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Drip Irrigation for Efficient Water Delivery in NUTMEG

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Drip Irrigation for Efficient Water Delivery in Nutmeg

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Drip irrigation, also referred to as trickle irrigation or localized irrigation, involves dripping water onto the soil at slow rate (2- 20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers.

It is the most efficient water and nutrient delivery system for growing crops. It delivers water and nutrients directly to the plant's root zone, in the right quantity, at the right time in a way that each plant gets the exact amount it requires to grow. With water losses through evaporation, runoff, infiltration and percolation being minimal, the water use efficiency ranges between 90-95 per cent.

Components of Drip Irrigation System

Drip irrigation system comprises a main line, submains and laterals; emitting devices such as drippers or emitters; control head consisting of pumps, filters and fertigation units; and other accessories such as valves, fittings, etc. The main line delivers water from water source with the help of pumping device to the submain and from submains to the laterals. The emitters which are attached to the laterals deliver water into the soil for irrigation. The typical layout of a drip irrigation system, arrangement of pipe network (main, submain, lateral) and layout of drip irrigation system in a field is shown in Fig.1.

Irrigation Management in Nutmeg Cultivation

Nutmeg (*Myristica fragrans*) is a popular spice all over the world and has been in use since ages. In Kerala, nutmeg is mainly cultivated as a homestead crop in coconut and arecanut gardens. Nutmeg is grown for nutmeg kernels and mace. It thrives well in warm, humid conditions in locations with an annual rainfall of 150 cm and more. Clayey loam, sandy loam and red laterite soils are ideal for its cultivation.

Irrigation plays an important role in raising and stabilizing yield and maintaining quality of the crop. Nutmeg requires a moist soil with the roots spreading up to ½ feet deep into the ground. Ideal spacing between the crops in a pure cropping system is six meters. In Kerala, nutmeg planting in the main field is done at the onset of rainy season. Dry climate and water logged conditions are not good for nutmeg cultivation. Tropical and sub-tropical climate with good rainfall is much suited for nutmeg cultivation. Irrigation is necessary soon after planting seedlings in the main field and also during summer seasons. At other times, irrigation is done as and when required.

Why Drip Irrigation?

Farmers generally adopt either of pipe irrigation, basin irrigation and other conventional methods. Using conventional means of irrigation, the water use efficiency is in the range of 30-45 per

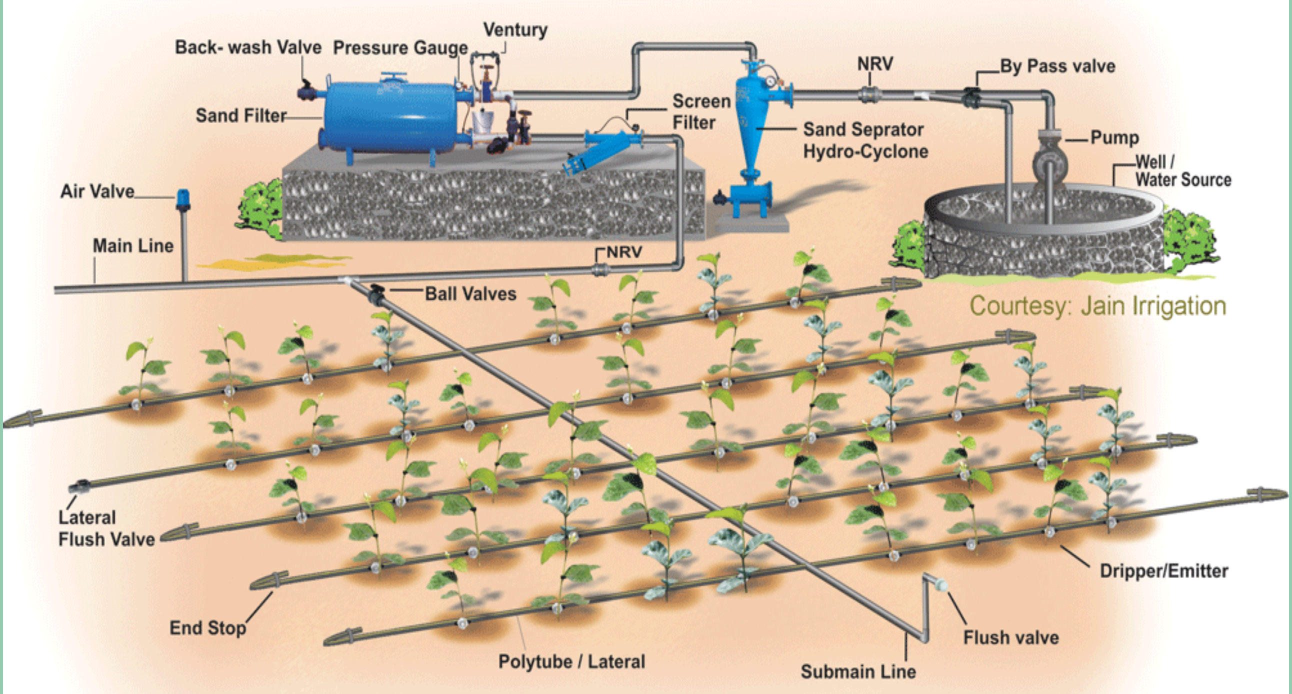

Fig. 1: Schematic layout of drip irrigation system (Source Jain-Irrigation Systems Ltd)

cent wherein considerable amount of water is wasted. To address this problem, drip irrigation systems can be adopted to save water and also to increase productivity since the per day crop water requirement for nutmeg is 200 litre/plant using conventional irrigation techniques.

Advantages of Drip Irrigation

1. Increases productivity of different crops by 30-70 per cent.
2. High water use efficiency of at least 90 per cent.
3. Water savings up to 60- 70 per cent.
4. Labour savings.
5. Reduces cost of cultivation.
6. Reduced weed growth.

Disadvantages of Drip Irrigation

1. Installation cost is high.
2. Improper filtration causes clogging.
3. Design of pump and lateral pipe dimensions requires skill.

Design of Drip Irrigation in Nutmeg

The drip system should be laid out according to the land pattern. Pressure should be maintained at the rate of 3 kg/cm^2. Based on the quality of water, the primary and secondary filters should be installed to the pump head. Control heads such as valves, filters, venturi, pressure gauge and ARV can be arranged in the main line. The main line is usually made of PVC, though HDPE pipes can also be used. These should be buried below the ground level at two feet

Drip irrigation system in nutmeg at a farmer's field depth. Perpendiculars to main line connect the submain and again perpendiculars to the submain connect the laterals. Since the spacing between the crops is six meters, the drippers are to be assembled accordingly. Control valves can also be integrated to each lateral to adjust the pressure. Various emitters, like online dripper, adjustable dripper, and 'J' lock dripper, are available in the market which can be integrated to the lines.

Through drip irrigation, we can irrigate water at 64 litre/day/plant, thus saving 60 per cent water. Dripper discharge rate should be 16 litre/day. The number of drippers should be 4 / plant. Irrigation should be scheduled for one hour, morning and evening. Interested farmers can also do fertigation by integrating venturi or pump injector to the lines. Water soluble fertilizers and liquid fertilizers are recommended based on the results of soil testing. It must be kept in mind that the fields are to be irrigated before and after carrying out fertigation as it clears the tubes of any sediments.

Benefits of Drip Irrigation

The technical data on the crop yield obtained by farmers under drip irrigation showed that drip irrigation gives 47.1 per cent increase in yield for nutmeg than that of surface method of irrigation.

Irrigation Method	Yield
Surface method of irrigation	8.5 kg/plant/year
Drip irrigation	12.5 kg/plant/year

Area under nutmeg cultivation in Kerala is 22,701ha with a production of 14,682 tonnes (Farm Information Bureau, 2020). The productivity of nutmeg in Kerala is 647 kg/ha. By adopting drip irrigation, productivity can be enhanced up to 2125 kg/ha.

Estimate for Drip Irrigation System

The table given below shows the approximate cost requirement for installation of drip irrigation system in nutmeg in an area of one hectare.

Sl.No.	Items	Amount (Rs.)
1	Main line, submain line, filters, lateral, dripper/ emitters	40360
2	Venturi assembly	1632
3	NRV,ARV, PVC Ball valve, submain flush valve, and other fittings	4896
4	Pump and fittings	25000
5	Transportation and installation charges	7500
6	**Grand Total**	**79388**

Maintenance Requirement

1. Clean the filter

- Manual cleaning of screen filter and disc filter.
- Back washing of sand and hydrocyclone filter.
- To clear the submain pipe and lateral tubes, remove the end cap, flush valve and let the water flow. Do this until the clean water comes.

2. Chemical treatment

- Acid treatment: Hydrochloric acid at 25 per cent dose is best for acid treatment.
- Cholrine reaction: This is useful to remove the biological impurities. Chlorination can be done either by using calcium hypochlorite, chlorine or bleaching powder.

Conclusion

With looming water scarcity, it is evident that water conservation is very much the need of the hour. Drip irrigation facilitates efficient use of water, supplies necessary nutrients to plants, cuts cost of cultivation and also rewards farmers with good yield. Since every drop counts, our farmers need to be educated more on the benefits of drip irrigation wherein the prime focus must be on water conservation.

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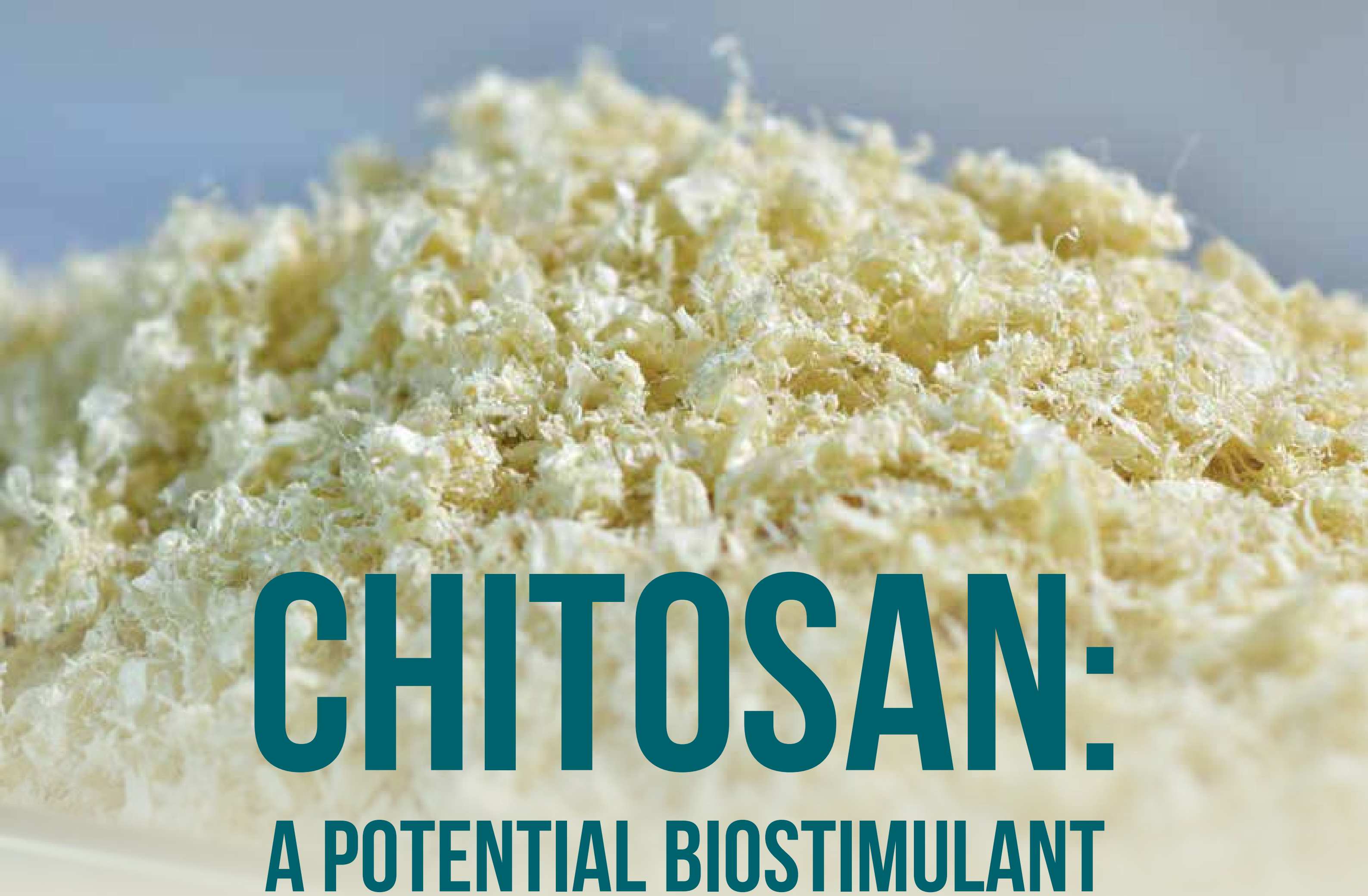

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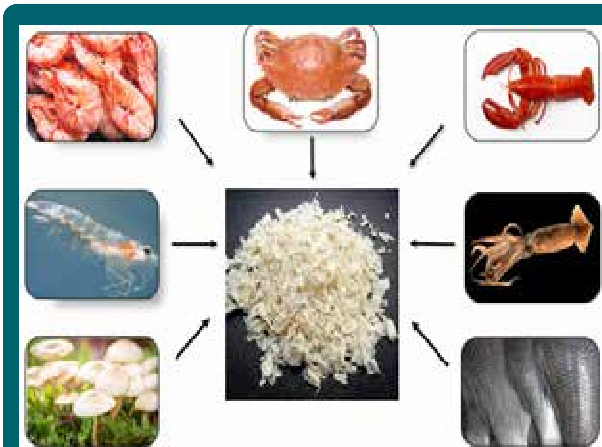
During food processing, waste is unavoidable and its disposal can be a real challenge for the industries and even for the society as a whole. Waste produced by the marine shellfish processing accounts for more than 5.9 million tonnes annually. Around 75 per cent of the total weight of crustaceans end up as by - products and it is usually thrown away at sea, burned, land filled or simply left out to spoil. However, they contain 30-40 per cent proteins, 30-50 per cent minerals and 20-30 per cent chitin and other compounds such as pigments. Chitin, which can be isolated from the cast-off shells, and its derivatives such as chitosan are currently gaining importance due to various functional properties. Chitin is highly hydrophobic and insoluble in water and even in most of the organic solvents. However, the potential of chitin can be increased when it is converted into chitosan. Chitosan exhibits various properties and has a multi-functional role in agriculture, food, cosmetics, textiles, pharmaceuticals, neutraceuticals, and biomedical industries.

Chitosan

Chitin was discovered by Henri Braconnot from mushroom in 1811, which he named as ‘fungine’. Later in 1859, chitosan was discovered by Prof. C. Rouget, when he boiled chitin in an alkaline medium which resulted in deacetylation of chitin and formation of chitosan. Ever since then, the interest in this multifaceted polymer is increasing constantly.

Chitosan is a cationic poly saccharide produced by the alkaline deacetylation of chitin. Chitin is the second most abundant natural polymer after

Extraction of chitosan



Sources of chitosan

cellulose. Chitosan is insoluble at neutral and alkaline pH in aqueous solutions but it is soluble in dilute acids such as acetic acid, formic acid, succinic acid, and lactic acid. Chitosan is considered to be nontoxic, bio compatible, and biodegradable.

Sources of Chitosan

Commercial sources of chitosan are the shells of crustaceans such as shrimp, crab, lobster, and krill. It can also be produced from molluscs such as squids, from fish scale, cell wall of fungi and exoskeleton of insects. Globally, 7.9 million tonnes of crustaceans are produced every year [FAO, 2018] and due to their abundance, crustacean shells are considered as the preferred source of chitin and thereafter chitosan isolation.

Extraction of Chitosan

Extraction of chitosan mainly involves four steps: demineralisation, deproteinisation, decolouration and deacetylation. Washed, dried, and powdered or ground crustacean shells are subjected to demineralization in order to remove the mineral constituents. Then the deproteinization of demineralized shells are done to remove the proteins. After that, decolouration step is carried out in order to eliminate the pigments present in the shells to obtain chitin. In the final step, deacetylation of chitin yields chitosan.

Two methods are involved in the extraction of chitosan, i.e., chemical and biological methods. In chemical method, demineralization is carried out by acid treatment with hydrochloric acid (HCl), deproteinization by alkali treatment using sodium hydroxide (NaOH). Whereas, in biological method, lactic acid producing bacteria are used for demineralization and deproteinization is done by proteases producing bacteria. Decolouration is done by using acetone or other organic solvents in both cases. The process of deacetylation to produce chitosan is done using sodium hydroxide in chemical method and by using chitin deacetylase enzyme in biological method. Chemical method is the commercially used method due to its short processing time. The interest in biological extraction is increasing since it is a safer and cheaper treatment due to the absence of effluents. But to date, it has been limited to laboratory scale only.

Applications of Chitosan in Agriculture

Chitosan is a versatile biopolymer having several applications in agriculture and has received much interest due to its bio-compatibility, biodegradability and bio-activity. Based on exhibiting such excellent properties, there is a striking interest in using chitosan biopolymers in agriculture systems. In agriculture, chitosan is mainly used for enhancement of crop production due to its bio-activities such as increasing seed germination, plant growth, chlorophyll content, photosynthetic rate and nutrient uptake, and reducing stress, and disease severity. Chitosan use is recommended to enhance antioxidant activities, fruit quality attributes, overall growth and yield of the crop and in post-harvest management. The exact

pollution under check. Chitosan can be considered as an organic fertilizer as it contains 6-9 per cent nitrogen. Also, it stimulates the growth of beneficial microbes in soil, since it acts as a carbon source and accelerates the conversion of organic matter into inorganic form thereby improving the nutrient uptake. It also acts as a chelating agent and thus increases the availability of nutrients like iron, copper and zinc. It also increases water holding capacity because of its highly porous nature. Hence, when chitosan is applied to soil as a fertilizer, it results in improved crop growth.

Recent studies have shown that chitosan induces mechanisms in plants against various biotic and abiotic stresses and also has plant - defense elicitor activity. Chitosan acts as a plant defense booster against biotic stresses by enhancing plant immunity and through anti-microbial activity. Chitosan treatment enhances the physiological response and mitigates the adverse effect of abiotic stress. Chitosan can mitigate the drought stress by promoting the activities of antioxidant enzymes such as super oxide dismutase and catalase, increasing proline accumulation, reduction of water potential, and reduction in transpiration.

mechanism for the biostimulant effect of chitosan is not yet clear, but may involve, induced stimulation of antioxidant defense machinery, stimulation of nitrogen metabolism, increased uptake of water and essential nutrients through adjusting cell osmotic pressure and through improved water use efficiency by reduction of transpiration. Method of application involves seed treatment, seedling dip, foliar spray and soil application.

Chitosan has shown great efficacy in combination with other industrial fertilizers and is helpful in reducing the fertilizer losses due to its coating ability, which is important in keeping the environmental

Chitosan can also be used in post-harvest management as a coating, since it delays ripening and increases shelf life, keeps the surface microbial growth under check, delays colour change, preserves water content, sustains fruit firmness, reduces weight loss percentage, improves antioxidant enzyme activity, and preserves fruit quality. It is also effective in keeping surface microbial growth under check.

Chitosan as a Biostimulant in Spice Crops

There are reports of chitosan improving the productivity in spice crops. Chitosan 5 g/L, when applied as foliar spray on ginger transplants at an

Ginger transplants applied with chitosan as foliar spray

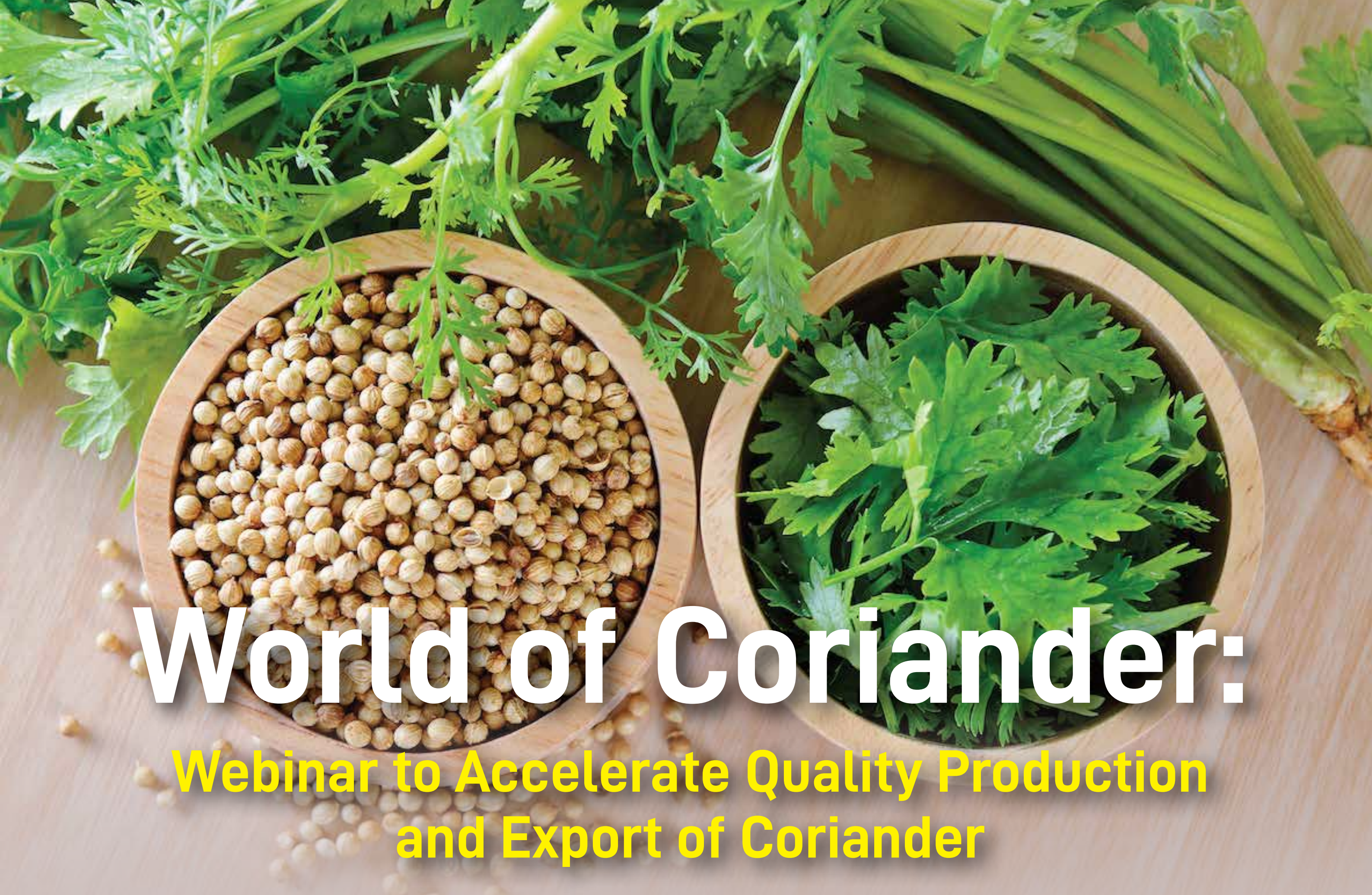
interval of 30 days for five months, enhanced the fresh rhizome yield to an extent of 1.96 fold. This proves chitosan as an effective biostimulant for yield improvement in transplanted ginger. In turmeric, foliar application of 0.1% chitosan at monthly interval was found to enhance the growth and fresh rhizome yield. Chitosan treatment also elicited the curcumin content and curcumin yield in turmeric. Chitosan when applied as dip at a concentration of 5g/L, was effective in controlling rhizome rot in ginger caused by *Fusarium oxysporum,* under storage conditions*.*

Chilli seedlings grown in soil mixed with 1.0 per cent (w/w) chitosan exhibited higher plant height, canopy diameter, leaf numbers and chlorophyll content, thus improving the growth of the plants. Chilli fruits when dipped in chitosan 0.8% for 1 minute, formed a coat over the fruits and was effective in controlling anthracnose disease caused by *Collectotrichum capsici.* Chitosan (0.5 per cent) when applied as fruit coating in post-harvest management of bell pepper was found effective in extending the shelf life. In bell pepper (*Capsicum* sp.), foliar application of chitosan at a concentration of 1g/L, was effective in reducing water use by 26–43 per cent suggesting it as an anti transpirant for agricultural uses.

In oregano *(Origanum vulgare*), chitosan spray, at a concentration of 200 mg/L given two weeks before anticipated flowering time, up regulated the polyphenol content and increased the plant height and growth.

Chitosan (0.2 per cent) given as seed treatment, alleviated the salinity stress in ajowan, increased the shoot and root length and enhanced the overall growth of the plants. Seed treatment with chitosan (1 g/L) in fenugreek *(Trigonella foenum-graecum* L.) was effective in reducing the adverse effect of salt stress and has shown improved leaf water content and photosynthetic parameters.

Currently, many companies are involved in chitosan production. In India, commercial production of chitin and chitosan was initiated by Matsyafed (Kerala State Co-operative Federation for Fisheries Development Ltd.) during 1988-89. Matsyafed established a Chitin and Chitosan factory at Kollam in 1988, for the separation of chitin from crustacean shell. Chitosan is available in the market as powder or flakes. Chitosan, as a unique abundant biopolymer, has a promising future in development of sustainable agricultural practices as well as food production and preservation.



World of Coriander:

Webinar to Accelerate Quality Production and Export of Coriander

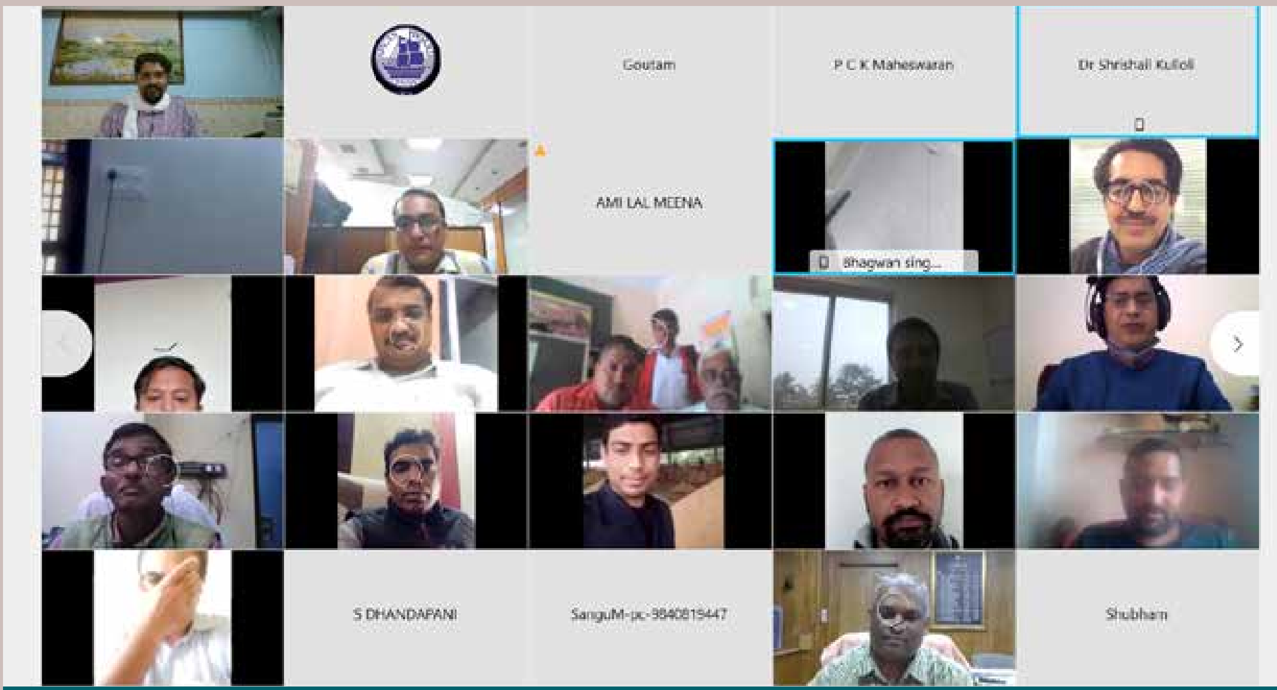
Spices Board and DBT-SABC Biotech Kisan Hub in collaboration with ICAR-National Research Centre on Seed Spices, Rajasthan State Agriculture Marketing Board and Kota Agriculture University organized the World of Coriander webinar 'Accelerating Quality Production, Post-Harvesting, Value Addition & Export of Coriander from India' on 4th January 2021, with participation of key stakeholders from various states.

The Hadoti region of Rajasthan surrounded by Madhya Pradesh grows coriander in large tracts and it is the epicenter of production of coriander and other seed spices in India. The Hadoti region of south-east Rajasthan and Guna district of Madhya Pradesh account for majority of coriander export which is estimated at 50,000 metric tonnes, out of the total production of eight lakh metric tonnes in 2019-20. Ramganj APMC Mandi located at Kota district is the largest coriander mandi in Asia, and thus Ramganj is also known as the 'Coriander city'. Recently, the Ministry of Food Processing Industries (MOFPI), Government of India has assigned coriander to Kota district in the list of One District One Product (ODOP).

Considering the vast potential for coriander production in Hadoti-Guna region, Shri D. Sathiyan IFS, Secretary cum Chairman, Spices Board, urged the entrepreneurs and exporters to tap the tremendous opportunities in export of whole coriander and other value added products such as coriander split (daal), powder, and essential oil.

Smt. Anu Shree Poonia, Spices Board Member, urged the need for integrated and coordinated efforts from all departments to make Rajasthan the hub for spice manufacturing and export. With the same outlook, Shri P.M. Suresh Kumar, Director (Admin & Mktg), Spices Board recounted the support extended by the Board in establishing the Spice Park at Ramganj Mandi in Kota to boost processing, value addition and export of coriander, which is reflected in the growing trend for export of coriander from the region.

Shri Tara Chand Meena, Administrator and Shri M.L. Gupta, Director (PHM), RSAMB, Government of Rajasthan informed that various schemes, incentives and funding opportunities at minimal cost are being worked out to set up agri-infrastructure, processing



Participants attending the webinar 'Accelerating Quality Production, Post-Harvesting, Value Addition & Export of Coriander from India' on 4th January 2021

and value addition centres as part of different schemes under PM-FME programme, agri export policy, FPOs, ODOP and Atmanirbhar Bharat initiative, etc. Shri T. Venkat Krishna, General manager of NABARD stressed the role of FPOs in collection, aggregation and delivery in supply chain.

Dr. S.S. Meena, Principal Scientist, ICAR-NRCSS, Ajmer and Dr. Pratap Singh, Director (Research), Kota Agriculture University, Kota emphasized the varietal improvement and screening of different cultivars, promotion of IPM based good agricultural practices (GAP) and popularization of disease resistance varieties such as *RKD-18* and *ACR-1* to overcome the menace of stem gall (*longia*) disease, which is becoming a challenge for farmers.

Dr Shrishail Kulloli, Spices Board Regional Office, Jodhpur pointed on the opportunities in value addition of coriander like vinegar, sausage, coriander powder and essential oils through accelerated processing mechanism and preserving quality of coriander products through proper storage facility. Dr Dinesh Singh Bisht, Scientist-C, Spices Board reminded the exporters to comply with quality standards and tackle issue of pesticide residue and sanitary and phytosanitary measures (SPS) with a great consideration to meet the growing quality requirements of importing countries particularly from developed countries including Japan, European Union and USA.

Shri Yashwant Bafna, Chairman, APMC, Ramganj Mandi and Shri PCK Maheshwaran, Coriander Exporter detailed the challenges faced by processors and exporters. They requested the central and state governments to immediately take measures to support farmers, industry and exporters from coriander price manipulation caused by future trading of coriander on NCDEX.

Summing up the world of coriander webinar, Dr Bhagirath Choudhary, Board member of APEDA and director of DBT-SABC Biotech Kisan Hub appealed the Central and State Governments to implement an actionable plan to increase quality production, aggregation by FPO, post-harvest management, value addition, and export of coriander from India. Inviting Rajasthan State Seeds Corporation (RSSC) of to engage in quality production of coriander seeds varieties such as *ACR-1* and *RKD-18,* which are resistant to stem gall (*longia*) disease, and newly developed late bolting coriander variety *AGCR-1* to minimize import of coriander seeds.

Shri M. Y. Honnur, Deputy Director, Spices Board proposed vote of thanks to all the participants.

Inspiring stories:

Great Ginger Chronicles of Bakki Govardan Yadav

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Nowadays, majority of the farmers opt for traditional crops, avoiding the risk of trying new varieties, as they give more stable yields even in the face of price fluctuations. However, Bakki Govardan Yadav from Dhanora village in Adilabad district of Telangana is an exception to this. It came to notice of Bakki Govardan Yadav that the traditionally cultivated old cultivars of ginger are low yielding and highly susceptible to pest and disease attack. As a successful farmer who follows highly ideal, scientific cultivation practices, Bakki Govardan Yadav introduced high yielding, highly disease resistant varieties of ginger namely Maran, Mahima and Nadiya in his farm and harvested a yield of 90 quintals per acre.

In the first year, he sold the fresh ginger as seed rhizomes to other ginger farmers with the help of agricultural institutes and other technical persons. He uses organic fertilizers such as animal dug and various chemical fertilizers such as single super phosphate and urea phosphate. Ridomil gold is used for seed treatment.

Bakki Govardan Yadav not only follows ideal farming practices but modern marketing methods are also tried to sell his produce. He followed delayed harvesting method to mitigate the low market price problem in ginger. If the ginger price is low in the market, he avoids harvesting and continues irrigation and application of fertilizers. New ginger flushes will emerge from this method and farmer can harvest the crop in April or May instead of January. He succeeded with this method and got 150 quintals of fresh ginger per acre when there was a huge demand in market for ginger.

It is noted that Bakki Govardan Yadav increased the per acre yield of ginger by applying delayed harvesting method and due to the same, he could make extra profit for the extra production. He got high returns by sale of ginger in Nanded market at a rate of Rs.5000/- per quintal in the second year.

Bakki Govardan Yadav also started steps for processing and value addition of ginger with technical assistance from supporting institutes. He is exploring markets for value-added products like dry ginger (Shonti) and Allam Murabba (a kind of ginger candy).

Shri Bakki Govardan Yadav at his ginger field.


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Soil Conservation Practices in Plantations -04

Mechanical Measures of Erosion Control

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Soil erosion can also be checked by certain mechanical measures or engineering structures designed to modify the slope, to permit runoff water safely to the waterways, to reduce sedimentation and runoff velocity and to improve water quality. These measures are either used alone or integrated with biological measures described in the previous section to improve the performance and sustainability of the control measures. In highly eroded and sloppy landscape biological measures should be supplemented by mechanical structures. A number of permanent and temporary mechanical measures are available such as terraces, contour bunding, check dams, gabions, diversion drains and geo-textiles. The choice of the method is decided based on the severity of erosion, soil type, topography and climate.

Bunding

Contour bunding, graded bunding and peripheral bunding are the three common methods of bunding. Contour bunding is used to conserve soil moisture and reduce erosion in areas having 2–6 per cent slope and mean annual precipitation of <600 mm with permeable soils. The vertical interval between two bunds is known as the spacing of bunds. The spacing of bund is dependent on the erosive velocity of runoff, length and steepness of the slope, rainfall intensity, type of crops, and conservation practices. Graded bunds are made to drain out excess runoff water safely in areas having 6–10 per cent slope and receiving rainfall of >750 mm with the soils having infiltration rate <8 mm/h. Peripheral bunds are constructed around the gully head to check the entry of runoff into the gully. It protects the gully head from being eroded away through erosion processes. It creates a favourable condition for the execution of vegetative measures on gully heads, slopes, and beds.

Earthen bunds, stone pitched contour bunds and graded bunds are commonly practised methods of bunding. Bunds are small embankment type structures made up of locally available earth materials. Land slope and soil characteristics are considered for selection of bund type and design.

Bunds help to check the velocity of the runoff, to carry excessive rainfall safely downstream and to let off stream flow in natural channels. Bunding increases the time of concentration of rainwater where it fall thereby allowing rainwater to percolate into the soil. Wherever possible agronomic conservation measures like agrostology, planting of grass specials etc are provided on the constructed bunds. Stone pitched contour bunds are constructed in contour at suitable intervals in slopes. The adoption of this intervention, has led to reduction in soil erosion and increased water availability for crop plants. This type of construction is very suitable for laterite soil or wherever stone is available, up to 35 per cent of slope areas can be protected by this way. Graded bunds are adopted in areas having low infiltration (<8 mm/hr) and more than 800 mm rainfall. Graded bunds are laid along pre-determined longitudinal grade instead of along the contours for safe disposal of excess runoff. Gradient given may vary from 0.4 to 0.8 per cent.(0.4 for light soils and 0.8 for heavy soils).

Contour trenching

Trenches are constructed at the contour line to reduce the runoff velocity for soil moisture conservation in areas having <30% slope. Bunds are formed on the downstream side of trenches for the conservation of rainwater. There are two kinds of contour trenching, continuous contour trenching and staggered contour trenching. Continuous contour trenches are constructed based on the size of the field in low rainfall areas with 10–20 cm trench length and 20–25 cm equalizer width without any discontinuity in trench length (10–20 m). **Staggered** trenches are constructed in alternate rows directly beneath one another in a staggered manner in high rainfall areas, where the risk of overflow is prominent. They are 2–3 m long with 3–5 m spacing between the rows. It is highly effective in preventing extension of gully head, soil loss and overflow.

Terracing

Terraces are earthen embankments built across the dominant slope partitioning the field in uniform and parallel segments. Generally, these structures are combined with channels to convey runoff into the main outlet at reduced velocities. It reduces the degree and length of slope thereby reducing runoff velocity, soil erosion and improves water infiltration. It is recommended for areas having a slope of up to 33 per cent, but can be adopted in places having up to 50–60 per cent slope, based on socio-economic conditions of a particular region. Where plenty of good-quality stones are available, stone bench terracing is recommended. Sometimes, semi-circular type terraces are built at the downstream side of the plants, known as half-moon terraces. **Bench terraces sloping outward** are used in low rainfall areas having permeable soils. A shoulder bund is provided for stability of the edge of the terrace and thus has more time for rainwater soaking into the soil. **Bench terraces sloping inward** are suitable for heavy rainfall areas where a higher portion of rainfall is to be drained as runoff. For this, a suitable drain should be provided at the inward end of each terrace to drain the runoff. These are also known as hill-type terraces. **Bench terraces with level top** are suitable for uniformly distributed medium rainfall areas having deep and highly permeable soils.

Contour wattling

Wattling is a technique of dividing the length of the slope into shorter sections and in these sections, the wattles are constructed at a vertical interval of 5–7 m up to 33 per cent slope and 3 m up to 66 per cent slope. It is not effective on slopes steeper than 66 per cent and on very loose or powdery rocks.

Crib structures

Crib structures are used to stabilize the steep slopes of >40 per cent by constructing log wood structures filled with stone or brushwood. Eucalyptus poles 2–3 m in length and 8–12 cm in diameter can be used for the construction of crib structures. These poles are joined together with the help of 20–25 cm long nails. The height of the structure is kept 1.5–2 m above the ground depending upon the land slope.

Geotextiles

Geotextiles are made up of natural fibres of jute or coir, which are used for stabilization of degraded slopes in mine spoil and landslides areas along roadsides. It facilitates the initial establishment of vegetation on highly degraded sloping lands by holding the vegetation in place and conserving moisture. The open mesh size of geotextiles varies from 3 to 25 mm. The biodegradability of geotextiles is generally for 2–3 years. It can absorb 12 to 25 per cent water under 65 and 95 per cent humidity respectively and when fully soaked in water it can absorb 40 per cent moisture.

Trenches

Contour trenches are used both on hill slopes as well as on degraded and barren waste lands for soil and moisture conservation and afforestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e., in both high and low rainfall conditions), varying soil types and depths. In the case of contour trenches, they are constructed continuously across slope with 45-50 cm depth and bottom width and trapezoidal in shape. Staggered trenches have a length up to 2-3 m spaced at 5-7m. It is suited for medium rainfall areas with dissected topography.

Strip terrace

It is used to control soil erosion in highly sloped areas. It basically involves construction of ridges and step like structures across land slope. Strip terraces are commonly adopted in area of rubber plantations in Kerala.

Moisture conservation pits

Any form of depression or micro pit is constructed over the land surface to arrest excess surface runoff and silting and thus leading to ground water recharge. Pits of suitable dimension are constructed in the field which would impound water and contribute o ground water recharge during rainy season. The silt accumulated in the pits could be dug out and used in the farmer’s field which would improve nutrient status of the soil.

Loose boulder/stone/masonry check dams

Check dams are effective for preventing runoff rate and severe erosion in steep and broad gullies, and most suitable for high elevation areas of the catchment. These structures are cheap, having a long life, and fewer maintenance requirements. The depth of gully bed is kept about 0.3 m and flat stones of 20–30 cm size are used for the construction of dams. A spillway is provided in the middle of the dam to allow the safe discharge of runoff water. Similarly, gabion check dams are also used for drainage line treatment in sharp slanted gullied areas to check sedimentation, erosion, and to conserve soil moisture.

Brushwood check dams

Branches of tree and shrub species are stacked in two rows parallel to each other filled with brushwood and laid across the gully or way of the flow. These are usually built to regulate the overflow in small and medium gullies which are supplemented with vegetative barriers for long term effectiveness. There is enough soil volume to establish the vegetation. The tree species are planted in 0.3 m × 0.2 m trenches across the way of gullies. It reduces the runoff velocity, soil loss, and improves soil moisture which helps in the successful establishment of vegetative barriers.

Diversion drains

The channels are constructed to protect the downstream area and for safe draining and diverting of runoff water. It is applicable in high rainfall areas to control runoff losses during the initial stage. The gradient of diversion drain should preferably be kept within 0.5 per cent. Generally, a narrow and deep drain does not get silted up as rapidly as a broad and shallow drain of the same cross-sectional area. Soil dug from the drain should be dumped on the lower side of the drain. Outlet end should be opened at natural drainage lines.

Conservation bench terrace

In the conservation bench terrace (CBT) system, the land is divided into 2:1 ratio along the slope in which the upper 2/3 area (donor area) contributes runoff to the lower 1/3 runoff collecting area (recipient area). The donor area is left in its natural slope condition. It is also known as the zingg terrace as it was developed by Zingg and Hauser in 1959. The runoff contributing area is used for cultivation of *kharif* while the lower 1/3 area with conserved soil moisture is used to cultivate *rabi* crops. This mechanical measure can be successfully applied in a semi-arid climate on mild sloppy lands (2-5 per cent) for erosion control, water conservation, and improvement of crop productivity. This system can be used in silty loam to silty clay loam soils. The CBT system resulted in the reduction of runoff from 36.3 to 7.4 per cent and soil loss from 10.1 to 1.19 t/ha as compared to the conventional system of sloping border. An average reduction of 78.9 and 88.0 per cent in runoff and soil loss, respectively was reported in the CBT system over the conventional system.

Future perspectives

The burgeoning world population, food insecurity and natural resource degradation are the major issues in the present era of climate change. It has been projected that the world population will be about 10 billion in 2050. Further, the rapid industrial growth and intensive farming practices are expected to increase the pressure on land and water resources in near future. Therefore, a paradigm shift in soil and water conservation, and its management is needed for agricultural sustainability. Some of the future concerns for soil and water conservation and sustainable agriculture are as follows:

- Formulation of new policies and development of new technologies based on social, economical and cultural aspect of a particular region.
- Implementation and adoption of effective conservation measures for sustaining agricultural productivity.
- Existing soil and water conservation practices should be improved and developed based on the level of natural resources degradation.
- Greater emphasis should be given on participatory approach for effective soil and water conservation.
- Post impact assessment and monitoring of soil and water conservation measures should be done to evaluate their efficacy in increasing productivity, monetary returns, and livelihood of the stakeholders.
- Development of cost effective conservation practices to restore the degraded lands and to sustain agricultural productivity.
- The efficient technologies for soil and water conservation should be demonstrated on farmers' fields with their active participation.
- Emphasis on research, education and extension of soil and water conservation effective technologies to the stakeholders.
- Adoption of efficient management practices and judicious use of soil and water resources.

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Coriandrum sativum flowering twig

Cilantro: The Wonder Spice of Kitchen Cabinet-Agronomics

Dr Shrishail K. Kulloli
Regional Office, Spices Board, Jodhpur, Rajasthan

Coriander (*Coriandrum sativum* L) is an aromatic annual herb that belongs to Apiaceae family with diploid number of chromosomes 20n=22. Its name is derived from the Greek word 'Kopria' meaning bedbug because of unpleasant fetid bedbug odour of the unripe fruits. It is grown mainly in India, Morocco, Russia, Bulgaria, Mexico, Argentina, China, Romania, Japan, and Italy.

India is the largest producer of coriander in the world and the spice is mainly cultivated in the states of Madhya Pradesh, Rajasthan, Gujarat, and Andhra Pradesh with scattered pockets in Tamil Nadu, Odisha, Karnataka, Haryana, Uttar Pradesh, and Bihar. India produces 5.68 lakh tonnes of coriander from 4.68 lakhs ha land, out of which Madhya Pradesh occupies the first position in production and acreage with 3.70 lakhs tonnes from 2.78 lakh ha land (Spices Board, 2018-19) with productivity of 1.1 to 1.6 tonnes /ha and an average of around 1 tonnes.

In the recent years, coriander has shown tremendous prospects for export in addition to the high domestic demand. The international standards of export of spices are becoming stringent over quality and pesticide residue levels. That is why major emphasis is given to adopt Good Agricultural Practices (GAP) including scientific organic farming for better quality and lesser pesticide residue to meet the international standards as well as to provide nutritional security with safe quality food.

Soil and Climate

Coriander can be grown in any type of soil having sufficient organic matter. It is cultivated as both irrigated and un-irrigated crop. Saline, alkaline and sandy soils are not suitable for its cultivation. Soils contaminated with heavy metals and industrial wastes are harmful for its cultivation. The soil pH should be near 7.0. As coriander is a tropical crop, it can be grown throughout the year for harvesting of leaves. But for seed harvesting, it is mainly cultivated as a *rabi* season crop, in areas free from frost during flowering. During the flowering and seed setting phase, dry and cold weather favours high seed production. Cloudy weather during flowering and fruiting stages increases the chance of insect pests and diseases. Germination is affected adversely at temperature above 30ºC and below 10ºC. However, lower temperature favours vegetative growth of the crop.

Field Preparation

The field must be ploughed with cultivator to obtain fine soil tilth. To prevent soil moisture loss, planking should be done immediately after ploughing. For irrigated coriander, if soil moisture is not sufficient, the field preparation should be done after pre-sowing irrigation. It will also help to germinate the weed seeds which can be uprooted and destroyed. Soil solarisation (15-20 days) is recommended to suppress the weeds and wilt disease.

Sowing

Coriander is propagated through seeds. Seed is split into two halves with splitter or manually to get good germination. Seed priming with PGRS or soaking in distilled water for 12hrs is recommended for early germination. Coriander should be sown when day temperature falls below 25ºC temperature. The optimum sowing time for North India is between mid October to mid November. Coriander crop for green leaves can be sown at any time during year. Depending up on seed size, varieties' growth habit, 10-12kg per ha seed is required for sowing under irrigated conditions whereas 15-20kg /ha seed is required for rainfed conditions.

To protect the crop from seed borne diseases, it can be treated with *Trichoderma* (4-6g/kg seed) or Bavistin 2-2.5g/kg seed). The seed can also be inoculated with 10g/kg Azotobacter and 10gm/kg Phosphate Solubilising Bacteria (PSB) to have a healthy crop growth. Sowing of coriander is done by broadcasting and line sowing method. Line sowing

Field ploughed with cultivator

Line sowing of coriander seeds

is more preferred as it saves about 15 per cent seed and facilitates intercultural operation. Hence coriander seed should be sown in lines of 30cm apart at 10cm plant distance.

Varieties Recommended for High Yield

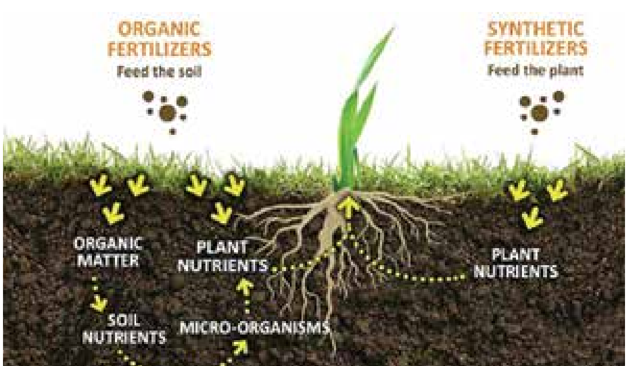
In India, many varieties of coriander are released with high yield as well as resistance to diseases from NRCSS Ajmer, SSRS Jagudan, JAU Junagadh, etc. Some of them are:

1. ACr-1 (average yield 1.4 T/ha, resistant to stem gall)
2. RCr-41 (resistant to stem gall),
3. GCr-1/2 (suitable for early sowing, high yielding variety)
4. Swathi (tolerant to white fly)
5. Sindhu, (resistant to aphids, wilt, and powdery mildew)
6. Pant Harithma (resistant to stem gall –Stem gall is a fungal disease by *Protomyces macrosporus*, an ascomycete fungus that forms galls. It is also tolerant to powdery mildew – *Erisyphe polygoni*)

Nutrient Management

Nutrient management should be done on the basis of soil fertility test. Normally crop should be fed with

1. 10 tonnes/ha farm yard manure or compost three weeks before sowing of the crop and 40kg Nitrogen (N), 30kg Phosphorus pentoxide (P_2O_5) and 20kg Potassium Oxide(K_2O) /ha.
2. One third of Nitrogen (N) and full dose of Phosphorus pentoxide (P_2O_5) and 20kg Potassium Oxide (K_2O)/ha should be applied as basal dose.
3. About 2/3rd Nitrogen should be applied in two equal split doses as top dressing at 30 and 60 days after sowing.
4. Highest yield can be expected after using 24kg of sulphur followed by spraying of zinc 0.5 per cent and Zinc sulphate ($ZnSO_4$).
5. Similarly, soil application of copper 11kg/ha with foliar application of iron 0.5 per cent W/V as Ferrous sulphate ($FeSO_4$) exhibits maximum yield of coriander.



Soil nutrient management through organic and synthetic inputs

Vermicompost in the Organic input chain

6. Organically, it can be produced with vermicompost 5tonnes/ha, Azotobacter+PSB 10g each/kg seed, *Trichoderma* as seed treatment 10gm/kg, *Trichoderma* soil application at 205kg/ha, soil application of Neem Cake at 150 kg/ha, Garlic extract as foliar spray, five percent and two percent Neem oil spray.

Water Management

Depending upon soil and weather conditions of the growing area three to five irrigations are required for successful cultivation of coriander.

In irrigated crops, water should be applied at different critical stages like,

1. Seedling stage (30-35 days)
2. Grand growth period (50-60 days)
3. Flowering stage (70-80 days)
4. Final irrigation at seed setting stage (100-110 days)

Irrigation with low pressure drip irrigation or micro sprinkler with line sowing results in maximum seed yield wherein one can save the water at about 50-60 per cent.

Irrigation through sprinklers in coriander

Intercultural Operations

In unirrigated crop, weeding and hoeing should be done once or twice so that water and nutrients available in the soil can be utilized by the crop efficiently. In irrigated crop, two or three weeding and hoeing operations are necessary to keep the crop weed free.

1. First weeding and hoeing: 5-40 days
2. Second weeding and hoeing: 60-65 days

Following IPM and IDM practices are advised for quality production in coriander cultivation

Stage	Practice	Target diseases pest
Pre sowing	Deep summer ploughing, soil solarisation	Soil borne pathogen and nematodes
	Crop rotation	All pest and diseases
	Application of mustard/castor/neem cake/combination	Soil borne pathogen and nematodes
	Avoid late sowing	Powdery mildew
At the time of sowing	Selection of tolerant /resistance varieties	Wilt /stem gall
	Seed treatment with fungicide carbendazim+ thiram @ 2gm/kg seed or *Trigonella viride* @10gm/kg and soil application of *T viride* @ 2.5kg/ha (mixed with FYM)	Wilt /stem gall
Vegetative	Timely hoeing and weeding, soil application of *T viride*,	Wilt /stem gall
	Avoid excessive use of irrigation and nitrogenous fertilisers	Wilt, sucking pests and stem gall
Flowering	Stop irrigation under cloudy and high dew condition	Blight
	Prophylactic spray of mancozeb/ chlorothalonil @0.2 per cent	Blight and stem gall
	Foliar spray of NSKE 5 per cent	Sucking pests
	Collection and killing of larvae of cutworm and leaf foliators	Cutworm
Post flowering /grain filling	Avoid irrigation at the time of active seed filling	Sucking pests
	Application of NSKE 5%, Neem oil 2 per cent and karanji oil (*Pongamia glabra*) 2 per cent	
	Spraying of propiconazole /picoxystrobin/ azoxystrobin	Blight and Stem gall
	Spraying of insecticides	Sucking pests
	Conservation of parasitoides and predators like Coccinalids, Chrysopids and Syrphid fly	Sucking pests
	Crop may be dusted with sulphur dust @ 25 kg /ha or spraying with wettable sulphur @ 0.25% or dinocap @0.1% at the initiation of powdery mildew	Powdery mildew
	Timely harvesting to minimize powdery mildew attack	Powdery mildew
Post- harvest	Seed should be properly dried and stored in bags	Storage pests

Chemical operations are not recommended due to pesticide residue issues but hand /animal operated weeder can be used.

Major weeds identified are nut grass (*Cyperus rotundus)* and scutch grass (*Cynodon dactylon)* (33%), *Echinochloa colonum* (19%), *Dactyloctenium aegyptium* (4%) and rest of the weeds (12%).

Chenopodiastrum murale, *C album* seen immediate after sowing are dicot weeds and *Heliotropium ellipticum*, *Rumex acetosella*, *Asphodelus tenuifolius,* and *Melilotus alba* are seen in the later stages.

Crop Protection

Coriander is prone to attack by various diseases and insect pests. To avoid this plant protection measures under organic farming should be practiced. The following dosages are recommended;

1. Phytological extract of Neem oil two percent, Karanji oil two percent, in combination or alone, and Garlic extract, Nigella extract, Ajwain extract

Intercultural operations for weed management

Major weeds in coriander

all one percent shall be used after one month of germination of crop.

2. Foliar spray of bio fungicides, neem oil plus karanji oil are also recommended for maximum yield of the crop (one can expect production of around 2.4MT /ha).

3. Integrated Pest Management (IPM) and Integrated Disease Management (IDM) also can raise the production by using the following combinations like Allyl isothiocyanate (two per cent), Sulphur extract of Karanji (two per cent) *Verticillium lecanii* 5ml/litre, and neem insecticides (0.05percent), Neem Oil (two percent), Insecticide soap (one per cent) in coriander crop. Insecticide soap is more effective in reduction of aphids

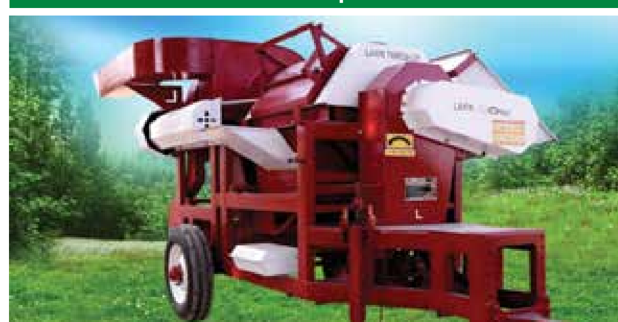
Management of Abiotic Stresses

Coriander is susceptible to frost injury during flowering and fruit setting. Even cold waves cause huge loss to the crop. To avoid these, protected cultivation which includes production of seed spices in insect proof nets, plastic walk tunnels and shade nets (used in off season for green coriander cultivation). In this plastic walk tunnels will be the best for maximum economic yield.

Harvesting and Yield

Harvesting should be done when 50 per cent seeds turn yellow. For extra earning one can pluck the leaves to the extent of 50 per cent at 75 days. Over ripening of seeds results in deterioration of the quality. Harvesting should be done on weekly intervals but the grains harvested in second and third week will be of good quality with lowest moisture, highest taste and colour marks. Threshing of the crop should be done with multicrop seed spice thresher. With cultivation of improved varieties and adoption of GAP, one can harvest 1.5 to 2.0 tonnes of coriander in irrigated fields and 0.8 to one tonne in rainfed crop. The harvested crop should be dried in shade to avoid loss of volatile oil and stored under appropriate conditions of temperature and humidity in the space designated for this purpose.

Plastic walk tunnels for protected cultivation



Seed spice thresher for post-harvest management

Calendar of Operations
March 2021

Timely planning and execution of farm operations based on agro climatic conditions of the area is important for successful farming for higher productivity and sustainability. To facilitate this a calendar of operations in respect of important spice crops for March is given below.

Small Cardamom

NURSERY

- Regular watering may be given to bed/polybag/sucker nursery based on necessity.
- Avoid exposure of nursery to direct sunlight from top or side to prevent the incidence of leaf spot.
- To control damping off/seedling rot/leaf rot diseases in nursery, soil drenching with 0.2% copper oxychloride. Clipping and destruction of severely affected leaves after spraying is to be done to avoid further spread to healthy leaves.
- As bio-control measure, *Trichoderma* or *Pseudomonas* or *Bacillus* species may be applied in the soil.

MAIN FIELD

- Continue irrigation based on necessity wherever irrigation facility is available.
- Light pruning may be done by way of removing only the hanging dry leaves and sheath.
- For Integrated Pest Management, prune dry leaves without removing green leaf sheath.
- Observe for occurrence of beetles of root grub. If noticed collect them with insect net and destroy the beetles to prevent them from egg laying.
- One round spray of Diafenthiuron @ 80 g/100 lit of water may be given for the control of thrips/borer.
- Keep constant vigil for any *katte* virus/*kokke kandu* affected plants to uproot and destroy, if found.
- For controlling leaf rust and chenthal and leaf spots, 1% Bordeaux mixture (2 to 3 rounds – 30 days interval).
- Root rot and leaf yellowing can be controlled by foliar spray and soil drenching with 1 % *Pseudomonas*.

- Cover the exposed roots with topsoil, proper mulching, irrigation and shade should be provided for the management of *Fusarium* diseases.
- Continue harvesting with a gap of 25-30 days depending upon the maturity of the capsules.
- Harvest only the matured capsules for getting better out turn.
- Ensure that 20-25 days pre-harvest interval is given if any pesticide spray has been done in the plantation.
- Wash harvested capsule thoroughly before drying in curing chamber.
- Timely removal of water vapour from curing chamber and maintaining proper temperature during curing will result in better green colour of produce.
- Always store the cured cardamom capsules at 10% moisture in 300 gauge black polythene lined gunny bags inside wooden box to retain green colour and quality.

Large Cardamom

NURSERY

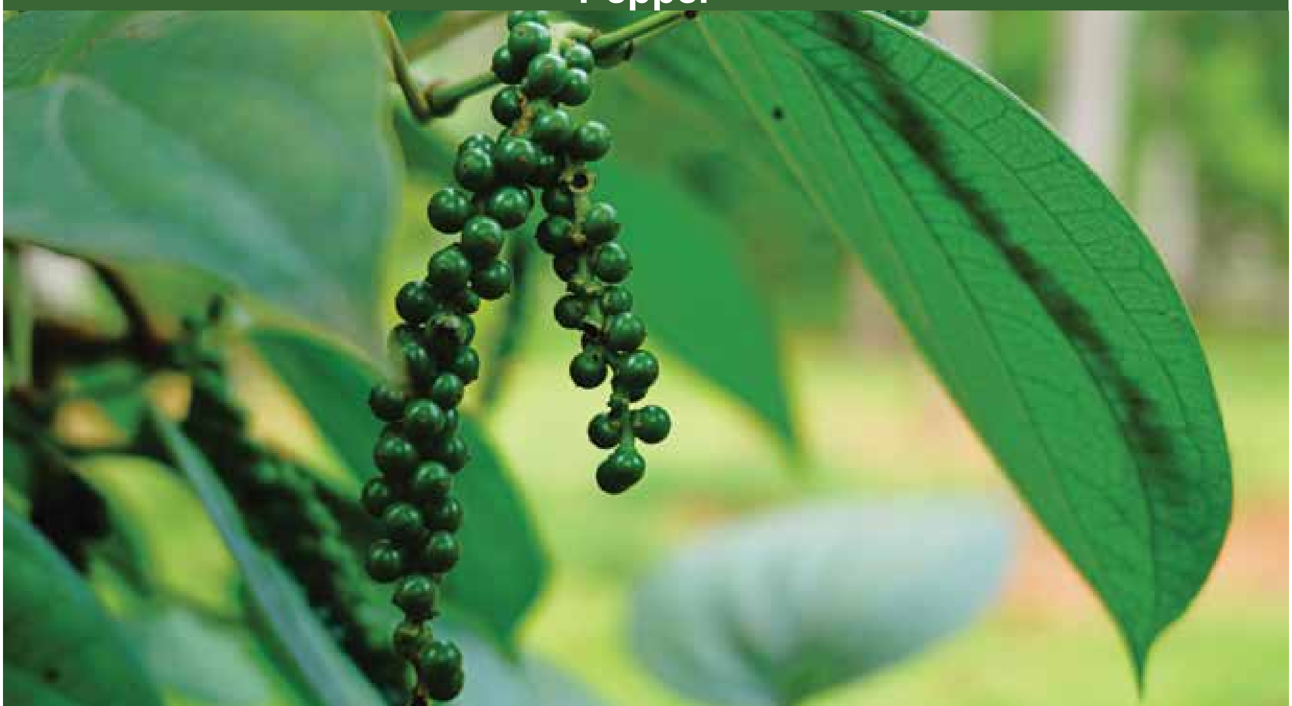
- Regular watering may be done in the sucker nursery with available water resources depending on moisture status in the soil.
- Dried or powdered cattle manure/organic manure/topsoil may be applied in the nurseries for healthy growth of suckers if not applied so far.
- Disease/pests infested suckers may be removed and destroyed.
- One round weeding may be attended followed by forking of soil at plant base and then plant base should be covered with topsoil and then mulched.

MAIN FIELD

- Large cardamom plants may be irrigated at regular intervals with available water resources, depending on rainfall and moisture status in the soil.
- Chirke and Foorkey infected plants may be destroyed by uprooting/burial at regular intervals in the pits.

- Regular inspections may be carried out to observe caterpillar/shoot borer/shoot fly incidence if any and may be handpicked and destroyed mechanically.
- Application of cattle manure/compost/ organic manures will help in getting sustained production, improving productivity and quality of the crop.
- One round weeding followed by mulching may be carried out to conserve soil moisture if it is not done earlier.
- All the aged/diseased/unproductive cardamom plants may be uprooted and destroyed and the cardamom field may be kept ready for marking lines, opening pits, so that timely replantation/ gap filling operations can be taken soon after getting the rains.
- Arrangements may be made for getting good shade tree saplings for planting in the open/ poor shaded areas.

Pepper



NURSERY

- If preparation of pepper cuttings for propagation was not done last month, carry out the same as detailed below.
- Runner shoots already marked and coiled on wooden pegs removed. Then cut them into bits with 2-3 nodes by rejecting the over matured and immature portion of the vines.
- Plant these cuttings in polythene bags of 6x4 cm filled with top soil, sand and farm yard manure in 3:1:1 proportion. Arrange the polybags inside a pandal and irrigate regularly.

MAIN FIELD

- Wherever irrigation facilities are available, start irrigating the plants once in a week by hose irrigation or daily by drip irrigation.
- Continue harvesting by observing the right maturity indicated by the colour change in one or two berries in a spike from green to orange or red.
- Always ensure threshing of pepper either by manual method or using mechanical pepper thresher hygienically.
- For drying use only clean floor made of concrete, clean bamboo mats or polythene sheets to get quality final produce.

Chilli

- Irrigation to be continued based on necessity and soil type.
- Collection of egg masses/early instar larvae of caterpillars found in groups may be done manually and destroy them.
- Erect pheromone traps for monitoring pod borers 6” above crop level @ 5 per ha. Change the pheromone cards once in 15 days for better results.
- Spray Need Seed Kernel Extract (NSKE) 5% or Bacillus thuringiansis var kurstaki (biological control agent) @ 500 g/ha for control of early instar larvae of pod borers.
- Harvest the ripe chilli fruits and dry in clean concrete floor, polythene sheets or cement yards with intermittent turnings.
- The optimum moisture content of dried produce is 10% for safe storage without any mould problem.
- Wherever possible use mechanical chilli drier or solar poly house driers to avoid any contamination likely to arise from open drying.

Fennel

- Harvesting of umbels may be done when they become fully matured and turn into yellowish green colour.
- Threshing, drying, processing and packing may be done under clean and hygienic condition.
- Cleaning and grading of the produce is beneficial to fetch good prices.
- Storage may be done in the godowns free of rodent, insects, etc., to protect the produce from contamination.

Cumin

- Harvesting may be done in the early morning hours to prevent shattering of seeds.
- Threshing, drying, processing and packing may be done under hygienic condition.
- Cleaning and grading of the produces may be done to fetch good prices.
- Storage may be done in the godowns free of rodent, insects, etc.

Fenugreek

- Crop may be harvested, threshed, dried, and packed.
- Produce may be cleaned and graded to fetch good prices.
- Cleaned and graded produce may be stored properly.

Coriander

- Crop may be harvested, threshed, dried, and packed. Produce may be cleaned and graded to fetch good prices.
- After harvest, the crop may be dried under partial shade to retain the green colour and its aroma.
- Cleaned and graded produce may be stored properly.

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