November and grower's start heading back of the plant, nursery can be prepared by collecting vines. Nursery can be raised on ground in the polyhouse or in the planting tube. Stem cuttings of pencil thickness (6 mm thick), 25-30 cm length and having at least 5-7 nodes, are taken from one-year old healthy vines. Cuttings are planted vertically in well-prepared nursery beds having 20 cm height from soil surface. Planting tubes should be 15 x 10 cm size having 4-5 holes at bottom and upper surface for better aeration and drainage. These polyethylene tubes/bags are filled with equal amount of soil; sand and well decomposed FYM or compost composted saw dust (4 month) could be used for nursery production. Single cutting, having 5-7 nodes are placed in the depth of 5-6 cm. Sprouting starts after 15-20 days and plants become ready for transplanting in 7-8 weeks. Ivy gourd cuttings sprout very well with the use of plant growth regulators (PGR) i.e. IAA and NAA. Results are presented in the table ()

**PLANTING METHODS**

The planting of ivy gourd can be accomplished by adopting following methods:

**(a) Raised –bed method:** Planting of ivy gourd on raised beds is advisable for getting higher yield with better quality produce. In this method ridge and furrow is prepared manually (with the help of spade) or mechanically (by using tractor drawn furrow opener). The raised beds are prepared by opening 45 cm wide furrows at the distance of 4.0 m. The well-developed plants are transplanted on the edges of channels.

**(b) Flat-bed method:** In this method, shallow pits of 60 x 60 x 45 cm size are dug at recommended distance of 4 m. The pits are left open 3 weeks before sowing for partial solarization. Then each pit is filled with the mixture of soil and 4 kg well decomposed farmyard manure or compost. Besides these, Urea 40 g, single super phosphate100 g, muriate of potash 70 g furadan 2g, neem cake 100 g and furadon 2.0g must be incorporated during pit preparation.

**(c) Mound method**: In this method, 15-20 cm-raised mounds are prepared. Well decomposed farmyard manure or compost @ 4 kg and fertilizers like Urea 25 g, Single super phosphate75

g, muriate of potash 60 g Furadan 2 g, and neem cake 100 g must be incorporated in the mound. Transplanting is done in the evening at a depth of 20 cm.

**Transplanting time**

Planting is preferably done during June-July (rainy season) and February-March when temperature is mild.

### 3. Sweet gourd (*Momordica cochinchinensis* Spreng.)

Sweet gourd (*Momordica cochinchinensis* Spreng.) is a perennial vegetable of Cucurbitaceae family with high nutritional value. The tender fruits, young leafy shoots are cooked and eaten in Bali and Philippines. Sweet gourd has high protein and vitamin C content and a greater proportion of edible flesh than bitter gourd (Maurya, 1976). Analysis of fruit is given in table (7.8).

**Table (7.8): Nutritive value of sweet gourd** (per 100 g of edible portion)

| Constituent | Amount |
|---|---|
| Moisture | 84.09 g |
| Protein | 2.61 g |
| Fat | 0.66 g |
| Carbohydrates | 5.69 g |
| Crude fiber | 5.93 g |
| Mineral matter | 1.02 g |
| Calcium | 21 mg |
| Phosphorus | 148 mg |
| Iron | 2.59 mg |

**Source:** WOI (1948-76)

Fig. 7.11 Sweet gourd fruits

Sweet gourd belongs to the genus *Momordica* which is native of old world. It comprises about 45 species, mainly occurring in Africa, 6-7 species have been recorded in India. Sweet gourd occurs wild and cultivated from India to Japan and Malaysia. It is found in growing in perennial state in Assam, the Garo hills of Meghalaya, West Bengal, most of South India and the Andaman Islands. Plants of sweet gourd possess several medicinal properties and its seeds are used in China to treat smelling, abscesses, ulcers and other disorders. Tuber contains hemolytic fraction (Ng *et al*., 1986). Fruits and leaves are used in external application for lumbago, ulceration and fracture of bone. The roots contain a triterpenoid saponin, which on hydrolysis yields oleanolic acid and fucose, glucuronic acid and arabinose. Alcohlic extracts yield a sterol, named bessisterol ($C_{29}H_{48}O$. ½H2O) which is identical with spinasterol. Kawamura *et al.* (1988) identified two new saponins 3 beta-[*O*-beta-D-Xylopyranosyl-*O*-beta-D-Xylopyranosyl-*O*-beta-D-glucopyranosyl)-Olean-12-ene-28-oic acid momordicin id. 28-beta-

D-gluco-pyranosyl ester. Fresh root of sweet gourd contains bisdesmoside where as monodesmoside is major constituent of dry root.The plant *Momordica cochinchinensis* has traditionally been used in Chinese medicine to treat a variety of illnesses. A range of bioactive molecules have been isolated from this plant, including two novel peptides, MCoCC-1 and MCoCC-2, containing 33 and 32 amino acids, respectively, which are toxic against three cancer cell lines. MCoCC-1 is the most toxic against a human melanoma cell line (MM96L) and is nonhemolytic to human erythrocytes (Chan *et al.*, 2009).

**Table (7.9): Difference between sweet gourd and spine gourd**

| **Kakrol or sweet gourd (*Momordica cochinchinensis* Roxb.)** | | **Kartoli or spine gourd (*Momordica dioica* Roxb.)** |
|---|---|---|
| Roots develop bigger tubers | : | Roots develop small tubers |
| Leaves are bigger | : | Leaves are small |
| Large flowers and white to yellow in colour | : | Small flowers yellows and in colour |
| There are umblicate glands in lamina base of leaves. | : | - |
| 1-5 glands in their petioles | : | - |
| There are 3 small deep black or blue circular dots at the base of petals | : | No circular dots at the base of petals |
| Anthesis occur during early morning | : | Anthesis occur during evening |
| Flowers take 72 minutes to open | : | Flowers take7- 72 minutes to open |
| Pollen remain viable for 36 hours | : | Pollen remain viable for 36 hours |
| Stigma receptivity remains up to 18 hours | : | Stigma receptivity remains up to 18 hours |
| Fruits are abnormally large and oblong | : | Fruits are round to oval |
| Individual fruit weight is around 60-80 g and can attain up to 500 g. | : | Individual fruit weight is around 10-15 g and can attain up to 30 g. |
| Fruit ripening starts from periphery to inner side | : | Fruit ripening starts from inner side to periphery |
| Fruits are light green to light yellow | : | Fruits are dark green in colour |
| Tough spine on fruits | : | Smooth and false spines |
| It takes 26 days to reach edible maturity | : | It takes 20days to reach edible maturity |
| Flowering and fruiting occur for a short period | : | Flowering and fruiting continue for a longer period |

***Source*:** Ram *et al*. (2002)

**Botanical Description**

Sweet gourd is a dioecious perennial climber with tuberous root. Sinha *et al.* (1996) reported somatic chromosome number (2n) = 28 and observed very high homogeneity in karyotype analysis. Chromosomes were usually short and with median and sub-median constriction. **Taxonomic positions of** *Momordica cochinchinensis* Spreng**.is given as under:**

Stem glabrous; leaves sub orbicular, deeply 3-5 lobed, glabrous; flowers white or pale yellow but blackish at base inside. Male flowers with peduncle 5-30 cm long, bearing an apical, sub orbicular, sessile bract, 3-4 cm and 4-5 cm; pedicel 3-10 mm long. Female flowers with much smaller bracts, situated near the middle of the peduncle. Fruit ovoid, 10-15 cm long, pointed, densely aculeate; turning red at maturity; seed ovoid, 26-28 mm long, compressed, sculptured on both sides.

**Fig7.11 Staminate and pistillate flower of sweet gourd**

**Climate and Soil**

Warm humid climate with 25º-35ºC and average annual rainfall of 1500-2500 mm is ideally suited for cultivating the sweet good. The plant can survive in winter at 10 cm below with the ground temperature more than 1ºC. Vines of sweet gourd remain dormant during winter season and sprouts with onset of spring. It a hardy crop and can be grown in different kinds of soil. However, fertile sandy loam soil with pH range from 6.5 to 7.0 is considered ideal. There should be adequate provision of drainage as crop is very sensitive to water logged conditions.

**Propagation :** Sweet gourd can be propagated by seeds, tuber or by stem cuttings. For seed propagation, about 3.5 kg seeds are required for a hectare sowing. Seeds have a long period of dormancy and low germination (50 per cent) (Mishra *et al.*, 1988). Further, a plant raised from seeds gives fruits only after 3-4 years. Vijay (1978) also counted 48.7 per cent female and 51.3 per cent male plants in seed propagated population. It is therefore, recommended that tubers from female plants should be selected and inter planted with male tubers in proportion of 1:9 ratio.

**By tuberous root:** Tuberous roots can be obtained from 2-3 year old plant. Due to dioecious nature of crop, planting materials of male and female plant should be collected separately, which can be identified by flowering and fruits. It was observed that the tubers collected from

stony or hard soil were smaller in size while those collected from sandy or sandy loam soil were bigger, soft and bearing finger like structure (Rathi *et al*., 2006). Average size of planting tuber pieces is 25-50 g. For enough planning material large tubers should be cut into pieces, keeping at least two buds in each piece. The cut tubers must be treated with 0.2% Dithane M. 45 and Seradix B No. 1 powder and keep in shade for 30 minutes. Ram *et al.* (2002) observed that piece of tuberous root of >40 g took minimum period in sprouting table (3.3).

**Table (7.10): Effect of tuber size and weight on sprouting and growth**

| Tuber size | Tuber weight (g) | Days to sprouting | Growth |
|---|---|---|---|
| Low | 35.00 | 19-22 | Weak |
| Medium | 36-40 | 16-18 | Vigorous |
| Large | 40-50 | 12-15 | Veryvigorous |

Source: Ram *et al.*(2002)

**By stem cuttings**

Stem cutting possessing two nodes are made for multiplication. Treating the cuttings in 200-500 ppm IBA accelerate the sprouting as well as rooting in cuttings. July-August is best month in North India for propagation through vine cuttings. When sprouted cuttings attain 4-5 leaves, they are planted in the main field.

**Time and method of planting**

For planting of tuberous root, field should be free from water logging. About 50,000 sprouted tubers are required for planting of a hectare field. The best time for planting is February under irrigated conditions and June-July in rainy season. If tubers are being multiplied in polythene bags or planting tubes, the size should be 6"×4" making holes at the bottom and 8-9 holes on surface of bags for aeration. It should be filled with a mixture of soil, sand and well rotten farm yard manure or compost in 1:1:1 ratio. Proper moisture is maintained for sprouting of the tubers. Well sprouted and rooted cutting of 40-50 days old are transferred in main field. While planting the cuttings, care should be taken that attached ball of planting material should not get disturbed during removing from the polythene or planting tube. Basins of 45 cm × 45 cm are prepared for direct planning of tuberous cuttings and each pit should be filled with 5 kg leaf mould compost, 150 g single super phosphate and 50 g muriate of potash (Mishra *et al*., 1988). After planning in basin, a light irrigation is required for sprouting.

**4. Spine gourd (*Momordica dioica* Roxb. ex.Willd.)**

Spine gourd (*Momordica dioica* Roxb. ex.Willd.) is a perennial, dioecious cucurbit found growing wild in forest areas. This prized vegetable can be spotted throughout the Indian subcontinent from Himalayas to Sri Lanka, Myanmar and China up to an altitude of 2,500 msl. It is often cultivated for its fruits which are used as a vegetable. Fruits of spine gourd are available from July to September-October in the North India. Fruits are good source of protein and iron. It is also rich in ascorbic acid content (275.10 mg per 100 g). It also contains iodine (0.7 g/100 g). The nutritive value of spine gourd fruit is given in table (7.11)

Fig 7.12 Fruits of spine gourd

Fruits and other plant parts possess several medicinal properties. Roots are applied in bleeding piles, bowels and urinary complaints. The root is pasted and applied over the body of a sedative in fevers. Two new aliphatic constituents, characterized as 6-methyl tritriacont-50on-28-of and 8-methyl hentracont-3-ene, have been isolated for the first time form the fruit of *Momordica dioica* along with the known sterol pleuchiol. Besides these, momodicaursenol, an unknown pentacylic triterpene isolated from the seeds, has been identified as urs-12, 18 (19)-dien-3 beta-ol on the basis of spectral data analyses and chemical means (Ali and Srivastava, 1998). Luo *et al.* (1997) isolated five compounds from dry root viz. oleanolic acid, gypsogenin, hederagenin, alphaspinasterol and stearic acid. Ghosh *et al.* (1981) isolated glycoprotein from the cotyledonary tissues of seeds having agglutinating activities. While studying the tephroprotective activity of *Momordica dioica* Roxb. in cisplatin induced nephrotoxicity , Jain and Singhai (2010) concluded that nephroprotective and curative activities of fruit extract are due to its antioxidant activity and this may be attributed to the phenolics, flavonoids and amino acids present in the extract. *Momordica dioica* Roxb. leaves have potent hepatoprotective action against carbon tetrachloride induced hepatic damage in rats. Ethanolic extract was found

**Table (7.11): Nutritive value of spine gourd**
(per 100 g of edible portion)

| Constituent | Amount |
|---|---|
| Moisture | 84.1 g |
| Protein | 3.1 g |
| Carbohydrates | 7.7 g |
| Fibre | 2.97 g |
| Ash | 1.1 g |
| Iron | 4.6 g |
| Calcium | 33 mg |
| Phosphorus | 42 mg |
| Carotene | 2700 IU |
| Thiamine | 45.2 µg |
| Riboflavin | 176.1 µg |
| Niacin | 0.59 mg |
| Ascorbicacid | 275.1 mg |

more potent hepatoprotective. Meanwhile, *in vivo* antioxidant and free radical scavenging activities were also screened which were positive for both ethanolic and aqueous extracts. This study suggests that possible mechanism of this activity may be due to free radical-scavenging and antioxidant activities which may be due to the presence of flavonoids in the extracts (Jain *et al* .,2008).Spine gourd is probably native of India. Plants are distributed from Himalayas to Sri Lanka; up to an altitude of 1500 m. Plants of spine gourd are found naturally growing in hilly tracts of Rajmahal, Hajuribagh and Rujgirt of Bihar and in wet hills of Maharashtra, Assam and West Bengal (Rathi *et al.*, 2006).


Fig 7.13. Variability in fruits of spine gourd

**Botanical Description**

Spine gourd belongs to the genus *Momordica* and species *dioica* Roxb. ex Willd. Its chromosome number (2n) is 28. It is a dioecious perennial climber with un-branched, glabrous tendrils, root tuberous. Leaves broadly ovate, membranous, c. 6.0 x 5.0 cm, glabrous on both sides, deeply 3-5-lobed, lobes trianglular ovate or oblong, acute, with undulate or minutely remotely denticulate margin; petiole 1-3 cm long, puberulous. Male flowers 5-6 cm across, yellow, on 4-6 cm long peduncles; bracts large, sessile, entire, glabrous, often ciliated or villous on both surfaces, cucullate, suborbicular or reniform, partly enclosing the flower. Petals 2-3 x 1.5-2.5 cm, obtuse. Female flowers yellow, on c. 2.5 cm long, ebracteate or minutely bracteate peduncles; calyx lobes linear-lanceolate, 5-6 mm long, villous; corolla similar to male flowers. Ovary ovoid, covered with long and soft papillae. Fruit ovoid or ellipsoid, 3-5 cm long, 2-3.5 cm across, yellow when mature, densely covered with soft spines, shortly beaked (prostrate) at apex. Seeds somewhat compressed, 6-7 x 5-6 mm irregularly corrugated.

**Climate and Soil:** Spine gourd is a plant of warm season. For prolific growth of vine, high

humidity and 25-30ºC temperature are required. It can successfully be raised in area where average rainfall is 150-250 cm. Plants of spine gourd remain in dormant conditions during winter months. Being a hardy crop, it can be grown in different kinds of soils; however, sandy soil rich in organic matter with provision of good drainage are considered ideal. Soil pH should be in range of between 6 and 7. Before planting, field should be deeply ploughed 3-4 times and thereafter harrowing is done to remove the pieces of perennial weeds.

**Propagation:** Spine gourd is propagated by seed as well as by vegetative means.

**Seed propagation:** Seeds of spine gourd rest in dormant conditions, hence, freshly extracted seeds should not be sown for 5-6 months. Seed dipping in tap water for 24 h before sowing stimulates germination process. Ali *et al.* (1991) observed enhanced germination of spine gourd seeds at 30ºC but not at 20 or 25ºC, when the seed coat was removed. There was no effect of gibberellic acid on germination of the intact seeds. The major problem of seed propagation is 1:1 ratio of male and female plants and delay in fruiting.

**By tuber:** Tuberous roots do not have dormancy and plants raised through tubers are healthy. Tubers are obtained from 2-3 years old plant and 80-120 g pieces are made for planting. Every planting piece of tubes must have at least 2 buds for sprouting. Panda *et al.* (1994) obtained enhanced sprouting of tuberous root cuttings (87.5%) following dipping in 1 per cent thiourea whereas untreated tubers had only 18.3 per cent sprouting. Planting may be done in month of early September-October or February-March. Ram *et al.* (2002) reported the best time for planning tubers is February under irrigated conditions and June-July in rainy season. In Bangladesh, Islam *et al.* (1994) obtained higher yield (31.5 t/ha) from planting on 1$^{st}$ February. Tuberous roots are planted at spacing of 3 metre intervals.

Fig 7.14 . Tuber ready for transplanting

Fig7.15 Staminate and pistillate flower of spine gourd

**By stem cuttings:** For raising plants through this method, cuttings are made from terminal portions, however, Sahu *et al.* (1995) did not observe any significant effects due to type of cutting (basal or terminal). The number of nodes did not influence percentage rooting, FW and DW of primary roots and the length, girth and FW of tuberous roots. Contrary to this observation, Tripathy *et al.* (1993) reported that terminal cutting produced more nodes per plant and leaves, leaf area and inter nodal length than basal cuttings. Ahmad *et al.* (1992) obtained highest percentage of rooting (93%) and number of roots per cutting (17) by cuttings comprising one axillary bud and a mature diploid leaf treated 5 s in 1500 ppm IBA and planted in a mixture of soil : sand : compost (1:2:1).

**Table (7.12): Yielding ability and morphological variation in spine gourd propagation**

| Method of propagation | Yield (kg) | Days taken to germination/sprouting/rooting | Days to first male flowering | Days to first female flowering | Days to first fruit set | Days to edible fruit maturity (days) | Days to seed maturity (days) |
|---|---|---|---|---|---|---|---|
| Seed | 1.45 | 30-35 | 56 | 54 | 61 | 88 | |
| | 3.30 | 16-20 | 46 | 40 | 55 | 72 | |
| Cutting (treated with Rootex No.1) | 2.80 | 28-30 | 50 | 45 | 50 | 80 | |

**Source:** Ram *et al*. (2001)

- **Shoot tip cuttings**

Shoot tip cutting treated with 200 ppm IBA solution response better sprout and plant development.

***In vitro* propagation**

Fig 7.16 Vegetative propagation in spine gourd

An efficient protocol for rapid in vitro clonal propagation of spine gourd (*Momordica dioica* Roxb.) genotype RSR/DR15 (female) and DR/NKB-28 (male) was developed through enhanced axillary shoot proliferation from nodal segments. Maximum shoot proliferation of 6.2 shoots per explant with 100 % shoot regeneration frequency was obtained from the female genotype on Murashige and Skoog's (1962) medium supplemented

with 0.9 µM N6-benzyladenine (BA) and 200 mg l(-1) casein hydrolysate (CH). While from the male genotype the optimum shoot regeneration frequency (86.6 %) and 6.4 shoots per explant was obtained on MS medium supplemented with 2.2 µM BA. CH induced vigorous shoots, promoted callus formation, and proved inhibitory for shoot differentiation and shoot length, especially in explants from male genotype. Rooting was optimum on half-strength MS medium (male 92.8 %, female 74.6 %) containing 4.9 µM indole-3-butyric acid (IBA). Plantlets were transferred to plastic cups containing a mixture of cocopit and perlite (1:1 ratio) and then to soil after 2-3 weeks. 84 % female and 81 % male regenerated plantlets survived and grew vigorously in the field. Genetic stability of the regenerated plants was assessed using random amplified polymorphic DNA (RAPD). The amplification products were monomorphic in the in vitro propagated plants and similar to those of mother plant. No polymorphism was detected revealing the genetic integrity of in vitro propagated plants. This micro-propagation procedure could be useful for raising genetically uniform planting material of known sex for commercial cultivation or build-up of plant material of a specific sex-type (Rai *et al*., 2012).

**Table (7.12): Effects of concentrations of BA, and casein hydrolysate on in vitro shoot proliferation from nodal explants of *M. dioica* after 30 days**

| BA(µM) | CH | Male | | | Female | | |
|---|---|---|---|---|---|---|---|
| | | Shoot response (%) | Number of shoots per explant (mean ± SE) | Average shoot height (cm ± SE) | Shoot response (%) | Number of shoots per explant (mean ± SE) | Average shoot height (cm ± SE) |
| - | - | 87.0 | 1.2±0.1 | 6.2±0.6 | 80.4 | 1.2±0.0 | 2.4±0.3 |
| - | + | 85.1 | 1.0±0.0 | 4.0±0.3 | 74.9 | 1.0±0.0 | 3.2±0.4 |
| 0.9 | - | 100.0 | 2.4±0.3 | 1.4±0.1 | 100.0 | 3.1±0.2 | 8.8±0.9 |
| 0.9 | + | 89.0 | 2.4±0.2 | 0.7±0.0 | 100.0 | 6.2±0.4 | 3.4±0.4 |
| 2.2 | - | 86.6 | 6.4±0.2 | 2.0±0.1 | 98.2 | 3.3±0.2 | .0±0.2 |
| 2.2 | + | 87.5 | 5.0±0.2 | 2.1±0.1 | 98.2 | 4.5±0.2 | 0.8±0.2 |
| 4.4 | - | 73.6 | 3.6±0.5 | 2.0±0.4 | 72.7 | 3.2±0.5 | 1.6±0.2 |
| 4.4 | + | 69.6 | 3.6±0.4 | 1.5±0.3 | 62.2 | 2.5±0.3 | 1.6±0.3 |
| 8.9 | - | 60.6 | 2.3±0.6 | 1.4±0.2 | 83.7 | 1.5±0.3 | 1.2±0.2 |
| 8.9 | + | 31.1 | 1.2±0.1 | 0.5±0.1 | 70.3 | 1.4±0.2 | 1.1±0.2 |

**Source**: Rai et al., 2012

**Grafting:** Spine gourd was grafted on rootstocks of *Cucurbita moschata, C. ficifolia* or $F_1$ hybrids of *C. maxima* x *C. moschata*. Control of *M. dioica* was grown on their own roots. Physiological measurements were made for mature leaves between $5^{th}$ and $9^{th}$ nodes under irradiances of 0, 50, 100, 200, 500, 700, 900, 1200 and 1500 (natural solar irradiation) µ mol

m-2, s-1 at 283ºC and 45% RH. The net photosynthetic rate, transpiration rate, stomatal conductance and intercellular $CO_2$ concentration were similar for grafted and control plants in response to irradiance. In grafted plants, total DM production was 2-3 times higher than in control at both vegetative and flowering

**Table (7.13): Effects of concentrations of IBA and MS medium strength on root induction from in vitro proliferated shoots of *M. dioica* after 40 days**

| MS media strength | BA(µM) | Male | | | Female | | |
|---|---|---|---|---|---|---|---|
| | | Root response (%) | Number of roots (mean ± SE) | Average root length (cm ± SE) | Root response (%) | Number of roots (mean ± SE) | Average root length (cm ± SE) |
| H | - | 38.3 | 2.6±0.3 | 2.5±0.2 | 34.0 | 1.3±0.2 | 1.2±0.2 |
| F | - | 30.6 | 2.3±0.1 | 2.0±0.1 | 12.9 | 0.9±0.7 | 1.0±0.5 |
| H | 1.0 | 27.4 | 4.0±0.3 | 2.0±0.2 | 36.1 | 4.0±0.6 | 2.0±0.2 |
| F | 1.0 | 14.4 | 3.1±0.3 | 0.8±0.1 | 26.4 | 2.6±0.2 | 1.6±0.1 |
| H | 2.5 | 64.3 | 2.3±0.3 | 2.5±0.1 | 76.2 | 2.6±0.3 | 3.9±0.7 |
| F | 2.5 | 32.2 | 3.8±0.3 | 1.9±0.1 | 40.1 | 1.6±0.1 | 3.4±0.1 |
| H | 4.9 | 92.8 | 3.8±0.2 | 4.1±0.4 | 74.6 | 4.6±1.2 | 4.6±0.5 |
| F | 4.9 | 49.5 | 5.9 ±1.8 | 2.2±0.3 | 69.3 | 2.6±0.6 | 3.2±0.9 |
| H | 9.9 | 97.1 | 8.6±1.8 | 2.2±0.2 | 76.4 | 4.8±0.6 | 2.2±0.1 |
| F | 9.9 | 47.4 | 1.4±0.2 | 0.7±0.1 | 25.0 | 1.1±0.2 | 1.4±0.2 |
| H | 24.6 | 67.5 | 9.1±0.8 | 0.6±0.0 | 73.0 | 7.4±1.0 | 0.5±0.1 |
| F | 24.6 | 0.0 | 0.0±0.0 | 0.0±0.0 | 0.0 | 0.0±0.0 | 0.0±0.0 |

Source: Rai et al. (2012)

**5. Bankunari (*Melothria*)**

*Melothria* is a dioecious cucurbit, bears edible fruits which are used for vegetable as well as salad. Beside immature fruits, fully ripe red coloured fruits are used as dessert purpose. Tender shoot and leaves are also utilized as a leafy vegetable. Plant develops tuberous root which is utilized as sweet potato. Tuberous roots are rich in calcium and they are much liked by children. Nutritive value of its fruits is given in table (7.14) and tuberous root in table (7.15).

Fig. 7.17. Fruits of Melothria

**Table (7.14) :Nutritive value of Bankunari fruit** (per 100 g of edible portion).

| Analytical factors | Values |
|---|---|
| TSS | 6.37 per cent |
| pH (fruit juice) | 5.95 per cent |
| Acidity (% malic acid) | 0.01 |
| Total sugars | 7.22 g |
| Reducing sugar | 4.62 g |
| Non reducing sugar | 2.58 g |

***Source:*** Bharathi *et al.* (2006)

**Table (7.15)*:* Nutritive value of tuberous root** (per 100 g of edible portion).

| Constituents | Value |
|---|---|
| Moisture | 66.5 g |
| Protein | 0.7 g |
| Fat | 0.4 g |
| Minerals | 0.9 g |
| Fibre | 1.6 g |
| Carbohydrates | 29.9 g |
| Energy | 126 k cal |
| Calcium | 200 mg |
| Phosphorus | 40 mg |
| Iron | - |

**Source:** Gopalan *et al.* (2004)

Plant of *Melothria* possesses several medicinal and curative properties. The root is considered stimulant, invigorating and purgative, it is used for gonorrhea and dysuria. Root juice added with cumin and sugar and given in the cold milk is considered a proven remedy for supermatorrhoea in the Konkan region. Juice of fresh leaf is recommended for diabetic patients Dry powder of tubes is used in several Ayurvedic medicines.

**Origin and Distribution**

*Melothria* (Syn. *Solena*) is genus of old World. About 12 species occur in India. Its plants are distributed throughout India ascending up to 2100 m in the hills. Beside India, its distribution has been reported in China, Australia, including South East Asia, but not in the Philippines (Siemmonsma and Piluek, 1993). In India, plants may be spotted in Rajmahal hills near Simra Dak Bungalow and Tikigora hills in Bihar. Its plants are also found in natural stand in Assam, Tripura, Garo hills in Meghalaya, Konkan and Deccan areas. Plants can also be seen in Nainital and Kumaon hills of Uttarkhand ( Pandey, 2007 , 2008)

**Botanical Description**

Bankunari belongs to the genus *Solena* and species *amplexicaulis* (Lamk.) Gandhi (Syn. *Melothria heterophylla* (Lour) Cogn. *Solena heterophylla* Lour. Under the genus *Solena*, 88 species are reported worldwide; out of which 12 species occur in India (Ambasta, 2000). Among various species, Bankunari is more diverse in nature. It is a typically hilly crop, often surviving under stress conditions (Hooker, 1885). **Taxonomic position of *Melothria* is given as under:**

Plant of *Melothria* is a scandent herb with tuberous root. Leaves polymorphous, ovate, sub orbicular, oblong or narrowly lanceolate, undivided or variously lobed, remotely denticulate;

flowers small yellow; staminate flowers are in a simple umbel, peduncle very short, apically 10-20 flowered, pedicel 2.8 mm, calyx tube 5 mm long, 3 mm in diameter, corolla yellow, stamens 3 and filaments filiform. Pistillate flowers are solitary, creamy white to yellow; grow on a sturdy 5-10 mm long pedicel, ovary ovate (2.5-3.5 mm) and stigma 3. The fruits are oblong ovoid, cylindrical, slightly ribbed, and fleshy, 2-6 cm long, and 2-5 cm in diameter. The first female flower appears between 7$^{th}$ to 10$^{th}$ nodes of the plant. The time taken from flower bud initiation to blooming of flower is 6-7 days. Anthesis takes place from 3 to 4.30 p.m. Male flower drop from the inflorescence within 24 hours after opening. Fruits are oblong, green in colour having white flesh, whereas ripe fruits are orange yellow to bright red. Seed numerous, spherical and smooth.

Fig .7.18 Variability in Melothria fruits

**Propagation**

Bankunari is a dioecious plant. It is propagated through seed, tuberous root and vine cuttings.

- **By seed:** Freshly extracted seeds rest in dormant conditions hence, 5-6 months after harvesting seeds should be taken for sowing. Generally very limited quantity of seeds is obtained and there is very poor germination (less than 20 per cent, Mishra, 1994). Further, the major problem of seed propagated plants are 50:50 ratio of female and male plants and inordinate delay of seed propagated plant to come in bearing.
- **By tuberous root cutting:** At the onset of winter during October-November in the North Indian conditions when plants go in rest period, tubers are dug from 2-3 year old plant. From the big tubers, small pieces are made for planting purpose. Tuberous root sprouts very early (20-22 days) and start flowering within 48-55 days and attain the edible maturity within 80 days. Ram *et al*. (2003) reported that big size tuber (more than 180 g) expressed early sprouting as compared to medium (120-140 g) and small size tubers. However, root development was poor in big size tubers.
- **By vine cutting:** During rainy season, when there is high relative humidity in the atmosphere, cutting of 5-7 cm length having one or two nodes are made. Cuttings may be treated with IBA @ 5000 ppm or commercially available Seradix No. 2. Treated cuttings are planted in polythene bag filled with sand: soil: cow dung in 2: 1: 1 ratio. Planted cuttings are

irrigated through sprinkler. Cuttings sprout in 15-20 days after planting and when they attain 3-5 leaf stages are planted in the main field.

**Table (7.16): Categorization of Bunkunari on the basis of tuber size, weight and days taken to sprout**

| Tuber Size | Tuber weight (g) | Sprouting (days after planting) | Root development | Plant growth | Accessions |
|---|---|---|---|---|---|
| Small | >120.00 | 18-20 | Good | Weak & Slender | DR/NKV-56, 67 |
| Medium | 120.00-140.00 | 15-16 | Good | Vigorous | DR/NKV-58, 59 |
| Long | >180.00 | 10-12 | Poor | Normal | DR/NKV-68, 69 |

**Source:** Ram *et al*. (2003)

**Planting and after care**

Planting is done in raised bed at the spacing of 50 cm between rows and 30 cm between plants. Planting may also be done in basin filled with 2 kg FYM, 25 g single super phosphate and 10 g *Trichoderma*. In each basin as per availability of type of planting material 6 seeds or one or two root cuttings or two sprouted vine cuttings are planted. At early stage of sprout growth, proper care should be taken to remove weeds. As soon as vine starts growth, staking is done for proper growth of vine.

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# Chapter -8

# Integrated Management of Disease and Pests in Nursery of Vegetable Crops

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Adaptation of plant protection measures in the nursery against the incidence of diseases and insect pest is very important task to get the healthy seedlings. The common occurring diseases and insects-pests in nurseries are following.

**Fungal diseases**

**Damping-off of seedlings:** Damping-off is a common disease of germinating seeds and young seedlings. Several fungi are capable of causing damping-off including *Rhizoctonia*, *Alternaria*, *Sclerotinia* and the water molds, *Phytophthora* and *Pythium*. Soil-borne fungi generally do not produce air-borne spores but are easily transported from contaminated soil to pathogen-free soil by infected tools, hose ends, water-splash and hands. Young seedlings are most susceptible to damping-off. However, later in the crop cycle, the same pathogens may cause root and stem rot.

**Symptoms:** Symptoms of damping-off include seedlings failing to emerge or wilting, often with a stem lesion that appears water-soaked or dark, necrotic and sunken at the soil line. Pathogens usually spread radially from a central point of origin so plants often die in a circular pattern. Vegetable seeds that are germinated in poorly drained, cool soils are especially susceptible. Young plants that do emerge are weak and often wilt at or below the soil line.

Cabbage, cauliflower, tomato and pepper seedlings may be girdled by brown or black sunken cankers.

**Management**: Damping-off must be prevented because it is difficult to stop once symptoms occur. There are several strategies to prevent damping-off.


Fig.8.1Damping off in Cauliflower

- Use only certified disease-free seed from reputable seed companies.
- Use fungicide-treated seed.
- Use pasteurized soil, properly produced compost-based or soilless mixes. Incorporate biological fungicides into soilless mixture or apply biological fungicides as a drench at planting.
- Disinfect all flats, cold frames, pots and tools.
- Germinate seed under conditions that will ensure rapid emergence, such as with the use of bottom heat.
- Avoid overwatering, excessive fertilizer, overcrowding, poor air circulation, careless handling, and planting too deeply.
- To avoid compaction, do not stack or "nest" filled trays or pots.
- Provide adequate light for rapid growth.
- Treat the nursery bed with formalin (1 part formalin in 7-10 parts water).
- Drench the nursery beds with Indofil M 45 or Rodomil MZ 72 WP @0.25%.

**Botrytis blight:** Botrytis can cause leaf blight, stem cankers, damping off and root rot. Plants may be attacked at any stage, but the new tender growth, freshly injured tissues and dead tissues are most susceptible. Air currents and splashing water can easily disseminate the spores. In general, germination of spores and infection is dependent on a film of moisture for 8 to 12 hours, relative humidity of 93% or greater and temperatures between 55° and 65°F. After infection, colonization of plant tissues can occur at temperatures up to 70°F.

**Management**: Fungicides alone cannot control Botrytis and this pathogen has a long history of fungicide resistance development.

- Control weeds and remove plant debris before and during production.
- Dispose of diseased plants and debris in a plastic trash bag. Keep the bag closed to help prevent spreading spores to uninfected plants as the bag is removed from the

greenhouse. Cover trash cans to prevent the airborne spread of spores from diseased plant tissue.

- Reduce humidity and leaf wetness duration to prevent spore germination. Provide good air circulation and reduce humidity within the canopy.
- Proper planting dates, fertility, watering and height management will prevent overgrown plants, thereby reducing humidity within the canopy.
- Water in the morning, never late in the day.
- Seed treatment with captom , thiram, etc.


Fig 8.2: Downy mildew in cabbage

**Downy mildew:** Infected leaves develop a diffuse yellowing that is easily confused with nutrient deficiency. Distinct vein bounded patches on the underside of the leaves develop that produce dark purple brown sporangia. The fuzzy, dark growth makes leaf undersides appear dirty.

**Management**: Management of environmental conditions such as temperature, humidity and duration of leaf wetness, sound cultural practices and fungicides will help prevent disease development.

- It is vital to reduce humidity and leaf wetness duration to prevent spore germination.
- Provide good air circulation and reduce humidity within the canopy. Proper planting dates, fertility, watering and height management will prevent overgrown plants, thereby reducing humidity within the canopy.
- Water in the morning, never late in the day. Rising temperatures during the day will cause water to evaporate from the foliage and dry the leaf surface.

**Bacterial diseases**

**Bacterial leaf spot:** Bacterial leaf spot is caused by *Xanthomonas campestris pv.* vesicatoria and is found primarily on peppers although all aboveground parts of plants. Spots on leaves are chocolate-brown with yellowing at lesion's margins and irregularly shaped with areas of dead leaf tissue. At first, the spots are less than 1/4 of an inch in diameter. Severely spotted leaves will appear scorched and defoliation may occur. This disease is most prevalent during moderately high temperatures and long periods of leaf wetness.

**Bacterial canker:** Bacterial canker is caused by *Clavibacter michoiganensis* pv. *michiganensis* (formerly *Corynebacterium michiganense*). The bacterium is seed-borne but may survive on plant debris in soil for at least one year. It can also survive in the greenhouse on wooden stakes

and flats. Wilt, leaf scorch, canker, pith necrosis and fruit spot may occur singly or in combination depending on the circumstances. When the bacterium is carried in the seed, the vascular system becomes colonized, resulting in wilt, pith necrosis and external cankers. Wilt initially occurs on one side of a leaf or one half of a plant because only a portion of the vascular system is blocked. Cankers and pith necrosis occur in later stages of disease development. Cankers are dark and water-soaked in appearance and often exude bacteria that are easily spread to adjacent plants. Pith necrosis is first evident as a darkening of the center of the stem that soon becomes chambered or hollow. When leaf scorch occurs, the petioles usually bend downward while the leaf edges curl up. The margins of the leaves become brown with a yellow border to the inside. Scorching of the foliage often develops in the absence of wilt or stem canker. Transplants may not express symptoms until six to eight weeks after infection and initial symptom expression is accelerated by environmental stress.

**Black rot:** Black rot, caused by the bacterium *Xanthomonas campestris* pv. *campestris* occurs where cruciferous plants are grown. All Brassica can be severely affected. The bacterium enters the leaves by colonizing the hydathodes (water pores) and moves from the leaf margins inward. Lesions may also begin at wounds. Diseased tissue is often V-shaped; flaccid, tan to yellow and with blackened veins. The blackened veins are diagnostic and are best seen by holding the leaf up to the light. When the lesions reach the petiole and stem, the bacterium moves systemically through the plant, resulting in premature leaf drop. At this stage of disease, a cross-section of the stem will reveal a ring of discolored vascular tissue.

**Management of bacterial diseases**: The management of these bacterial diseases is similar and includes the following strategies:


Fig. 8.3. Black rot in cabbage

- Buy certified disease-free seed from a reputable source.
- Use hot water-treated seed. There is a risk that germination percentages will be reduced if the seed crop is grown under stressful environmental conditions.
- Promptly remove infected plants and adjacent plants to prevent further infection and avoid unnecessary handling of plant material.
- Avoid overhead irrigation, splashing or periods of extended leaf wetness.
- Disinfect all benches, equipment, flats and stakes.
- Follow sound practices for weed and insect control.

**Viral Diseases**

**Cucumber mosaic virus:** Cucumber mosaic virus (CMV) has a wide host range of over 400 species of plants including vegetables, ornamentals and weed hosts.

**Symptoms:** Infected plants may show mild mosaic patterns and mottling, flecking, and fern leaf distortion. CMV is primarily spread by aphids that can acquire the virus in as little as 5 to 10 seconds. Aphids then move the virus from plant to plant for a few hours.

**Management**: Rogue diseased plants. Eliminate weeds from nursery site,they may be reservoirs for CMV.

**Tobacco Mosaic Virus (TMV):** TMV has a wide host range but is especially a concern on solanaceous crops. TMV is not transmitted by insects. It is a very stable virus that can be spread by contact. Workers can easily spread TMV when they handle plants or when cutting tools become contaminated. Symptoms include yellow mottling, upward leaf curling and overall stunting. Some infected plants may not show any symptoms at all.

**Management:** Discard infected plants including roots. Disinfect hands by washing with tri-sodium phosphate and then thoroughly with soap and water. Smokers need to wash their hands before entering the greenhouse so they do not infect plants. In greenhouses, hard surfaces such as doorknobs, or flats can become contaminated after handling virus-infected plants and remain a source of infection. Thoroughly disinfect the growing area with a commercial disinfectant. Control perennial weeds in the solanaceous family.

**Tospoviruses:** Tospoviruses are a group of viruses that include impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV). They may infect hundreds of plant species including tomatoes, peppers and eggplant. These viruses are primarily spread by thrips. Tospoviruses are not seed borne but are brought into the greenhouse on vegetatively propagated plants or seedlings that have been exposed to the virus. Once the thrips in the greenhouse become infected, they can transmit the virus to susceptible crops and weeds.

**Symptoms:** Symptoms include stunting, foliar ring spots and black lesions on stems. Symptoms of INSV and TSWV will vary depending upon the host.

**Management:** To manage Tospoviruses, it is necessary to discard infected plant material, including weeds and to manage thrips. Infected vegetable transplants planted into the green house or field will be stunted and will not produce a harvestable crop. Since INSV and TSWV

are not seed-borne, vegetable transplants may be kept free of Tospoviruses if they are not brought into contact with other infested crops or thrips carrying the virus.

**Common Insect -Pests in nursery**

**Aphids:** Aphids are small insects, ranging from yellow to green to red, and may or may not have wings. Look for these insects on the undersides of the leaves. Aphids feed by inserting needle-like mouthparts in leaves, stems, and fruit to remove plant nutrients. Aphids occur on almost all the crops and are of special concern on tomatoes, peppers, squash, melons, and cucumbers. They may transmit virus diseases among crops and can be very damaging.

**Control**

Fig. 8.4.Infestation of green peach aphid

- Removal of residues of earlier crop from nursery site. Use nitrogen fertilizer in less amounts and FYM in ample amounts.
- Aphids may be controlled by natural factors including rain, wind, parasitoids (e.g., tiny wasps) and predators (e.g., lady beetles).
- Spraying solution of soap and cow urine or neem cake extract.
- Spraying of Dimethoate @1.7 ml/liter. orPhosphamidon @ 0.5 ml/liter. or Oxydemeton methyl @ 1ml/liter reduces the pest population.

**Thrips:** Thrips are very small insects that rasp, tear, and remove nutrients from leaves, causing a silver streaking of the leaf tissue and leaf curling. They often are very abundant early in the season and the damage may be very notable on cotyledons and first true leaves.

Fig. 8.5. Infestation of thrips

**Control**

- Deep ploughing of the nursery site in summer can kill pupating thrips.
- Organic control may be achieved by repeated, direct applications of neem oil or pyrethrum.
- Spraying of Dimethoate 30 EC @1.7 ml/liter is very effective.

**Caterpillars and cutworms**

Caterpillars and cutworms are worm-like larval stages of insects that will mature into moths or butterflies. They emerge from small eggs laid on plant tissue and can grow to several inches in length. Caterpillars have chewing mouthparts and feed on leaves and stems. Most caterpillars are found feeding on leaves and their activity is often noticed by the presence of excrement on leaves or soil.

Fig. 8.6. Infestation of black cut worm

**Control**

- Transplants can be protected from cutworms by placing 'collars' around the base of the plant stems.
- Mixing of 5 % Aldrin in nursey soil at time of seed sowing.

**Leafhoppers**

Leaf hoppers are about 2-3 mm long and walk sideways when disturbed. They lay green banana-shaped eggs on the underside of the leaves. Nymphs and adults suck cell sap from leaf cells. In severe infestation the entire leaf turns light green in color.

**Control**

- Organic control is best achieved with applications of neem oil or pyrethrum.
- Spraying Lambda-cyhalothrin 0.5 ml/liter or Acetamiprid 0.5 ml/liter

Fig. 8.7. Adult leaf hopper

**Mites**

Mites are spider-like insects which forms an airy web of thin threads. Mites are smaller than 1 mm, often yellow, red or orange in color and lay eggs on the underside of leaf. Larvae and adult insects suck sap from the leaves and stems which turns yellow and dries. The mite infestation and damage is more in summer and dry season.

**Control**

- Infested plants can be washed thoroughly with a direct stream of water early in the morning to allow the leaves to dry before evening.
- Spray with soap or kerosene-soap solution.

- Spraying of Dicofol can reduce mites populations.

**Seed borne disease and treatment of seed for hi-tech transplant production**

Vegetable transplant damaged by different causal organisms in nursery, therefore for quality seedling production proper care should be taken. There some important diseases which are transmitted by seed are listed in table ( 8.1).

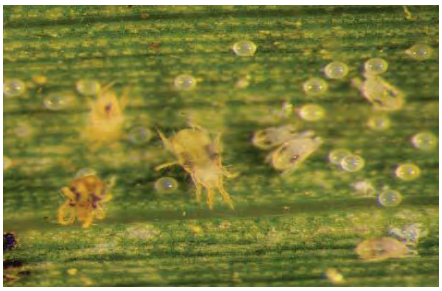


Fig. 8.8. Infestation of mites

**Table (8.1) : Diseases of vegetable crops caused by seed borne pathogens**

| Crops | Diseases | Crops | Diseases |
|---|---|---|---|
| Cole crops | Alternaria leaf spot | Brinjal | Alternaria early blight |
| | Bacterial leaf spot | | Anthracnose |
| | Black leg | | Phomopsis |
| | Black rot | | Verticillium wilt |
| Tomato | Anthracnose | Sweet pepper | Anthracnose fruit rot |
| | Bacterial canker | | Bacterial leaf spot |
| | Bacterial speck | | Cucumber mosaic virus |
| | Bacterial leaf spot | | Pepper mild mottle virus |
| | Cucumber mosaic virus | | Tobacco mosaic virus |
| | Early blight | | Tomato mosaic virus |
| | Fusarium wilt | | |
| | Late blight | | |
| | Leaf mold | | |
| | Septoria leaf spot | | |
| | Tomato mosaic virus | | |
| | Verticillium wilt | | |
| Onion | Botrytis neck rot | Lettuce | Anthracnose |
| | Downy mildew | | Bacterial leaf spot |
| | Purple blotch | | Lettuce mosaic virus |
| | Smut | | Septoria leaf spot |
| | Stemphylium leaf blight | | Verticillium wilt |
| Spinach | Anthracnose | Celery | Bacterial leaf spot |
| | Cladosporium leaf spot | | Cercospora leaf spot |
| | Downy mildew | | Septoria leaf spot |
| | Fusarium wilt | | Phoma crown and root rot |
| | Verticillium wilt | | |
| | Stemphylium leaf spot | | |
| | Cucumber mosaic virus | | |

**Vegetable seed treatment :** Treatment of vegetable seeds to kill disease-causing organisms carried within or on the seed has repeatedly been shown to prevent plant disease epidemics. Seed treatment can be useful in reducing the amount of pesticide required to manage a disease, because an effective seed treatment can eliminate the need to make foliar applications of fungicides or bactericides later in the season. This reduction in pesticide use is both economically and environmentally beneficial. Treatments may disinfect (kill pathogens borne within the seed), disinfest (kill externally borne pathogens), or protect the seed.

**Seed disinfection:** The purpose of seed disinfection is to eradicate seed-infecting pathogens from the seed coat, the embryo, or both. If properly used, hot-water soaks will kill most seed borne fungi and bacteria without killing the seed. Seed lots of poor quality or lots more than one year old may not germinate well after hot-water treatment. Therefore, a small sample of each seed lot should be treated and tested for germination before the entire lot is treated. The water temperature must be carefully controlled, since a slight reduction in temperature may result in a failure to kill the fungi or bacteria, and a slight increase may result in severe seed injury. It is generally best to purchase seed that has been hot water treated by a commercial seed company. However, the following procedures should be strictly followed when commercially treated seed is not available or desirable.

- Prewarm seed in a loosely woven cotton bag for 10 minutes in water at 100°F. Fill the treatment bag no more than half full and gently squeeze it during this soak to eliminate all air pockets and to make sure all seeds are wetted.
- Place prewarmed seed in a water bath (5 to 10 times the volume of seed to be treated) that will hold the water at the recommended temperatures (Table-2). The time and temperature of treatment must be exact.
- Immediately after the required treatment time has elapsed, place the sacks in cold water for a few minutes.
- Spread the seeds out to dry. Old screens make excellent drying racks.
- Apply a protective seed treatment.

**Seed disinfestations**

The purpose of seed disinfestation is to kill pathogens living on the surface of the seed. Fungicides and bactericides, such as streptomycin, can be used. Some bacterial pathogens that are carried on the seed surface, such as those causing bacterial spot on pepper and tomato

**Table (8.2): Recommended temperature and time for hot water seed treatment**

| Crops | Water temperature (ºF) | Time (minutes) |
|---|---|---|
| Broccoli | 122 | 20-25 |
| Brussels sprouts | 122 | 25 |
| Cabbage | 122 | 25 |
| Carrot | 122 | 15-20 |
| Cauliflower | 122 | 20 |
| Celery | 122 | 25 |
| Chinese cabbage | 122 | 20 |
| Collard | 122 | 20 |
| Coriander | 127 | 30 |
| Cress | 122 | 15 |
| Cucumber | 122 | 20 |
| Eggplant | 122 | 25 |
| Kale | 122 | 20 |
| Kohlrabi | 122 | 20 |
| Lettuce | 118 | 30 |
| Mint | 112 | 10 |
| Mustard | 122 | 15 |
| New Zealand Spinach | 120 | 60-120 |
| Onion (sets) | 115 | 60 |
| Pepper | 125 | 30 |
| Rutabaga | 122 | 20 |
| Shallot | 115 | 60 |
| Spinach | 122 | 25 |
| Sweet Potato (roots) | 115 | 65 |
| Sweet Potato (cutting, sprouts) | 120 | 10 |
| Tomato | 122 | 25 |
| Turnip | 122 | 20 |
| Radish | 122 | 15 |
| Parsley | 122 | 30 |
| Celeriac | 118 | 30 |
| Yam (tubers) | 118 | 30 |

and bacterial canker on tomato, can be eliminated by dipping the seed in a solution of 1.0 quart household bleach (5.25 to 5.45 percent sodium hypochlorite) and 3 quarts of water for 1 to 2 minutes. Use 1 gallon of solution per pound of seed (Sen, and Kapoor, 1974). Bleach soaks are also used to free asparagus seed from the Fusarium wilt and root rot fungus. Seed in a cheesecloth bag should be continuously agitated for 40 minutes to a solution containing 1.0 pint of liquid household bleach (5.25 to 5.45 percent sodium hypochlorite) and 8.0 pints of water. Use 1 gallon of solution per pound of seed. Transmission of tobacco mosaic virus on pepper and tomato seed can be eliminated or reduced by soaking seeds in a solution of a trisodium phosphate. Use 1 pound of trisodium phosphate per gallon of water; soak seed for 30 minutes, rinse, and dry before treating with household bleach. After the seed is treated using

bleach or trisodium phosphate, it should be air-dried and treated with a protectant fungicide such as captan.

**Seed protection**

The purpose of seed protection is to prevent seed rots and damping-off caused by soil-inhabiting fungi. Fungicides such as thiram, captan, etridiazole, metalaxyl, chloroneb, maneb, mancozeb, and PCNB are commonly used as seed protectants. Specific recommendations are given in table (8.3). Pretreated seed is available from most vegetable seed supply houses. Be certain to read the label carefully to determine what, if any, treatment has been used. Many growers combine both a fungicide and an insecticide in a seed treatment. Current insecticide recommendations, label precautions, and a compatibility chart should be consulted before combining a fungicide and an insecticide (Goswami *et al*., 2008).

**Treatment methods:** Seed treatment chemicals, used in seed disinfestation or protection, may be applied by either the dust method or the slurry method.

1. **Dust method:** Place the seed and fungicide in a closed container (Mason jar or drum) and agitate vigorously for several minutes until the seed is uniformly coated with dust. Best results are obtained when the container is twice the volume of the seed to be treated.
2. **Slurry method:** Add enough water to a wettable powdery formulation of the selected fungicide to make a sloppy paste. Place the seed in the slurry and stir or swirl until the seeds are thoroughly coated. Dry the seed before planting.

**Table (8.3): Seed Treatment, Materials, and Disease Control for Vegetable Crops**

| Crops | Chemical & method | Disease controlled, remarks |
|---|---|---|
| Beans | Captan D, S, PB<br>Chloroneb S,PB<br>Etridiazole and<br>PCNB D,S,PB<br>Metalaxyl S<br>PCNB D,S<br>Streptomycin S<br>Thiram D,S | Seed rot, damping-off, *Pythium* and *Rhizoctonia* root rot. Streptomycin is partially effective in eliminating surface contamination by the halo blight organism. PCNB can be used for better protection against *Rhizoctonia*. Metalaxyl will provide optimal control of Pythium. |
| Beet | Captan D,S<br>Thiram D,S | Seed rot, damping-off, black rot (seedling stage). Application of Solubor may reduce damping-off if boron is deficient. |

| | | |
|---|---|---|
| Carrot | Hot water soak, followed by thiram D,S | Hot water soak controls seedborne bacterial blight. Thiram controls seed rot and damping-off. |
| Corn (Pop & sweet) | Captan D,S<br>Metalaxyl S<br>Thiram D,S,<br>Carboxin S,PB | Most of these products control seed rot and damping-off. Metalaxyl controls only Pythium. |
| Cole crops, radish and turnip | Hot water soak, followed by<br>Captan D,S<br>Thiram D,S | Hot water soak controls seedborne black rot, blackleg, downy mildew, anthracnose, and Alternaria leaf spot and blight. Fungicides control seed rot and damping-off. |
| Eggplant | Hot water soak, followed by<br>Captan, D,S<br>Thiram D,S | Hot water soak controls seed borne Phomopsis blight and Collectotrichum fruit rot. Thiram controls seed rot and damping-off. |
| Endive | Thiram D,S | Seed rot, damping-off |
| Garlic (cloves) | PCNB D,S | White rot |
| Okra | Metalaxyl S<br>Thiram D,S | Seed rot, damping-off |
| Onion | Thiram D,S,<br>Pelleted with methocel sticker | Seed rot, damping-off, smut |
| Pea | Captan D,S,PB<br>Etridiazole and PCNB M,PB<br>Metalaxyl S<br>PCNB M,D,S<br>Thiram D,S | Seed rot, damping-off. Give partial control of Ascochyta and Mycosphaerella blights. |
| Pepper | Hot water soak or bleach soak, followed by<br>Captan D,S<br>Thiram D,S | Soaks control seedborne anthracnose and bacterial spot. Fungicides control seed rot and damping-off. |
| Potato | Captan D<br>Maneb D<br>Mancozeb D, dip thiophanate methyl and fir bark, D | Fusarium or seed piece rots or decays |
| Spinach | Hot water soak, followed by<br>Captan D,S<br>Thiram D,S | Soak controls seed borne downy mildew and anthracnose. Fungicides control seed rot and damping-off. |
| Sweet potato | Botran dip | Black rot, stem rot, scurf |

| | | |
|---|---|---|
| | Thiabendazole dip | |
| Swiss chard | Captan D,S<br>Thiram D,S | Seed rot, damping-off, leaf spot. |
| Tomato | Hot water soak, followed by Captan S, Thiram D,S, or Mancozeb S | Soak controls seedborne bacterial spot, anthracnose, and Phoma rot. Fungicides control seed rots and damping-off. |
| | Trisodium phosphate soak, followed by Captan S, Thiram D,S, or Mancozeb S | Soak controls seedborne tobacco mosaic virus. Fungicides control seed rots and damping-off. |
| | Trisodium phosphate and bleach soak, followed by Captan S, Thiram D,S, or Mancozeb S | Soaks control seed borne tobacco mosaic virus, anthracnose, and bacterial spot. Fungicides control seed rots and damping off. |
| Cucurbits | Captan D,S,PB<br>Thiram D,S | Seed rot, damping-off, seedborne Fusarium, foot rot of squash, black rot. |

**Biocontrol Agents for the management of biotic stress:** An attractive alternative method to chemical pesticides is the microbial biocontrol agents. They are the natural enemies devastating the pest and pathogen population with no hazard effects on human health and the environment. Biocontrol agents like bacteria (BBAs), fungi (FBAs), entomopathogenic nematode (EPNs) has an important position among all the biocontrol agents because of its route of pathogenicity, broad host rang and its ability to control both fungal pathogen and insect pests including sap sucking pests such as mosquitoes and aphids as well as pests with chewing mouthparts, yet they only cover a small percentage of the total insecticide market.

**Classification of entomopathogenic fungi (EPFBAs):** Entomopathogenic fungi are found in the divisions Zygomycota, Ascomycota and Deuteromycota (Samson *et al.*, 1988), as well as the Chytridiomycota and Oomycota, which were previously classified within the Fungi. Many of the genera of entomopathogenic fungi currently under research either belong to the class Entomophthorales in the Zygomycota or the class Hyphomycetes in the Deuteromycota. It is important to mention that fungal infections occur in other arthropods as well as insects and/or species which are not pests of cultivated crops.

***Beauveria bassiana* (Balsamo) Vuilemin:** The first microorganism to be recognized as a disease agent was the fungus *B. bassiana* (Bassi, 1835). The genus *Beauveria* has been monographed by MacLeod (1954), who recognized two species, *B. bassiana* and *B. brongniartii*, that attack all stages of insects of all groups. *B. bassiana* occurs worldwide; it has one of the largest host lists among the imperfect fungi and occurs in soil as a ubiquitous saprophyte (McCoy *et al.*, 1988; Tanada and Kaya, 1993). Entomopathogenic mitosporic ascomycete, *B. bassiana* is an important natural pathogen of insects and it has been developed as a microbial insecticide for use against many major arthropod pests in agricultural, urban, forest, livestock and aquatic environments (Faria and Wraight, 2007). It has been developed as a microbial insecticide for use against many major pests, including *lepidopterans* and *orthopterans*. About 33.9% of the mycoinsecticides is based on *B. bassiana*, followed by *M. anisopliae* (33.9%), *Isaria fumosorosea* (5.8%) and *B. brongniartii* (4.1%) (Faria and Wraight, 2007); however, to increase the market share of *B. bassiana*, the killing speed which is the major hindrance limiting their use as mycoinsecticides should be accelerated, (St Leger and Wang, 2009).

Fig. 8.8. *B. bassiana*

***Nomuraea rileyi* (Farlow) Samson:** The fungus *Nomuraea rileyi* (= *Spicaria prasina* = *Spicaria rileyi*) is pathogenic to a number of economically important lepidopterous insect pests. The infected larvae are covered with a dense white mat of hyphae that, upon conidia formation, turn pale green. Conidia of *N. rileyi* germinate in two days post infection at 25°C and high humidity. The germ tube passes directly through the epicuticle. The points of entry are darkened, indicating lysis, presumably due to enzymatic action. Lysis is observed in the epicuticle and exocuticle but not in the endocuticle. By the fourth day, laterally branched hyphae penetrate the endocuticle. These hyphae grow parallel to the endocuticular laminae. They penetrate into the haemocoel about five days after application of conidia. Hyphal bodies are formed by budding from pre-existing hyphae and by abstriction of terminal pegs. The hyphal bodies are short, thick; mostly one to three celled filaments and distinctly nucleated. The blood cells are the first to be invaded, followed by fat lobes, malpighian tubules, muscles, and

Fig. 8.9. *Metarhizium anisopliae*

mesentron. At death of the host larvae, hyphae began to grow outward. *N. rileyi* is known to secrete chitinase, protease, and lipase on the substrate during penetration and growth.

***Metarhizium anisopliae* (Metschnikoff) Sorokin:** *Metarhizium* species, also known as green muscardine fungi, have long been recognized for their biological control potential against arthropods. As early as 1879, fungi from this genus were being evaluated for control of wheat chafer beetles, *Anisoplia austriaca* and sugar beet curculio, *Cleonus punctiventris*, in Ukraine. The species name of the widely researched *Metarhizium* species (*M. anisopliae*) was derived from this beetle. Morphological features for identifying *Metarhizium* species can be imprecise as there can often be overlap of characters among species. Molecular techniques have shown that what used to be called *M. anisopliae* represents a complex of nine species (Bischoff *et al.*, 2009). *M. anisopliae* was isolated from the beetle, *Anisoplia austriaca* by Metchnikoff in 1879. He suggested it be used as a microbial agent against insect pests.

***Verticillium lecanii* (Zimm. Viegas):** *Verticilium lecanii* (which is previously known as *Cephalosporum lecanii*) is a widely spread entomopathogenic fungus. It can also exist as a saprophyte or as a hyperparasite on rust fungi, the mildew and even on other entomopathogenic fungi. In nature *V. lecanii* is spread in the regions of moderate, subtropical and tropical climate. In tropical conditions the infestation of insects occurs regularly. It connects with humidity, which is favourable for fungus development. But in the regions of moderate climate infestation happens rarely, usually in cultivation buildings. *V. lecanii* is a specific parasite and it doesn't constitute danger for plants, entomophages, birds, fish and mammals. Owing to it the fungus is widely used as a component of biological systems in agricultural crop defence. The practical application of biopesticides made on the base of *V. lecanii* was searched on different species of phytophages especially on aphids, mealy bugs, thrips, mites and nematodes. The greatest effectiveness is observed when the fungus is applied for the biological control of whiteflies. The fungus mainly infects larvae of the whitefly and under high humidity it also kills pupae and adult insects. But eggs are not affected. Some strains of the fungus *V. lecanii* are used against agricultural pests such as various aphids and thrips (Pandey *et al.* 2019).

***Paecilomyces* sp:** *Paecilomyces*, is a genus of nematophagous fungus which kills harmful nematodes by pathogenesis, causing disease in the nematodes. Thus, the fungus can be used as a bionematicide to control nematodes by applying to soil. *Paecilomyces lilacinus* (Thorn) Samson, principally infects and assimilates eggs of root-knot and cyst nematodes. The fungus has been the subject of considerable biological control research following its discovery as a

biological control agent in 1979. *Paecilomyces fumosoroseus* (Wize) Brown and Smith (Seryczyńska and Bajan, 1975) (Hyphomycetes) is one of the most important natural enemies of whiteflies worldwide, and causes the sickness called "Yellow Muscardine" (Kim *et al.,* 2002; Pandey Rajesh Kumar 2015). Strong epizootic potential against *Bemisia* and *Trialeurodes* spp. in both greenhouse and open field environments has been reported. *P. lilacinus,* has been considered to have the greatest potential for application as a biocontrol agent in subtropical and tropical agricultural soils.

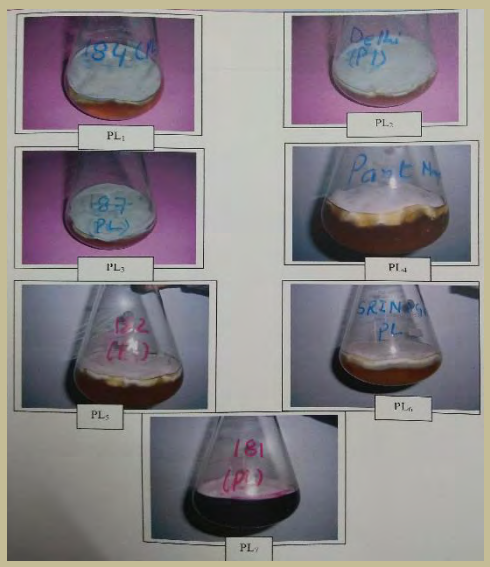


Fig. 8.12

The ability of this fungus to grow extensively over the leaf surface under humid conditions is a characteristic that certainly enhances its ability to spread rapidly through whitefly populations. Natural epizootics of these fungi suppress *B. tabaci* populations. Epizootics caused by *P. fumosoroseus* also lead to substantially reductions in *B. tabaci* populations during or immediately following rainy seasons or even prolonged periods of cool, humid conditions in the field or greenhouse (deFaria and Wraight, 2001). However, in general, epizootics of naturally occurring fungi cannot be relied upon for control. Only a few species of fungi have the capacity to cause high level of mortality and development of natural epizootics which is not only dependent on the environmental conditions, but also influenced by various crop production practices. Also, epizootics often occur after intense injury has already been inflicted by whiteflies (deFaria and Wraight, 2001; Pandey, *et al*. 2011). Kim *et al.*, (2002) reported that *P. fumosoroseus* is best for controlling the nymphs of whitefly. These fungi cover the whitefly's body with mycelial threads and stick them to the underside of the leaves. The nymphs show a "feathery" aspect and are surrounded by mycelia and conidia (Nunez *et al.*, 2008, Rathour, et al. 2007). *P. furiosus* is also used to control mosquito sp. *Culex pipiens* (Sandhu and Mishra, 1994; Singh *et al*. 2013).

**Entomopathogenic nematodes (EPNs):** Entomopathogenic nematodes (EPNs) have been utilized in classical, conservation, and augmentative biological control programs. The vast majority of applied research has focused on their potential as inundatively applied augmentative biological control agents. Extensive research over the past three decades has demonstrated both their successes and failures for control of insect pests of crops, ornamental plants, trees and lawn and turf. The target insects include those from foliar, soil surface, cryptic

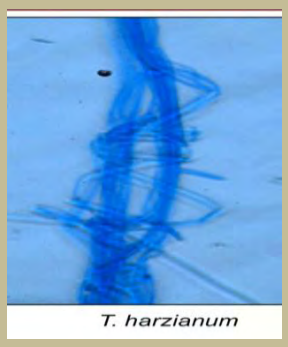
and subterranean habitats. Advances in mass-production and formulation technology of EPNs, the discovery of numerous efficacious isolates/strains, and the desirability of reducing pesticide usage have resulted in a surge of commercial use and development of EPNs.

**Fungal bioagents for the management of foliage and soil borne pathogens in crops:** The term antagonism was coined by Roberts is control of plant pathogens with the help of other micro-organisms. Sanford and Broadfoot (1931) were the first to introduce the term "biological control" and conducted experiments in the biological control of plant pathogens with antagonists. Biological control of plant pathogens is an attractive alternative to the strong dependence of modern agriculture over chemical fungicides, which cause environmental pollution and development of resistant strains (Widyastuti *et al.,* 2003). One factor limiting commercial interest in biocontrol is the high cost of production for most biocontrol agents. This may be due to high cost of substrate, low biomass productivity, or limited economies of scale. The purpose of production is to produce the greatest quantity of efficacious propagules in the shortest period of time. Processes that produce the most propagules are not always those that produce the best type of propagule for formulation or the most efficacious propagules. For some biocontrol agents, we know a great deal about how to manipulate the production medium to induce production of the desired propagules. Large-scale production of *T. harzianum* involves starting the fungus in a commercial medium in shake flasks, then transferring to a proprietary medium in a seed fermentor, before transferring to fermentors up to 4000 L (29). Droby *et al*. (1998) used fermentation with a cheap agricultural and industrial waste material to scale-up production of biocontrol agent for diseases.

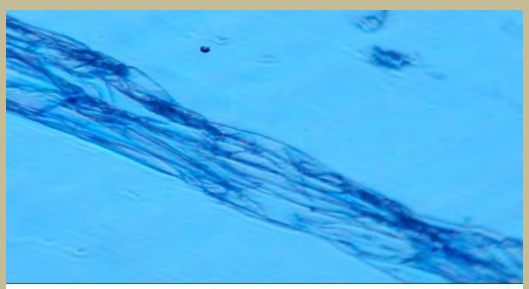
Fungal bioagents have been known to manage soil borne pathogenic fungi particularly wilt causing *Fusarium* spp. infecting a wide range of crops. Out of the fungal bioagents in the present study *Trichoderma* spp. have been selected out which *Trichoderma harzianum* has recently been observed to possess both fungicidal and nematicidal properties (Goswami *et al*. 2005; Pandey 2014).

***Trichoderma spp.*:** *Trichoderma* spp. are among the most frequently isolated soil fungi and present in plant root ecosystems (Harman *et al*., 2004). These fungi are opportunistic, avirulent plant symbionts, and function as parasites and antagonists of many phytopathogenic fungi, thus protecting plants from diseases. Several workers have proved that fungi produced metabolites that are toxic to root-knot nematode. Many others evaluated the species of *Trichoderma* against

various soil borne fungal pathogens. Elad *et al.* (1980) discovered an isolate of *Trichoderma harzianum* capable of lysing mycelia of *Sclerotium rolfsii* and *Rhizoctonia solani* from a soil naturally infested with wilt pathogen. In culture *Trichoderma harzianum* grew better than *Sclerotium rolfsii* and invaded its mycelium under growth conditions adverse to the pathogen (Goswami *et al*. 2005).


T. harzianum

**Myco-parasitism, enzymes and hormones:** *Trichoderma* spp. interacts with plant pathogens in a variety of way. The initial detectable interaction shows that the hyphae of the mycoparasite grow directly towards the host by a chemotropic reaction (Chet and Baker, 1981). When the mycoparasite reaches the host, its hyphae coils around it and penetrates into the host mycelium by partial degradation of its cell wall (Elad *et al*., 1983). It appears that the main mechanism involved in the antagonism to pathogenic fungi by *Trichoderma* spp. is the release of lytic enzymes. The production of extracellular β-1, 3 glucanases, chitinases (Elad *et al*., 1982 &1984) and protinase (Geremia *et al*., 1993) increased significantly when *Trichoderma* is grown in the medium supplemented with either autoclaved mycelium or fungal cell walls. These enzymes play an important role in the destruction of the pathogens (Chet and Baker 1981; Hadar *et al*., 1979). The lytic activity of several strains of *Trichoderma* spp. on cell walls of phytopathogenic fungi was correlated with the degree of biological control of these pathogens *in vitro* (Papavizas, 1985). Harman *et al*. (1993) purified and characterized a 41 KDa endochitinase from the culture filterate of *T. harzianum*. Likewise, Fekete *et al*. (1996) identified a chitinase sequence in *T. harzianum* which showed high level of similarity to a 42 KDa chitinase gene of *T. harzianum*.


T. viride


T. virens

**Antibiosis:** Most *Trichoderma* strains produce volatile and non-volatile toxic metabolites that impede colonization by antagonized microorganisms; among these metabolites, the production of harzianic acid, alamenthicins, tricholin, peptaibols, antibiotics, masssoilactone, 6-pethyl-α-pyron, viridin, gliovirin, gliosoprenins, heptelidic acid and others have been described (Vey *et al.*, 2001). Included in this group are antibiotics, which are natural products able to inhibit microbial growth. Antibiotic production is often well correlated with biocontrol ability, and the application of purified antibiotics was found to show effects on the host pathogen similar to

those obtained by using the corresponding living microbe. Ghisalberti *et al*. (1990) demonstrated that the biocontrol efficacy of *Trichoderma harzianum* isolates against *Gaeumannomyces graminis* var. *tritici* is related to the production of pyrone-like antibiotics. Production of antifungal metabolites has been reported in many other biocontrol agents. *Trichoderma harzianum* is reported to produce larger quantities of fugistatic metabolites like trichodermin (Godtfredsen and Vangedla, 1965), dermadin (Pyke and Dietz, 1966) and trichoviridin (Yamano *et al*., 1970). These compounds exhibit haemolytic and membrane modifying properties. *Trichoderma harzianum* reported to produce trichoarzianines, which are hydrophobic peptides, interact with phospholipid membranes and induce membrane permeability (Merlier *et al.*, 1984, El Hajji *et al.*, 1987).

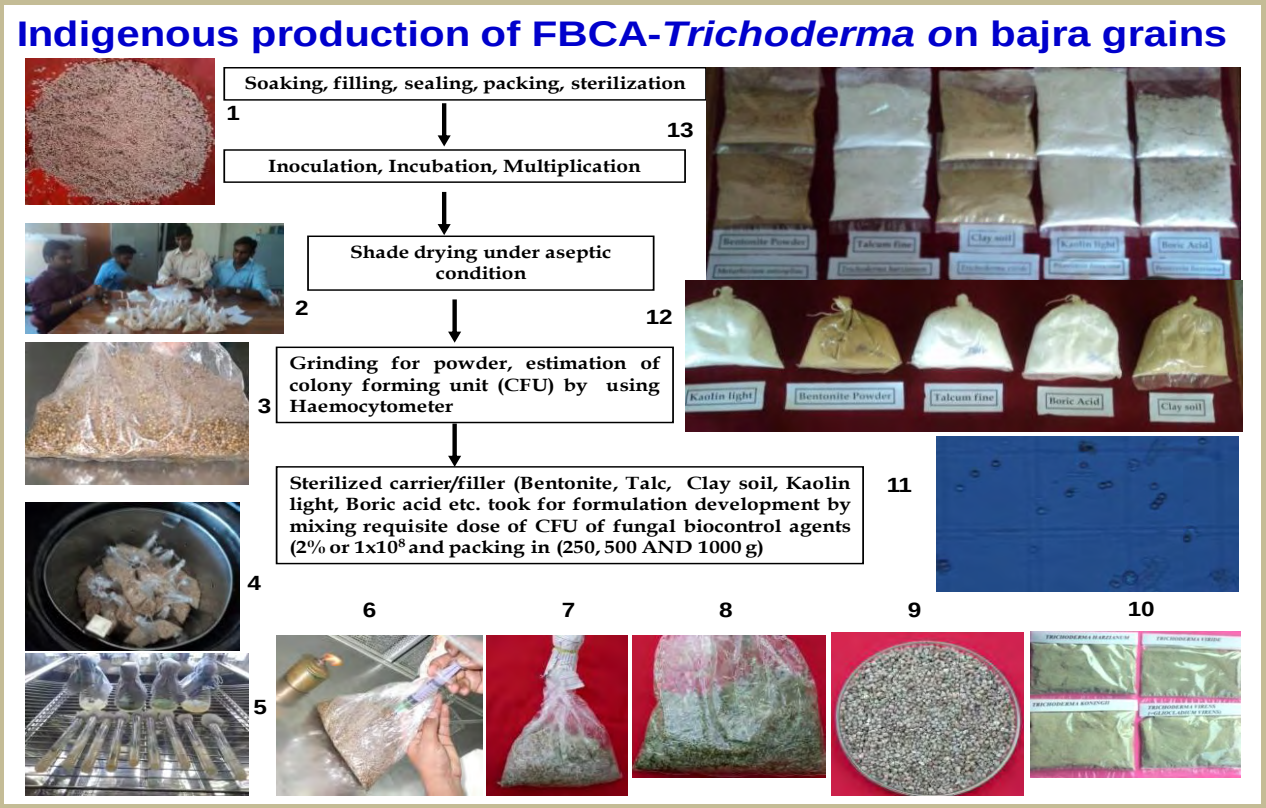
**Volatile compounds:** Hutchinson and Cowan (1972) studied the significant reduction of growth and sporulation of *Aspergillus niger* and *Pestalotia rhododendri* by volatile metabolites released from *Trichoderma harzianum*. Studies on production of volatile compounds of *Trichoderma* spp. by Padmodaya and Reddy (1996) revealed that various isolates of *Trichoderm viride* were equally efficient in reducing the radial growth of the pathogen *Fusarium oxysporum* f. sp. *lycopersici* after three days but *Trichoderma viride* (H) was significantly superior over the other isolates after 7 days.

**Non-volatile compounds:** The inhibition of the growth of *Sclerotium rolfsii* through the non-volatile substances produced by *Trichoderma harzianum* was observed by Upadhyay and Mukhopadhyay (1983). Calvet *et al.* (1990) tested two isolates each of *Trichoderma harzianum* and *Trichoderma aureoviridae* against *Fusarium oxysporum* and *Verticillium dahliae in vitro*. Non-volatile compounds released by both *T. harzianum* growing on cellophane discs over malt agar significantly reduced growth of *F. oxysporum* and *V. dahliae*.

**Production of secondary metabolites:** *Trichoderma* produces a plethora of secondary metabolites with biological activity (Ghisalberti and Sivasitham param, 1991; Sivasithamparam and Ghisalberti, 1998). The term ‘‘secondary metabolite’’ includes a heterogeneous group of chemically different natural compounds possibly related to survival functions for the producing organism, such as competition against other micro- and macroorganisms, symbiosis, metal transport, differentiation, etc. (Demain and Fang, 2000). The production of secondary metabolites by *Trichoderma* spp. is strain dependent and includes antifungal substances belonging to a variety of classes of chemical compounds. They were classified by Ghisalberti and Sivasithamparam (1991) into three categories: (i) volatile antibiotics, i.e. 6-pentyl-a-pyrone (6PP) and most of the isocyanide derivates; (ii) water-soluble

compounds, i.e. heptelidic acid or koningic acid; (iii) peptaibols, which are linear oligopeptides of 12–22 amino acids rich in a-aminoisobutyric acid, N-acetylated at the N-terminus and containing an amino alcohol (Pheol or Trpol) at the C-terminus (Le Doan *et al*., 1986; Rebuffat *et al*., 1989).

**Bioformulation of the antagonistic, *Trichoderma spp.*:** Formulation can affect many aspects of biocontrol performance, shelf life, and safety. Formulation of biocontrol agents has been reviewed recently (Burges 1998; Fravel *et al*. 1998; Warrior *et al*. 2002; Pandey and Goswami, 2005; Pandey *et al*., 2006). A reasonable amount of literature on formulation notwithstanding (Harris and Adkins 1999), many believe that most of the knowledge in this area is proprietary and thus not generally accessible. As with any biological system, three parameters that greatly affect success are water, food, and environment. Water activity can profoundly affect survival




of biocontrol agents in formulations (Connick *et al*. 1996; Pandey *et al*.,2005; Pandey *et al*., 2011). A dry product is less weight to ship and at lower risk of possible contamination.

Hjeljord *et al*. (2000) demonstrated that conidia of *Trichoderma* spp. formulated in commercial products were significantly slower to germinate and colonize senescent strawberry leaves than fresh conidia, even though there was no

difference in germination on laboratory media. Rehydration of microorganisms may require some care.

For field application of a potential fungal bioagent, an inert immobilizing substrate is essentially required which could carry maximum number of propagules of the biocontrol agent with minimum volume and necessarily maintain integrity of the organism. Various carriers viz., peat, seeds, meals kernals, husks, brans, bagasse, farm yard manure, cowdung cake, compost, oil seed cakes, wood bark, vermiculite, sand, clay etc. have been tested to prepare commercial formulations or biopesticides, however, none proved ideal. Backman and Rodriguez-Kabana (1975) prepared commercial formulation of *Trichoderma harzianum* on sterilized granules of diatomaceous earth impregnated in 10% molasses for 4 days. The antagonist remained viable after air drying for upto one month in cold storage.

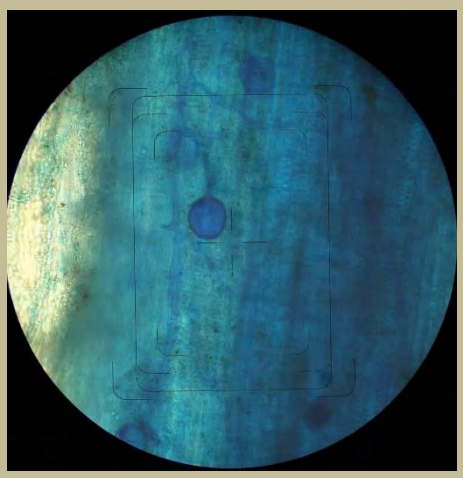
**Organic amendments and Oilseed cake for the management of soil borne disease:**

Linford and Yap (1930) and Linford and Oilveira (1938) were the pioneers to demonstrate reduction in root-knot population by incorporating in soil 50-200 tones/acre of chopped pineapple leaves. Exhaustive work on the application of oil seed cakes for the control of soil borne fungal and plant parasitic nematodes have been done in India. The first investigation on the control of root-knot nematodes with oilcakes was conducted by Singh (1964), Verma (1954).. He reported that neem, mustard and karanj oil seed cake (*Pongamia glabra*) reduced root-knot development on tomato both in pot and field conditions but high dose was required for field conditions. By virtue of augmentation, soil health would attain the health status to help the crops in enhancement of quality and productivity. Amendments of compost and oil seed cake in soil not only play a vital role in improvement of resistance of host plant, it is also playing substantial role as a substrate in augmentation of beneficial microbes as a results conducive soil would convert in to suppressive soil (Pandey *et al*. 2005).

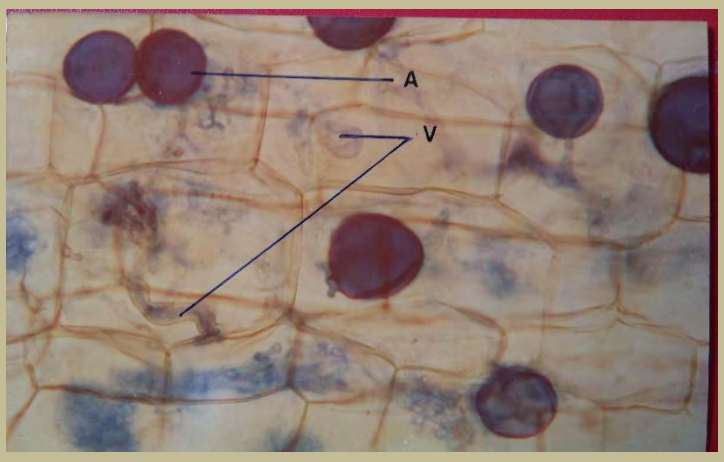
Singh and Sitaramaiah (1966, 1971) found that oilcakes of margosa, castor, peanut, linseed, mustard and majua were capable of reducing root galls when incorporated into infested soil in field plots. The role of oilseed cakes as nematicidal and fungicide with improving the plant, soil and final human health is continuous attempt of plant protectionists to save their crops (Goswami and Swarup, 1971)

**VAM or the management of soil borne fungal pathogens:**

Mycorrhizal roots are functionally longer than non-mycorrhizal ones and thereby they seem to be less susceptible to certain types of pathogenic attack. Therefore, major interest has centered on its relevance in the control of soil-borne diseases, which are otherwise very difficult to control by conventional fungicidal and nematicidal application. The role of VAM fungi in the biological control of plant diseases has been reviewed (Plenchette, 1982; Jalali and Chand, 1988) with particular emphasis on the influence of mycorrhizal fungi on disease incidence and development.



Many reports have presented evidences that plants previously inoculated with fungal symbiont exhibit an increased resistance to fungal root diseases like wilts and root rots (Schenck and Kellam, 1978). Role of VAM in biological control has been established in a number of other soil-borne diseases including root-rot of tomato plants caused by *Fusarium oxysporum* f. sp. *lycopersici* (Caron *et al.*, 1986). Mycorrhizal fungi and plant parasitic nematodes exert a characteristic but opposite effect on plant health (Hussey and Roncadori, 1982). Several reports show that the severity of nematode disease is generally reduced in mycorrhizal plants (Oliveira and



Zambolinn, 1986; Cooper and Grandison, 1987). In several studies, mycorrhizal fungi have been shown to exert an antagonistic influence on the population of plant parasitic nematodes (Kellam and Schenck, 1980).

Mass multiplication of VAM fungi has been fraught with difficulties owing to their obligate dependence on host plants. Hayman (1974) and Kruckelmann (1974) pointed out that the field population of VAM fungi may be manipulated by certain cultural practices such as application of manures and choice of crop management schemes. Gaonker and Sreenivasa (1994) observed a positive influence of locally available organic amendments on the proliferation of *G. fasciculatum* in wheat crop with increase in plant height, shoot biomass and seed yield. They found organic amendments with narrow C: N ratio to have greater influence on VA-mycorrhizal fungi and organic amendments was studied by Sreenivasa (1994). He observed all the organic amendments to increase the proliferation of VAM fungi. Inoculation of *G. macrocarpum* in conjunction with warm caste with a narrow C: N and yield of chilli.

Application *Glomus fasciculatum* as beneficial microbes which are reported as nematicidal and fungicide with improving the plant growth by supplying soluble phosphorus from soil converting non-soluble one and many other mineral and elements. Through establishing a network of mycelium around rhizosphere of root in soil *Glomus fasciculatum* protecting the plant with pathogens and improving the soil and plant health is continuous attempt of rhizosphere biologist to save crops.

**Modules for the application of biopesticide in integration with other safe components:**

In case of transplantable crop-nursery based, as a representative**:**

**A). For Soil-borne diseases –** fungal (wilt, root rot) bacterial (soft rot) and root-knot nematode:

1). At Nursery level:

**a). Soil solarization and Soil treatment/drenching:** Soil solarization for about 4-5 weeks on the ploughed soil covered with the plastic tunnel is better. Drenching of the soil 15-20 days earlier of sowing @4-5 liter of water with concentration of 1.5-2 % of formalin solution per square meter and covered with the plastic sheet. Application of the fungicide like Captan and Thiram which will also kill the pathogens 5-6 gm of any square meter nursery area. Furadon, Heptachlor are some insecticides which is mixed in the dry soil @4-5 gm/$m^2$ and should be mixed up to the depth of 15-20 cm for nursery preparation.

Supply of the hot steam at least 4 hours continuously under the covered polythene sheet and allow the soil for the seed bed preparation. For this, organic amendment with neem oil seed cake @500g/$m^2$ and + 200g VAM/$m^2$ were done 10 days prior to sowing followed by constant watering for decomposition while at sowing, fungal bioagents@100g//$m^2$ (*Trichoderma viride*@50g/$m^2$ /acre + *Paecilomyces lilacinus*@50g/$m^2$) were applied.

b). Seed priming/ treatments: Protection of spermosphere is utmost concern of nursery growers of agricultural crops due to high cost of seeds. For seed priming/seed treatments, dust based formulation would be more appropriate and effective to manage the soil borne disease which are known to hamper the seed germination and seedling growth. Use of biocontrol agents @8-15g/kg seeds would be very effective for seed treatments (Goswami, *et al*. 2007).


c). Foliar spray with a mixture of fungal bioagents 50g in 5 liter/ $m^2$ (*Trichoderma viride* @250g + *Beauveria bassiana*@250g) and drenching of neem oil seed cake/neem seed kernel @500g + 200g VAM/$m^2$ on soil should be done with first spray after two week after sowing followed 3 more sprays at intervals of 5 days.

2). Bare root dip treatment/drenching: At transplantation healthy seedlings, subjecting them to bare root dip treatment for 30 to 60 minutes in a sticker containing solution of fungal biocontrol agents (*Trichoderma* sp.@15g/lit. + *P. lilacinus*@15g/lit.).

3). Transplantation of seedlings to the 'hot spots' on ridges prior to which spreading of farm yard manure (FYM) and vermin-compost with deep ploughing followed by application of a mixture of fungal bioagents @1kg (*Trichoderma viride* @500g/acre + *Paecilomyces lilacinus* @500g/acre) grown on sorghum grains or talc based + 25 kg summer solarized Farm Yard Manure + 10 kg neem oilseed cake/acre + 2kg VAM/acre applied (Goswami, *et al*. 2006) as soil treatment in spot of transplantation or furrows.

B). Foliar treatment/drenching of crops for diseases (blight, Cercospora & leaf curl) and insect pests (beetle, thrips, white fly, diamond moth etc.) should be done by:

- Foliar spray with a mixture of fungal bioagents 1kg in 200 liter/acre (*Trichoderma viride* @500g + *Beauveria bassiana*@500g) and drenching of neem oil seed cake@10 kg + 200g VAM/acre should be done at a 12 days of transplantation followed 4-6 more sprays at intervals of 10 days.

In case of directly seeded crops- okra, cucurbits, leafy vegetables etc: Okra as a representative,

A). For Soil-borne diseases - wilt, rot fungi, termites and root-knot nematode:

Seed treatment: For this, fungal bioagents grown on sorghum grains *T. viride* @ 50g/kg + *P. lilacinus* @50g/kg were dissolved in mixture of 1 liter fresh water, 50g jaggery as a sticker and 100g neem oilseed cake. Prior to sowing, seeds were mixed in above solution followed by shade drying.

Soil treatment/drenching: For this, organic amendment with neem oil seed cake @50kg/acre was done 10 days prior to sowing followed by constant watering for decomposition while at sowing, fungal bioagents (*T. viride* @500g/acre + *P. lilacinus* @500g/acre) and 2kg VAM/acre were applied (Shakil *et al*. 2008)

B). Foliar part of crops for diseases (blight, Cercospora & mosaic) and insect pests (beetle, white fly, moth) is to be done before the time of attack of diseases on foliar part by foliar spray with a mixture of fungal bioagents 4kg in 200 liter/acre (*T. viride* @2kg + *B. bassiana*@2kg) and neem oil seed cake @10 kg was done with first spray after a week of germination followed 4 more sprays at intervals of 10 days.

**Conclusion:**

Above mentioned package and practices require special emphasis and must be popularized in order to utilize their potential to combat many diseases and pests and also increasing in production, productivity, quality of vegetable crops for doubling of income of vegetable growers. Utilization of above protocol and package would greatly help in nurturing the seeds sown in nursery and nursery seedlings.

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# Chapter -9

## Hardening, Packaging and Marketing of Vegetable Seedlings

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Hardening is the process of altering the quality of plant growth to withstand changes in environmental conditions that occur when plants are transferred from a greenhouse or nursery to the main field. A severe retardation in growth may occur if plants produced in the nursery are planted outdoors without undergoing a transition period. Hardening is less critical for crops planted later in the season than for early crops when adverse climatic conditions can be expected. Hardening is accomplished by gradually lowering temperatures and relative humidity while also reducing water. This results in an accumulation of carbohydrates and a thickening of cell walls. The change from a soft, succulent type of growth to a firmer, harder type of growth is desired. Hardening should be started at least two weeks before planting in the main field. After proper hardening, however, they can be planted outdoors as bright light will not damage them. When hardening vine crops, tomatoes, peppers, or eggplants, do not lower temperature more than 3°C below the recommended minimum growing temperatures. Low temperature causes chilling that can injure plants and delay the growth after transplanting in the main field. Do not harden rosette vegetables (e.g. endive, escarole, celery) by lowering the temperature because low temperature exposure increases early bolting. Hardening off times depends on the type of plants, temperature and temperature fluctuations. Generally two methods are followed for hardening of vegetable seedlings.

**1. Gradual longer periods of time outdoors**

a) Begin 7 - 10 days before transplanting date.
b) Place the seedlings in a sheltered, shady spot outdoors. Leave them for 3-4 hours and gradually increase the time spent outside by 1-2 hours per day.
c) Bring the seedlings back indoors each night.
d) After 2-3 days, move the seedlings into morning sun and return them to the shade before the noon.

e) After 7 days, the seedlings should be able to stand and bear sun for the entire day and stay out at night, if temperatures stay around 10° C. Keep an eye out that the soil doesn't dry and bake the seedlings, if the weather is warm.
f) After 7 -10 day seedlings are ready to transplant. Transplanting is carried out in evening time or on a cloudy day or and proper watering is must after transplanting.

**2. Lowering down the temperature:** Lowering down the temperature also enhances the hardiness in seedlings of cool season vegetable crops. So, gradually exposing the seedlings to low temperature imparts hardening plant tissues which will helps in surviving the chilling night temperature.

**3. Withholding of irrigation:** Allowing seedlings to temporary wilting has the same effect as gradually exposing them to harsh environmental condition.

a) Starting about 2 weeks before transplanting date, don't wateringthe seedlings until they begin to show the signs of temporary wilting.
b) At this stage, irrigate normally, and again wait for them to show symptoms of temporary wilting again.
c) After 2 weeks of this process, seedlings should be ready to transplant. Try to do so on a cloudy day and be sure to water well after planting.

**4. Use of plant growth regulators (PGR) for hardening of transplants:** PGR's are the organic compounds which regulates the growth and development of plants. Some PGR responsible for controlling plant height, enhances green leaves, reduce water use and disease suppression. Precautions to be taken as the spray should be uniform on whole plant otherwise plant will grow non-uniformly. Spray should be done either early in the morning or in late evening, if spray during noon it should be under shady place. Paclobutrazol (Cultar) and Gibberellins are used for this purpose. By spraying of 2000 ppm of cycocel also helps in hardening of seedlings. In melons in order to improve the quality of melon seedlings and their growth after transplanting, a low concentration of 10mg $lit^{-1}$PBZ hardening procedure at an early growth stage i.e., "first true leaf stage"can be followed.

**5. Mechanical hardening of transplants:** Generally mechanical hardening reduced plant height and root mass but increase stem diameter and forms a more compact and stronger plant, but it also lead to delayed flowering and reduction in flower number as observed in *Brassica napus*. To improve the growth and quality of melon seedlings after transplanting a low intensity brushing of 10 strokes per min at an early growth stage can be given.

**Packing and transportation of seedlings**

**1. Packing:** It is defined as placing the seedlings into a suitable container like plastic crates etc., for maintaining their viability and vitality during storage and transportation. The seedlings should not be exposed to speedy wind, so it should be placed properly in container and container are placed either in single layer or double layer. Packing and transport of nursery material is to be done from time to time. Emphasis should be given on packaging while transporting seedlings over a longer distance. To have a better price of the products, a nurserygrower should pay high attention to the packing of the planting material.

**Materials used for packing**

| | |
|---|---|
| Hessian cloth | Made from the good quality jute fibers. |
| Sacking cloth | Made from the raw grade jute fibers. |
| Plastics | Low & high density polyethylene, polypropylene, nylon. |
| Paddy and wheat straw | For wrapping the earthen ball of the seedlings |
| Sphagnum moss | For wrapping the earthen ball of the seedlings |
| Dried Grass | For wrapping the earthen ball of the seedlings |
| Moistened moss grass | For wrapping vegetable seedlings before packing. |
| Bamboo-Matted Boxes | For storage of bulbs, tubers and corms |

**Transportation of seedlings:** The plants must be picked up the day they were received by the transport agency. These agencies do not have proper seedling storage facilities and thus the seedlings deteriorate rapidly in these conditions. The interval between receiving the seedling from transport and planting them should be minimized, ideally 24 to 72 hours. Seedlings must be transported in an enclosed vehicle. If there is no option to an open back vehicle the seedlings must be covered with a tarpaulin. This will keep seedling packages out of direct sun and protect them from drying in the wind. While transporting seedlings, never park the vehicle in the direct sun. Even in the boxes or bales seedlings can heat up to damaging temperatures in the sun. Do not throw or drop the boxes and bales. The seedlings can be damaged from bruising.

**Care of seedlings:** After arrival of the seedlings from transportation, they must be kept in cool, shady place so that they lose the heat absorbed during the transit. The label indicating the variety, number of plants packed, etc. must be confirmed. The leaves and roots must be kept moist by sprinkling water. Storage of the plants at field condition must be avoided. Seedlings should not be stored for too long before planting.

**References**:

Cipollini, D.F. (1999). Cost to flowering of the production of a mechanically hardened phenotype in *Brassica napus* L. *Int. J. Plant Sci*., 160 (4):735-741.

Ayastuy M.E., Hernández, L.F., Rodríguez, R.A., Fernández, J.A. and Cantamutto, M.A. (2011).Field performance of melon seedlings hardened by brushing or with paclobutrazol. *Acta Hort*., 898:299-306.

# Chapter -10

## Nanotechnology for Quality Transplants and Vegetable Production

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Agriculture is the sole source of food apart from roles in growth and development of the nation. To feeds the healthy foods for a rapidly growing population it needs to increase the production and productivity with quality of all agriculture produces including vegetables and fruit crops. With advancement of science and technology, it has given innumerable tools and technology such as biotechnology, nanotechnology and nano-biotechnolgy for the crop improvement conjunction with operational basic hand tools. Here nanotechnology is the playing most important tools for development of modern agriculture with increasing the sources of income in next future. However this area is not new for human, it goes back to the Mesopotamia civilization where nanoparticles used for generate a glittering effect on the surface of pots even though it is small things. It is coming now top field after the IT and Internet. Even Indian government has already started nanoscience and nanotechnology initiatives and various funding agencies like the Department of Science and Technology.

Nanotechnology is a part of technology about the control of matter on the atomic and molecular scale. The term nano comes from the Greek word “nanos” means “dwarf”. The standard size of nanoparticles is about 1 to 100 nm. However, practically some nanoparticles may be about 500 or 1000 nm in size. In relation to horticultural crops nanotechnology is playing pivotal roles to maintain the healthy and quality horticulture produces in different horizons starting with increasing the shelf life, packaging, transporting, labelling and reduce pesticide use to vegetables produces besides removing residual pesticide and bacterial contamination, act as a agrochemical agents and improve crop productivity with new delivery mechanisms.

**Definition**

It is a branch of technology that deals with design, production, characterizations, and

application of *structures, devices, and systems by controlled manipulation of size and shape at the* nanoscale dimensions to produce desired product for human welfare is called nanotechnology. For examples carbon nanotube, titanium nano flower and silver nano tube aerosol, fogs, virus and DNA diameter etc. all are comes in nano range scale etc.

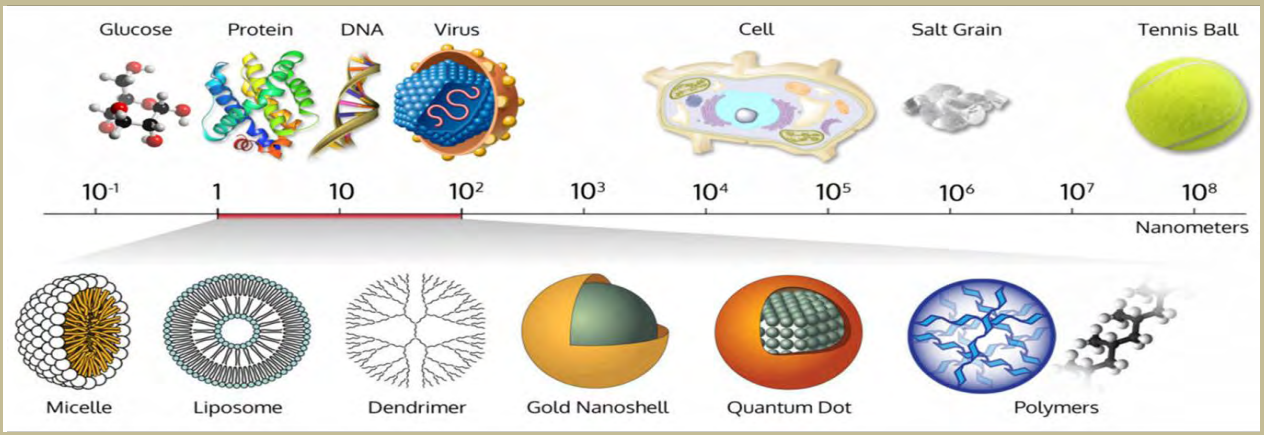


**Figure.1: Range of nanoparticles with examples**

Source: https://www.wichlab.com/nanometer-scale-comparison-nanoparticle-size-comparison-nanotechnology-chart-ruler-2/.

**Concepts**: Richard Feynman is the called of founding father of nanotechnology, through his famous lecture, There's plenty of room at the bottom. However the term of nanotechnology was coined by Norio Tanguchi and according to him Nanotechnology is ability to engineer materials precisely at the scale of nanometre.

Richard Feynman

Source:https://www.google.com/search?q=Richard+Feynmans.

Norio Tanguchi

Source : https://www.google.com/search?q=norio+taniguchi.

**History of Nanoparticle Research**: The history of nanoparticle research is not new; it was known that the use of nanoparticles dates back to the 9th century in Mesopotamia when artisans used silver and copper nanoparticles to generate a glittering effect on the surface of pots. Michael Faraday provided the first description, in scientific terms, of the optical properties of

nanometre-scale metals in his 1857 paper. In 1980 K. Eric Drexler established the department of molecular nano technology.

| | |
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| A representative picture of Mesopotamia civilization where artisans used to silver and copper nanoparticles to generate a glittering effect on the surface of pots. The lustre can still be visible if the film has resisted atmospheric oxidation and other weathering which contained dispersed homogeneously glassy matrix of the ceramic glaze. |  <br>Mesopotamia Civilization<br>Source: www.google.com/search?q=mesopotamia. |

Michael Faraday

Source : https://en.wikipedia.org/wiki/Michael_Faraday.

K. Eric Drexler

Source : https://www.google.com/search?rlz=1C1CAFB_enIN793IN793&q=K.+Eric+Drexler.

**Synthesis (Formulation) of nanoparticles :** There are two main approaches for the synthesis of nanoparticles the first one is called top-down approach (Comminution, emulsification, high pressure homogenization etc.) and another is bottom-up approach (figure.2). (the sol-gel process, nanoprecipitation and coacervation etc.)

In comminution (the pulverization of materials), such as through industrial milling or natural weathering; by pyrolysis (incineration); or by sol-gel synthesis (the generation of inorganic materials from a colloidal suspension) is known. Examples of those three processes (comminution, pyrolysis, and sol-gel synthesis) include the production of titanic nanoparticles for sunscreens from the minerals anatase and rutile, the production of fullerenes or fumed silica (not to be confused with silica fume, which is a different product), and the production

of synthetic (or Stöber) silica, of other "engineered" oxide nanoparticles, and of quantum dots. For the generation of small nanoparticles, comminution is a very inefficient process.

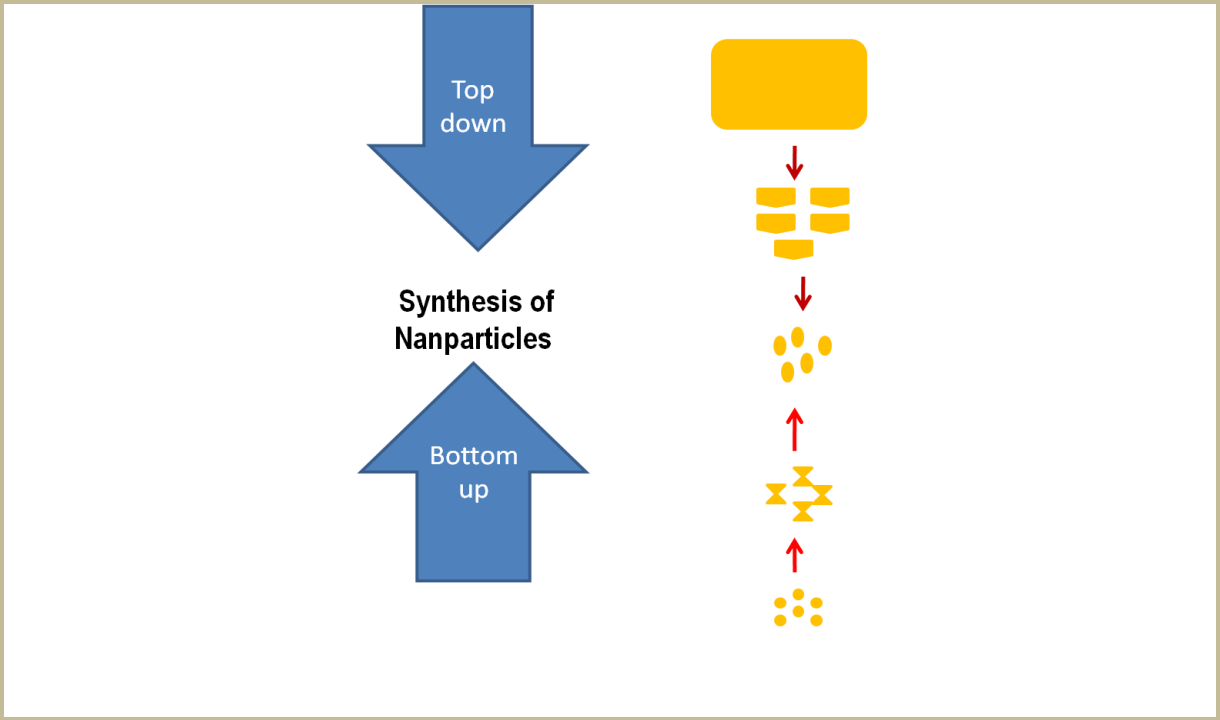


Figure.2: Schematic illustration of the preparative methods of nanoparticles

***Tools and techniques***

The detection and characterization of nanoparticles is challenges job being smaller in size and they are observable under optical microscopes only. Therefore specialized techniques are required to see the nanoparticles such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM). Those techniques can image nanoparticles, directly measure sizes, and infer shape information, but they are limited to studying only a few particles at a time. In general, however, those techniques can be quite effective for obtaining basic information about a nanoparticle.

**Scanning Tunnelling Microscope (STM)**

Scanning Tunnelling Microscope (STM) is used for imaging surfaces at the atomic level. This method can be used in different modes like air, water, high vacuum, liquid and gas.

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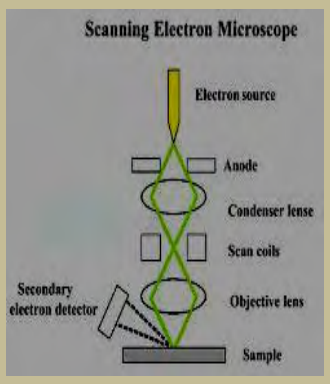
| The lateral resolution of an STM lies around 0.1 nanometre and depth resolution lies around 0.01 nanometre. This measure is more than enough to manipulate a good image. It can also be used in very high and low temperatures. |  <br>  <br>Source:<br>https://www.google.com/search?q=Scanning+Tunnelling+Microscope+(STM). |

Transmission Electron Microscope (TEM): It is a microscopy technique in which a beam of electrons is transmitted through a specimen to form an image. The specimen is most often an ultrathin section less than 100 nm thick or a suspension on a grid. An image is formed from the interaction of the electrons with the sample as the beam is transmitted through the specimen.

| | |
|---|---|
| The resolution of TEM is very high which is about 0.22 nm and information limit of about is about 0.16 nm. TEM instruments boast an enormous array of operating modes including conventional imaging. |  |

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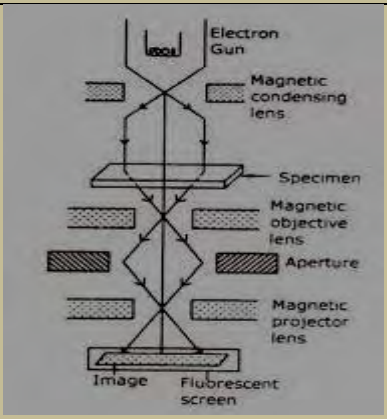
| |  <br>Source : https://www.google.com/search?q=Transmission+Electron+Microscope+(TEM). |

**Atomic Force Microscope (AFM)**

Atomic force microscopy (AFM) is also known as Scanning force microscopy (SFM). This device is used to visualizing, imaging, taking measures and for manipulating objects that are in nanometre scale. The AFM was developed in the year 1986 by Binnig, Quate and Gerber at the IBM Research – Zurich and earned them the Nobel Prize for Physics for the same year. A highly accurate scanning procedure then takes place, through which the corresponding electronic signals are generated using piezoelectric materials.

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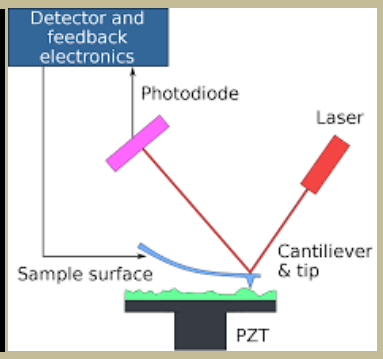
| The resolution of such a device is said to be in the order of fractions of a nanometre. The earlier version of the AFM was called the Scanning Tunneling Microscope, developed in the early 1980's. |   <br>Source: https://www.google.com/search?q=https%3A%2F%2Fwww.Atomic+Force+Microscope+(AFM). |

**Important properties of nanoparticles**

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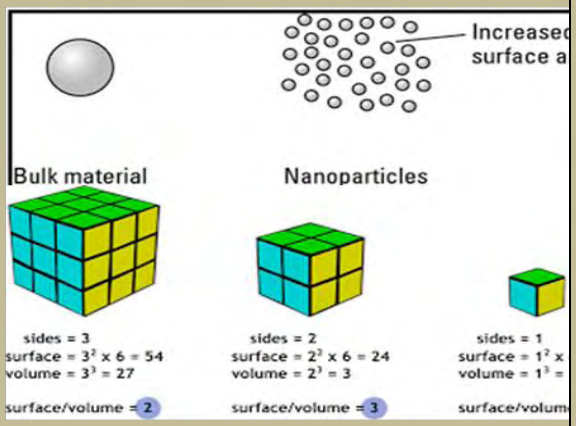
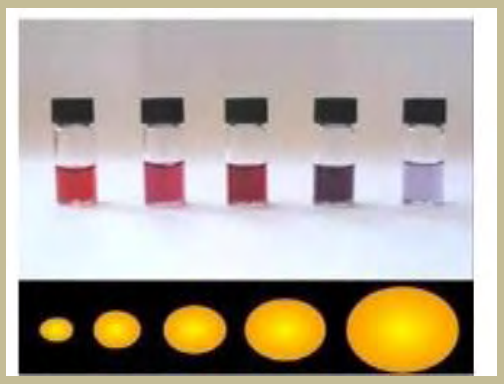
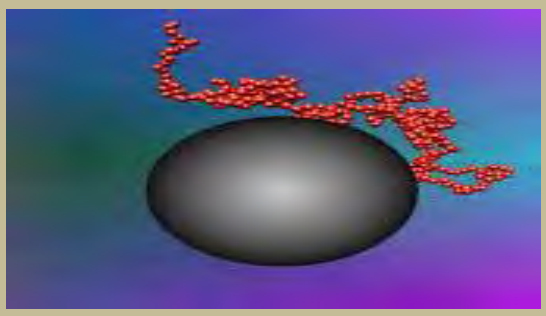
|---|---|
| 1. First, nonmaterial have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties. |  <br>Source : https://www.google.com/search?q=nonmaterial+have+a+relatively+larger+surface+are. |
| 2.It has high surface energy, spatial confinement, and reduced imperfections |  <br>Source : https://www.google.com/search?q=Nanoparticles+high+surface+energy%2C+spatial+confinement%2C+and+reduced+imperfections. |
| 3. It exhibits quantum effects: can begin to dominate the behaviour of matter at the nanoscale particularly at the lower end – affecting the optical, electrical and magnetic behavior of materials. Materials can be produced that are nanoscale in one dimension (for example, nanowires, nanorods and nanotubes), in two dimensions (plate-like shapes like nanocoatings, nanolayers, and graphene) or in all three dimensions |  <br>Source: https://www.google.com/search?q=nanoparticles+exhibits+quantum+effects. |

| | |
|---|---|
| 4.It show high range of free movability |  <br>Source: https://www.google.com/search?q=Nanoparticles+show+high+range+of+free+mobility. |

**Types of nanoparticles:** They can exist in single, fused, aggregated or agglomerated forms with spherical, tubular, and irregular shapes. Common types of nanomaterials include nanotubes, dendrimers, and quantum dots and fullerenes. Nanomaterials can be classified primarily into two types: Natural ones and artificially fabricated ones. Examples of Nanomaterials Nanomaterials (such as gold, carbon, metals, Meta oxides and alloys) have with variety of morphologies and shapes some are depicted in figure. 3.

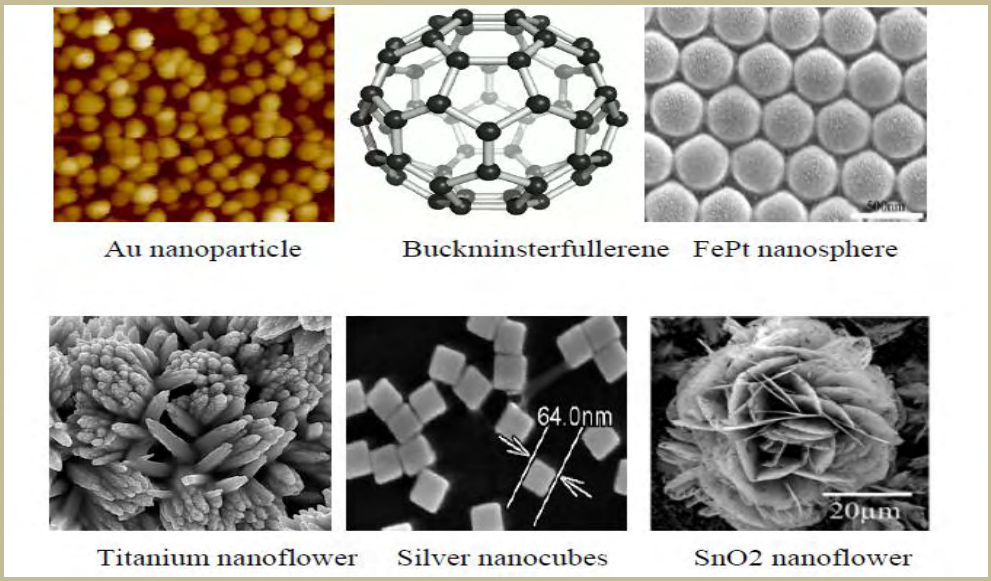



Figure.3: Nanomaterials with a variety of morphologies

Source: www.google.com/search?q=Nanomaterials+with+a+variety+of+morphologies.

**Natural nanomaterials:** These include nanomaterials that exist in biological systems; eg: viruses (capsid), substances in our bone matrix, butterfly wing scales, milk, blood etc.

**Artificial nanomaterials:** Second ones are artificial/synthetic nanomaterials e.g. carbon based nanomaterials fullerene, carbon nanotubes, graphene , graphene oxide, graphene quantum dots

etc. According to Siegel, (On the basis of applications) these materials can be categorized as functional materials (at least one dimension is in nanometre range and have very specific properties in comparison to raw material) and non functional materials.0 D - 0 dimensional nanomaterials which have all the 3 dimensions in nano scale range eg. Spheres and clusters. (0D nonmaterial means all the dimensions are measured within the nanoscale range i.e within 100 nm range)1 D - 1 dimensional nanomaterial which has any 1 out of 3 dimensions in nano scale range eg. Surface films. 2 D - 2 dimensional nanomaterials which have any 2 out of 3 dimensions in nano scale range (eg. strands or fibres). 3 D - Formed by arrangement of multiple 0D, 1D or 2D materials forming 3D structure.Three dimensional nanostructures (eg. particles) in figure 2. Nanomaterials are materials which are characterized by an ultra fine grain size (< 50 nm) or by a dimensionality limited to 50 nm.

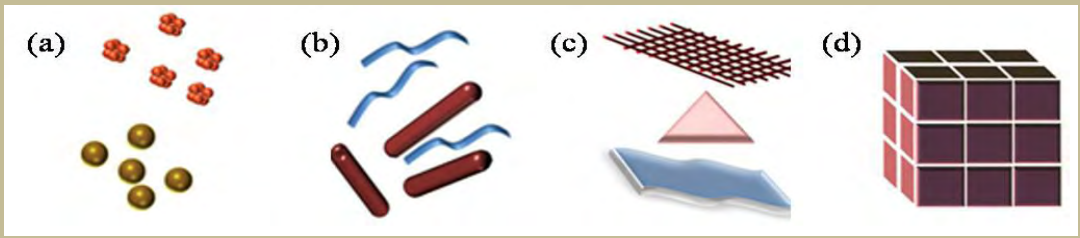



Figure. 4: Classification of Nanomaterials (a) 0D spheres and clusters, (b) 1D nanofibers, wires, and rods, (c) 2D films, plates, and networks, (d) 3D nanomaterials

Source:www.google.com/search?q=According+to+Siegel%2C+(On+the+basis+of+applications)these+materials+can+be+categorized+as+functional+0+D++0+dimensional+nanomaterials.

**How to use and potential entry points of nanofertilizer into plants**

There are mainly two ways of application of nano-fertilizer the one is foliar spraying and another is adding the nano-fertilizer in root zone as depicted in figure.5. Therefore nanomaterils are entering in plant either through the root zone or via the leaves and stem pores. It has been shown that when the nanomaterils enter the plant through outer protective layers it is mobilize either apoplastic and symplastic pathways. Apoplastic transport occurs outside the plasma membrane through the cell wall i.e. the through cell walls however the symplastic movements involve the transport of water and solutes between the cytoplasm of adjacent cells i.e. through the cytoplasm. Thereupon nanoparticles may subsequent internalize preferentially by endocytosis. When the NPs present in cytoplasm, cell to cell movements of are facilitated by plasmodesmata. Finally small particles can reach the xylem and phloem and it can translocate in the different tissues and organs of whole plant.

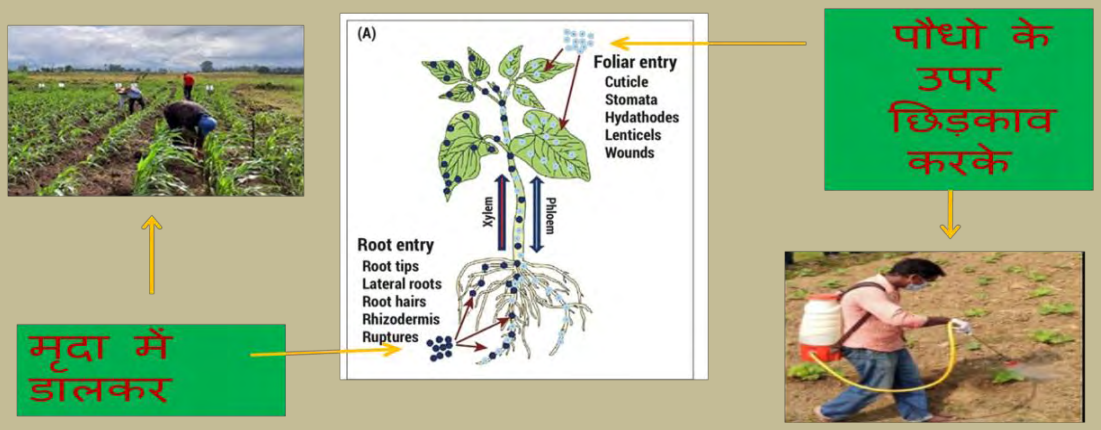



Figure. 5: Methods of nanoparticles applications

Source: http://www.indiancooperative.com/iffco/farmers-begin-using-nano-fertilizers-with-encouraging-results/ and http://www.pcaarrd.dost.gov.ph/home/portal/index.php/quick-information-dispatch/3647-fertigroe-nanofertilizers-help-reduce-amount-of-fertilizer-application.

**Nanoparticles for seed germination (As a quality Nursery transplanting materials)**

As we know that seed is a very important factor to ensure the crop productivity and for quality nursery management to gets quality transplanting materials beside it is basic and primary input of agriculture. Therefore, it is advisable to use quality and healthy seeds to ensure good germination. Even sometimes we are not sure about getting good germination because of factors related to moisture, viability of seeds and high amount of negative regulator regarding the abscisic acids. In this conjucture the use of nanoparticles to enhance the seeds germination could be one possible solution toward the ensure the good germination. Here we have shown that the copper oxide nanoparticles can enhance the seed germination of okra or lady finger (*Abelmoschus esculantum*) seeds. The protocol we follow here as mention below in detail:

First we prepared the sufficient amount of copper oxide nanoparticles by using our own developed protocol (unpublished data) and taken the sample material for example here we have taken okra seeds in clean wicker or in petriplate accordingly to our convenient. Added the sufficient amount of nanoparticles solution in same wicker and uniformly mixed the seeds through proper swirling the sample. Leave the nanoparticles treated seeds for overnight at room temperature without disturbing the same in absence of light. Next day morning before starting the sowing or related to any experiment removes the residual nanoparticles. Here we have shown that observed okra seed germination after two days of treatment of nanoparticles and

observed phenotype depicted in figure.6 treated versus non-treated nanoparticles in petriplate.

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| Observed phenotype of Copper oxide treated nanoparticles: Here we observed increasing in the seed germination in okra. |  Non-treated Nanoparticles Treated Nanoparticles |

Figure. 6: Observed phenotype of Copper oxide treated nanoparticles

**Applications of nanoparticles for quality vegetables**

In the agricultural sector, nanotech research and development has profound effect development however some important use of nanotechnology mentions below:

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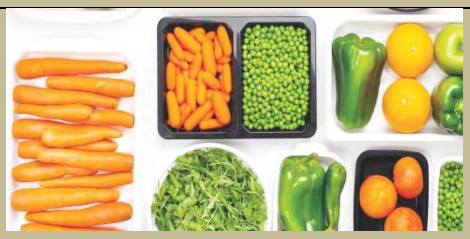
| Nanoparticles use in protection of Sugar beet vegetables as a anti-microbial activities. A University of Toronto graduate school project is now extending the life of widely used crop protection products. Vive Crop Protection's trademarked Allosperse Delivery System uses nanotechnology to create new application methods for existing biological and conventional crop protection products. |  Source : https://farmtario.com/crops/nanotechnology-breathing-new-life-into-existing-crop-protection-products/. |
| Nanoparticles extended the shelf-life of vegetables by injecting with Syringe. |  Source: https://www.whatech.com/market-research/food-beverage/641017-new-study-explores-excellent-growth-of-food-nanotechnology-market-2020-with-new-business-opportunities-and-key-players. |

| | |
|---|---|
| It is inreasing the anti-oxidant properties of different vegetables. |  Source : https://www.intechopen.com/books/functional-food-improve-health-through-adequate-food/the-role-of-legumes-in-human-nutrition. |
| It is use in increasing the yield of cucumber vegetables. |  Source : https://blog.teamtrade.cz/nanotechnology-improves-greenhouse-growing/. |
| Nanotechnology used in transporting of vegetables from one place to other as nanoparticles based packing boxes. |  Source: https://www.thebetterindia.com/223668/bengaluru-startup-log9-coronaoven-covid19-innovation-disinfection-chamber-india-nor41/. |
| It is use in increasing the size of different vegetables. |   Source : https://pl.pinterest.com/gcelichowski/nano/. |

| | |
|---|---|
| Nanostruted polycarbonate green house (called green house-nano) increasing the size of tomatoes about 30% percent more. |  Source: https://blog.teamtrade.cz/nanotechnology-improves-greenhouse-growing/. |
| Nanoparticles use in increasing the food safety by using nano-based solutions in the food packaging industry. |  Source: https://nano-magazine.com/news/2019/2/20/study-says-consumers-prefer-nanotechnology-in-active-food-packaging. |
| Nanoparticles improved the freshness of vegetables crops beside reduced the food waste. |  Source: http://gonano-project.eu/nanotech-developments-in-the-food-sector/. |
| It is use in increasing the self-life of cucumbers. |  Source : https://www.researchgate.net/publication/331944127_Nanotechnology_-_A_shelf_life_extension_strategy_for_fruits_and_vegetables. |

| | |
|---|---|
| The application of nanoparticles improved the freshness of vegetables by the minimal processing methodology. |  <br>Source : https://www.researchgate.net/publication/327333235_Application_of_edible_coatings_on_fresh_and_minimally_processed_vegetables_a_review. |
| The use of nanoparticles increases the nutrient content, growth and as well as antioxidant properties. |  <br>Source : https://northdallasgazette.com/2015/11/20/nanoparticles-give-tomatoes-more-antioxidants/. |
| Nanotechnology being used in plastic for food packing finally makes its stronger, lighter and performs better after packaging. |  <br>Source::https://www.magzter.com/article/Technology/Food-Marketing-Technology-India/Nanotechnology-Redefining-Beverage-Packaging-Industry. |
| Vegetable Cleanse: NANO CLEANING SUSPENSION comprising clay mineral nanoparticles complemented by two liquid ingredients, for eliminating unwanted pesticides and bacteria. Collectively confer exceptional capacities in favour of efficaciously cleansing fruit and vegetable produce. |  <br>Source : https://www.taylorfrancis.com/books/e/9781351046312/chapters/10.1201/9781351046312-16. |

| | |
|---|---|
| A researcher from the Sultan Qaboos University (SQU) has invented a nanocomposite anti-microbial packaging that extends the shelf- life of okra. |  Source: https://www.omanobserver.om/oman-researchers-tech-gives-veggies-long-shelf-life/. |
| Nanoparticles use in increasing the size of chilly vegetable. |  Source:https://katanaproject.eu/future-trends/nanotechnology/. |

**Scope of Nanotechnology**

It is an emerging area and engages almost every technical discipline from basic sciences to applied science. The job searches such as students */farmers/educationalist can work in the following areas of nanotechnology as follows:*

i. It is rapidly expanding area of research in agriculture

ii. It can be used across all the basic science fields, such as chemistry, biology and physics

iii. It can be used in materials science, engineering sciences and microscopic sensors

iv. It is one of the top ranked subject related to academic and research.

v. It provide technological solutions in the field of energy

vi. It has huge potential to solve our problems in environment sciences.

vii. Aspirants can create their career in this field to pursue higher studies

viii. One can find job as nanotechnologists in the specialists or scientists.

ix. Job opportunities are also available in National Physical Laboratory and Astrophysics

x. Candidates with Ph.D can also join as faculty members in Universities fields.

## Conclusion and future prospective

Nanotechnology is an emerging technology in the field of agricultural besides the comfort the human life, although it is not new technology. As we have seen its wide applicability in the arena of agriculture starting from food packaging industry to nutrient delivery. Although researchers have reported many merits of nonmaterial such as packaging in terms of product quality, processing attributes and prolonged storage duration namely, food processing, food additive delivery systems, fruit and vegetable packaging besides discussing their antimicrobial barrier and coating properties.etc. Nevertheless, steps should be taken to ensure its usage keeping in view consumer acceptability and safety.

Appropriate labelling and adherence to ensure safety and efficacy. Nanotechnology is quickly making its own niche in processing and packaging of food products. No harmful effects have been reported till date. Still these applications are largely intended to address some of the limitations such as fine-tunne uses of nanoparticles for micro-management of soils beside the its judicious manageability .Therefore it needs intensive integrative research approach for full exploitation of nanotechnology in the field of agriculture with minimum inputs to reach the every corner of nation and each door of farmers.

**For further reading**


1. https://www.wichlab.com/nanometer-scale-comparison-nanoparticle-size-comparison-nanotechnology-chart-ruler-2/.

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# Disclaimer

- *Mention of specific products by registered name does not constitute endorsement or recommendation. It is for the purpose of illustration only. Where possible, metric and non-metric equivalent measurements are provided.*
- *The author of this bulletin advises that growers carefully read labels for instructions before applying pesticides, herbicides and fertilizers.*
- *The views expressed herein are those of authors and can therefore in no way be taken to reflect the official opinion of RLBCAU, Jhansi- 284 003*

# उद्यान एवं वानिकी महाविद्यालय

## रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय झाँसी – 284003

पौधषाला प्रबंधन एवं सब्जियों की गुणवत्ता युक्त पौध उत्पादन

पर

ऑनलाइन प्रशिक्षण कार्यक्रम

### उद्घाटन सत्र

मुख्य अतिथि

**प्रो. अरविन्द कुमार,** मा. कुलपति,
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

मुख्य संबोधन

**डॉ. आर के तिवारी,** निदेशक,
केन्द्रीय कृषि वानिकी अनुसंधान संस्थान, झाँसी

स्वागत संबोधन

**डॉ. ए.के.पाण्डे**
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

विशेष संबोधन

**डॉ. निशी राय**
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धन्यवाद ज्ञापन

**डॉ. सती शंकर सिंह**
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

### तकनीकी कार्यक्रम 12:10–5:00

**सब्जी पौधशाला प्रबंधन की आधुनिक प्रौद्योगिकी**

**डॉ. ए.के.पाण्डे**, अधिष्ठाता,
उद्यान एवं वानिकी,
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

**सब्जी पौध तैयार करने हेतु उपयुक्त खाद एवं रूटिंग मीडिया**

**डॉ. गौरव शर्मा**, सह प्राध्यापक, उद्यान विज्ञान विभाग,
रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

**पौधशाला में लगने वाले रोग एवं कीट व्याधियों का प्रबंधन**

**डॉ. राजेश कुमार पाण्डे**, सहायक प्राध्यापक, वनस्पति विज्ञान विभाग,
बुंदेलखण्ड विश्वविद्यालय, झाँसी

**गोभी वर्गीय सब्जियों का पौध तैयार करना**

**डॉ. अर्जुन लाल ओला**, सहायक प्राध्यापक, उद्यान विज्ञान विभाग, रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

**पृथक लिंगी कद्दू वर्गीय सब्जियों का वानस्पतिक प्रसारण**

**डॉ डी आर भारद्वाज**, प्रधान वैज्ञानिक,
भारतीय सब्जी अनुसंधान संस्थान,
वाराणसी

**वेजिटेबुल सीड कोटिंग एवं प्राइमिंग**

**डॉ. युमनाम विजीलक्ष्मी देवी**, सहायक प्राध्यापक, प्राकृतिक संसाधन प्रबंधन विभाग, रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

**संरक्षित दशा में सब्जियों का गुणत्तायुक्त पौध उत्पादन**

**डॉ. अवनी कुमार सिंह**, प्रधान वैज्ञानिक, सब्जी संभाग भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली

**गुणवत्तायुक्त सब्जी एवं पौध उत्पादन हेतु नैनो प्रौद्योगिकी**

**डॉ. अभिषेक कुमार**, शिक्षण सहायक,
जैव प्रौद्योगिकी विभाग, रानी लक्ष्मी बाई केन्द्रीय कृषि विश्वविद्यालय, झाँसी

4:15–5:00 समापन सत्र