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A REVIEW

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A review on organic farming in vegetable sector

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ABSTRACT : Growing awareness of health and environmental issues associated with the intensive use of chemical inputs has led to interest in alternate forms of agriculture in the world. Organic agriculture is one among the broad spectrum production methods that are supportive of the environment. At present 35million hectares of agricultural land are managed organically by almost 1.4 million producers all over the world. In India, total area under organic management is 4.48 million hectare, out of this, cultivated area is 1.08 million hectare and remaining 3.4 million hectare is wild forest harvest collection area. The various components of organic farming are: Organic materials such as FYM, composts, green manures etc. for enrichment of soil fertility, biofertilizers for economizing nitrogen and phosphorus fertilizers, biopesticides, bioagents for controlling diseases, pests etc, high yielding varieties and hybrids resistant to biotic and abiotic conditions, crop rotation, intercropping, mulching etc. Organic farming reduces the need of purchased inputs, prevents environmental degradation, improves soil physical, chemical and biological properties, helps to sustain production and better yields, properly utilizes organic wastes, avoids pesticide residues in food and results in better quality product . Use of FYM, biofertilizers and vermicompost has resulted in maximum fruit yield in vegetables like tomato, brinjal and better nutritional qualities like increased ascorbic acid content in okra (Thakur *et al.*, 2010 and Reddy, 2008). Use of biopesticides like spinosad helps in controlling diamond back moth in cabbage, biocontrol agents like trichogramma spp. reduces infestation of helicoverpa *armigera* in tomato, while use of mulches help in reducing weed infestation, disease incidence and improve overall yield of vegetable crops. In India, organic farming, in spite of the reduction in crop productivity by 9.2 per cent, provided higher net profit to farmers by 22.0 per cent compared to conventional farming. This was mainly due to the availability of premium price (20–40%) for the certified organic produce and reduction in the cost of cultivation by 11.7 per cent.

KEY WORDS : Organic agriculture, Components, Vegetable crops

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Organic farming was practiced in India since thousands of years. Entire agriculture was practiced using organic techniques where the fertilizers, pesticides were obtained from plant and animal products. According to Codex Alimentarius (FAO), organic agriculture is a holistic production management system which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity.

Components of organic farming :

The major components and practices followed in organic production are :

High yielding varieties and hybrids resistant to pests and diseases :

There are some varieties in each crop, which perform very well under restricted resource availability and are resistant to biotic and abiotic conditions. Such varieties can be grown to reduce the cost of cultivation. Further such varieties can meet the standards of organic farming, as they do not need agri-chemicals. The breeders have to develop crop varieties, which can successfully compete with weeds and resist to insect-pests and diseases. It has been found that the crop varieties, which show early vigour, generally hamper the growth of weeds.

Biofertilizers for economizing nitrogen and phosphorus fertilizers :

Biofertilizers are the products containing living cells of different types of micro-organisms that have the ability to mobilize nutrients from unusable form to usable form through biological processes. These are symbiotic and non symbiotic bacteria, phosphate solubilizing micro organisms, fungi, mycorrhizal fungi etc., these micro organisms play a vital role in improving the soil fertility and crop productivity due to their ability to fix atmospheric nitrogen and solubilize inorganic phosphorus.

The biofertilizers which are of great significance in vegetable production are:

Nitrogen fixers :

– Symbiotic nitrogen fixers - *Rhizobium*

– Asymbiotic nitrogen fixers - *Azotobacter, Azospirillum*

Phosphorus mobilizers :

Vesicular Arbuscular Mycorrhiza (VAM), Ectomycorrhizae

Phosphorus solubilizers :

Bacillus, Pseudomonas, Micrococcus, Phosphobacteria

Nitrogen fixers:

The commonly used nitrogen fixing microbial

Growing of high yielding varieties and hybrids resistant to biotic and abiotic conditions

Sr. No.	Crop	Pests/diseases	Varieties
1.	Brinjal	Bacterial wilt	BWR12, Arka Nidhi, Annamalai
		Shoot and fruit borer, Little leaf virus, Phomopsis blight	Pusa Purple Round, Punjab Neelam, Punjab Barsati, Pant Rituraj, Pant samrat
2.	Chilli	Leaf curl virus, CMV, TMV and leaf curl	Pusa Jwala, Pusa Sadabahar, Punjab Lal
		Mosaic, wilt and dieback	Punjab Surkh,
3.	Cabbage	Black rot, cabbage yellow,	Pusa Mukta, Green land hammer
4.	Cauliflower	Black rot, Sclerotinia rot, curd blight	Pusa Shubra,PSBK-1
5.	French bean	Common mosaic virus and rusts, Anthracnose, Rhizoctonia wilt	Pusa Anupama, Tendrette, Pintado, Sea
6.	Okra	Yellow Vein Mosaic Virus	Varsha Uphar, Arka Anamika, A. Abhay, Prabhani Kranti, Hisar unnat
7.	Onion	Thrips, Alternaria blight, Purple Blotch, Downy mildew	Arka Niketan, Pusa Ratnar, Pusa Naroya
8.	Water melon	Anthracnose, Powdery mildew, red pumpkin beetle	Arka Manik, Candy red, Afghani
9.	Cucumber	Anthracnose, Powdery mildew, Red pumpkin beetle, Bacterial wilt	All season Korea, Table green, Vodolei
10.	Musk melon	Downy mildew, Powdery mildew, red pumpkin beetle, fruit fly	Pusa Sharbati, Arka Rajhans, Hara Madhu,
11.	Potato	Early blight, late blight, tuber moth	K. Sindhuri, K. Pukhraj, K. Swarna, K. Jyoti
12.	Tomato	Bacterial wilt	Roma, Chhuhara, Angurlata, Pant Bahar, Solan Gola
		Shoot and fruit borer, leaf curl virus,	
13.	Capsicum	Bacterial wilt	Nishat-I, Waxy Globe, KAU cluster
		Fusarium wilt	
14.	Cowpea	Bacterial wilt	Pusa Komal
15.	Pea	Common mosaic virus, wilt, Powdery mildew, leaf minor	Wisconsin, Mithi Phali, Pusa Vipasa, Alaska

inoculants in vegetables include:

Rhizobium species:

They are the most commonly used inoculants in case of leguminous crops like beans, pea etc. Rhizobia enter the roots through root hairs multiply there and form tumor like out growths called nodules. These rhizobia fix atmospheric nitrogen with the help of enzyme nitrogenase. Rhizobia exhibit a great degree of specificity in infecting the legumes e.g R. leguminosarum v. phaseoli can colonize only beans, R. meliloti can infect only Lucerne species.

The air we breathe is primarily a mixture of nitrogen and oxygen. A column of air over a hectare of land contains 80, 000 tones of N, but in this form it is not useful to plant life. Among bio-fertilizers, *Rhizobium* inoculants are most important. They fix atmospheric nitrogen in symbiotic association with legumes. *Rhizobia* colonize the roots of legume vegetables, enter the roots of legume vegetables through root hairs, multiply and form tumor like structures called nodules. *Rhizobia* fix atmospheric nitrogen in the nodules, whereas nodules provide them protection and food. The process of nitrogen fixation depends upon enzymes nitrogenase which is found in bacteroid zone of nodule. Both rhizobial inoculants and legume vegetables show a certain degree of specificity. A particular grade of rhizobial inoculant can infect a specific legume. However they may sometimes show cross infection due to mutation in the Rhizobial inoculants. For instance *Rhizobium leguminosarum* can nodulate peas only, while as *Rhizobium leguminosarum* pv. *phaseoli* can nodulate French beans and other beans. *Rhizobial* inoculants are broadly classified in two groups: (i) *Rhizobium* (fast growing) (ii) *Bradly Rhizobium*

Crop response :

Method of inoculation :

Seed inoculation :

Make 10 per cent sugar solution to serve as a sticker for rhizobial cells in 500-1000 ml of water. Boil the solution and cool. Open one packet of inoculants and mix the contents in the cooled solution thoroughly. Heap the seed on the clean surface and pour the inoculant slurry. Mix the seed with slurry evenly. Dry the inoculated seeds in shade and sow immediately. 300 grams of inoculant are sufficient for treating 10 kg of seed. It can also be applied by drilling the granular form of the inoculant along with seed in the soil or by broad casting the inoculant directly in the soil by mixing 2.5-5.0 kg of *rhizobium* inoculant with 30-50 kg of fine soil or well decomposed FYM.

Non-symbiotic nitrogen fixers :

Azotobacter :

It is free living nitrogen fixer and is one of the most important non-symbiotic nitrogen fixing micro-organism. It is highly aerobic, heterotropic bacterium growing in neutral to alkaline soils. There are three species of *Azotobacter*, out of which *Azotobacter chrococcum* is the most dominant species. *Azotobacter* requires more moisture and high amount of organic matter in the soil for its growth and proliferation as compared to other micro-organisms. *Azotobacter* inoculant is used widely in vegetable crops and it is known to promote growth and yield of vegetable crops, besides providing a nitrogen economy of 10-20 per cent. Increase in yield ranges from 0-30 per cent. The beneficial effects of *Azotobacter* are attributed to its N_2-fixing ability, production of growth promoting substances and anti-fungal activities. It was observed that response of vegetable crops to *Azotobacterization* was better than any other crop and increase in the crop yield varied according to location and *Azotobacter* strain used.

Azospirillum :

Is a group of bacteria, which are found in loose association with root system of many crops. These bacteria grow under reduced oxygen levels. There are four species of *Azospirillum* out these two species *A. lipoferum* and *A. brasilense* are commonly found. They fix atmospheric nitrogen 10-40 kg ha^{-1} by colonizing the root system of many vegetable crops. *Azospirillum* is used as a potential biofertilizer in vegetable crops and is reported to increase the yield as well as compensate some quantity of chemical nitrogen upto the tune of 25-30 per cent. However, the response varied with the crop, season, location, level of native micro-organisms and nutrient status of soil. Crop response could be attributed to its ability to fix atmospheric nitrogen, increase in root biomass and production of certain hormones. In addition to *Azotobacter*, *Azospirillum* several species of *Bacillus* are also used to colonise the rhizosphere of vegetable crops, thereby improving vegetative growth of crops. They also produce growth-promoting substances, but are considered weak nitrogen fixers.

Methods of inoculation :

Seed treatment:

Same as in *Rhizobium.* The quantity of biofertilizer required for seed treatment varies according to the size of the seed. In cole crops and other small sized seeds 300-500 g is sufficient for treating the seeds required for one hectare. In crops like beans, peas 300 g is sufficient for inoculating 10 kg of seed.

Seedling dip method:

In this method one kg of *Azotobacter* inoculant is mixed in 20 litres of water. Seedlings/Seed tubers are dipped in the slurry for 20-30 minutes and then planted immediately. 2-2.5 kg of biofertilizer is sufficient for one hectare. However in case of potato seed tubers, the quantity of inoculum can be increased according to need. Same holds good for *Azospirillum* and *Bacillus.*

Soil inoculation:

Azotobacter inoculant is directly applied to the soil. 2.5-5 kg of inoculant is mixed with well refined 30-50 kg of soil or FYM ha^{-1}. It should be applied two days after chemical fertilizer application. Same holds good for *Azospirillum* and *Bacillus.*

Phosphatic biofertilizers :

Next to nitrogen, phosphorus is the other nutrient required by vegetable crops in more quantity. Most of the soil phosphorus is in unavailable form and hardly 1-2 per cent of it is incorporated in the plant root zone area. The phosphatic fertilizers which we apply, only 15-20 per cent of it is consumed by plants, rest gets fixed in the soil. Another factor which effects the utilization of phosphorous is its low mobility in the soil. Nature has provided certain biological organisms which help in overcoming these problems. Species of *Pseudomonas, Micrococcus, Flavobacterium Phosphobacteria* can make the fixed phosphorus available to plants by converting them into soluble form by secreting organic acids such as acetic, furmaric and succinic acids etc. These acids lower pH and bring about dissolution of bound forms of phosphate. They are also known to produce amino acids, vitamins and growth promoting substances which help in better growth of vegetable crop. The increase in yield due to phosphorus solublizers ranges from 10-15 per cent and in general 40 per cent superphosphate can be saved. The problem of low phosphorus mobility in soil can be eliminated by the use of mycorrihizal fungi, which form most common fungal association among angiosperms. The vesicular arbuscular mycorrihizae (VAM) are formed by non-septate phycomycetes fungi. They produce vesicles and arbucules inside the root system. Improvement in growth due to VAM inoculation can be attributed to more nutrient and moisture availability, improvement in soil texture, production of growth promoting substances and resistance to many soil borne pathogens like *Phythium,* nematodes, *Rhizoctonia* and *Phytopthora*. Inoculation of vegetable crops with PSM has depicted an increase in yield, besides helping in saving some quantity of chemical phosphorus. Vegetable crops have responded well to phosphorus solubilizers and phosphorus mobilizers and proved effective in increasing the yield and saving phosphatic fertilizers.

Application of biofertilizers is of great significance in organic farming. Application of biofertilizers in conjugation with organic manures and crop residues constitutes an efficient nutrient management strategy in vegetable crops and has exhibited improvement in growth, yield and quality attributes of various vegetable crops (Table 1).

Nutrient status of some organic manure			
Sources	Nutrient content (%)		
	N	P_2O_5	K_2O
FYM/compost	0.5-1.0	0.15-0.20	0.5-0.6
Poultry manure	2.87	2.90	2.35
Cattle dung	0.3-0.4	0.10-0.15	0.15-0.2
Sheep and goat dung	0.65	0.05	0.03

Organic materials such as FYM, composts etc. in place of inorganic fertilizers :

Compost:

Compost is organic matter that has been decomposed and recycled as a fertilizer and soil amendment. Compost is a key ingredient in organic farming. At its most essential, the process of composting requires simply piling up waste outdoors and waiting a year or more. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air and carbon- and nitrogen-rich materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture. Worms and fungi further break up the material. Aerobic bacteria manage the chemical process by converting the inputs into heat, carbon dioxide and ammonium. The ammonium is further converted by bacteria into plant-nourishing nitrites and nitrates through the process of nitrification.

Compost can be rich in nutrients. It is used in gardens, landscaping, horticulture, and agriculture. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In ecosystems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover (see compost uses). Compost can also be used to generate biogas through anaerobic digestion.

Green manuring:

In green manuring undecomposed green plant tissue is ploughed or turned into the soil. It increases organic matter and nitrogen content of soil. Green manuring crop absorbs nutrients from the lower layers of soil and make them available in upper layers. Reduce runoff, erosion and growth of weeds. Green manuring crops are classified into two groups *viz*., legumes and non-legumes and legumes are further sub-divided under two groups in each *viz*., green manure (Dhiancha, Sunhemp, Kolinji) and green leaf manure (Gliricidia, Cassia, *Pongamea glabra*).

Some common leguminous green manure plant species are listed below:

Leguminous green manure plant species	
Botanical name	Local name
Sesbania speciosa	Sesbania
Sesbania aculeata	Dhaincha
Crotlaria juncea	Sunnhemp
Phaseolus trilobus	Cowpea
Vigna unguiculata, (Syn. V. sinensis)	Clusterbean (Guar) Greengram
Cyamopsis tetragonoloba	(Mungbean) Blackgram

Some of the common shrubs and trees used as green leaf manures are the following:

Cassia auriculata, Derris indica, Ipomoea cornea, Thespesia populnea, Azadirachta indica, Glyricidia maculata, Leucaena leucocephala, Calotropis gigantea, Delonix regia, Delonix elata, Jatropha gossypifolia, Cassia tora, Cassia occidentalis, Tephrosia purpurea.

Nutrient content of green manure crop and green leaf manure :

Crop/plant	Scientific name	Nutrient content (%) on dry basis		
		N	P_2O_5	K_2O
Sunhemp	*Crotolaria juncea*	2.30	0.50	1.80
Dhaincha	*Sesbania aculeata*	3.50	0.60	1.20
Neem	*Azadirachta indica*	2.83	0.28	0.35
Gulmohar	*Delonix regia*	2.76	0.46	0.50
Water hyacinth	*Eichhornia crassipes*	3.01	0.90	0.15
Cassia	*Cassia fistula*	1.60	0.24	1.20

Vermicomposting :

The process of composting organic wastes through domesticated earthworms under controlled conditions is vermicomposting. Earthworms have tremendous ability to compost all biodegradable materials. Wastes subjected to earthworm consumption decompose 2 to 5 times faster than in conventional composting. During composting the wastes are de-odourised, pathogenic micro-organisms are destroyed and 40 to 60 per cent volume reduction in organic wastes takes place. It is estimated that the earthworms feed about 4 to 5 times their own weight of material daily. Thus one kg of worms decompose approximately 4 to 5 kg of organic wastes in 24 hours.

Biodegradation of organic matter by earthworms is one of the recent developments in which earthworms and microbes work together and produce vermicompost or vermicastings which is a fecal matter with worm casts. The worm cast contains all the nutrients in available form and in addition, a great deal of organic matter is provided to the soil which makes it very productive.

Currently earthworm species *Eisenia foetida, Eudrilus eugeniae, Perionyx excavatus, Lumbricus rubellus* and *Pheretima longate* are being used for compost production. Paddy straw, sugarcane trash, maize, vegetable waste, etc. are suitable crop wastes which favour faster development of earthworms. Vermicompost provides vital macro elements like N, P_2O_5, K_2O, Ca, Mg and micronutrients such as Fe, Mo, Zn, Cu, etc. apart from growth substances like NAA, cytokinins, gibberellins, etc. It also harbours beneficial micro flora within it (Table 1).

Earthworms play key role in soil biology as versatile natural bioreactors. They effectively harness the beneficial soil micro flora, destroy soil pathogens and convert organic wastes into valuable products such as biofertilizers, vitamins, enzymes, antibiotics and growth hormones. Hence, we can call the earthworms as 'artificial fertilizer factories',

Major nutrients (%)			Minor nutrients (ppm)			Micro-organisms (per g)		
N	P	K	Cu	Fe	Zn	Fungi	Bacteria	Actinomycetes
1.10	0.86	0.98	52.0	930.0	186.6	$2.65x10^4$	$1l.37x10^7$	$10.43x10^4$

Earthworm's gut is an effective tubular bioreactor, with raw materials (feed) entering from one end and the product (castings) coming out through the other end. Gizzard is a novel colloidal mill in which the feed is ground into particles smaller than 2 microns, giving thereby an enhanced surface area for microbial processing. They have an in-house supply of enzymes such as protease, lipase, amylase, cellulase and chitinase, which bio-degrade complex biomolecules into simple compounds utilizable by the symbiotic gut microflora.

Weed control in organic vegetable production :

Vegetables crops are found infested with a number of weed species including grassy, non-grassy and sedges. The vegetative growth of weeds is so fast they completely cover crop plants if not weeded at proper stage, particularly during rainy season. In general, critical period of crop-weed competition in vegetables has been observed between 15-60 days after sowing/transplanting. Most vegetables are initially slow growing crops, incapable of offering any competition to the aggressive weeds. Dense growth of weeds in vegetables hides fruits, which (i) are variously discoloured in the absence of natural light, (ii) become over-ripe, and (iii) finally rot. For harvesting vegetables at their intended development stage, the visibility of vegetables should not be hindered by weeds. Root vegetables are malformed in the presence of weeds because of underground competition for space. Following methods can be used individually or in different combinations to control weeds in vegetable crops:

Mechanical methods :
- Tillage
- Soil solarization
- Hand weeding
- Stale seed bed technique
- Use of mulch
- Thermal weed control method

Biological methods :

Crop rotation :

The weeds cause expensive and laborious hand weeding in carrots normally somewhere between 100-300 man-hours per hectare. The weed problems are most severe in early sown crops with slow early development, e.g. root crops and onions. The main problem is usually annual weeds within the row. Perennial weeds may also cause problems but can more easily be controlled mechanically between the crops. The hand-weeding is mainly a problem of getting labour rather than a economical problem. At least in Sweden, the additional price for alternatively grown products well includes the extra costs for hand weeding. Mechanical and thermal control inputs are important control methods which reduce the need for hand weeding. However, harrowing, row cultivation and flaming, as they are used today, all have one thing in common; they only have a short term effect and in general they cannot control the weeds in the row we enough.

By delayed sowing several weeds can be killed before sowing and crop emergence. The aim is to knock down the early germinating weeds, and perhaps a second flush of weeds, without further soil tillage

Organic materials such as straw or cut fresh green manure can be spread out immediately after planting the crop. With this type of mulching the need of hand weeding is almost eliminated.

Flame weeding, also called flame cultivation, relies on propane gas burners to produce a carefully controlled and directed flame that briefly passes over the weeds. The intense heat sears the leaf, causing the cell sap to expand and disrupt cell walls. The flamed weeds soon wilt and die, usually in one to three days. Weeds are most susceptible to flaming when they are seedlings, 1 or 2 inches tall. Broadleaf weeds are more susceptible to lethal flaming than grasses. Grasses develop a protective sheath by the time they are approximately 1 inch tall and may require a second flaming.

The biological control of weeds involves the use of living organisms, such insects, animals, disease organisms. Biological method of weed control in vegetable crops has still long way to go. However bio herbicides are coming up for future use effectively.

Pest management in organic vegetable production:

Physical methods
- Soil solarization

Some commercial mycoherbicides:			
Sr. No.	Name of the pathogen	Trade name	Weed controlled
1.	*Bipolaris sorghicola*	BIOPOLARIS	Johnson grass (*Sorghum halepense*)
2.	*Alternaria cassiae*	CASST	*Cassia obtusifolia*
3.	*Cercospora rodmanii*	ABG 5003	Echhorinia crassipes
4.	*Streptomyces hygroscopicus*	BIOLOPHOS (fermented microbial toxin)	Non specific general vegetation

Bio control agents for weed management		
Sr. No.	Insect	Weed controlled
1.	*Cactoblastis cactorum, Dactylopius ceylonicus*	Prickly pear cactus, spiny prickly pear
2.	*Zygogramma bicolorata*	*Parthenium hysterophorus*
3.	*Neochetina eichhorniae, N. bruchi*	Water hyacinth
4.	*Bactra verutana*	*Cyperus rotundus*
5.	*Echinochloa* spp.	*Emmalocera spp.*

– Mechanical control

– Light and pheromone traps

Cultural methods :

– Field and plant sanitation

– Habitat diversification (Crop rotation, Trap cropping)

– Time of planting/ sowing

– Tillage operations

– Water management

Biological methods :

– Biopesticides and

– Bio control agents

Biopesticides and bio-control agents :

Biopesticides are derived from animals, plants and microorganisms such as bacteria and viruses. The advantages of biopesticides are:

– They are inherently less harmful than chemical pesticides;

– They are more target specific than chemical pesticides affecting only the target pests and their close relatives. In contrast, chemical pesticides often destroy friendly insects, birds and mammals.

– They are often effective in small quantities. Also, they decompose quickly and do not leave problematic residues.

The most commonly used biopesticides include *Bacillus thuringiensis* (Bt), Baculoviruses and neem. In addition to these, trichoderma, which is a fungicide, is also used. Biocontrol agents, such as Trichogramma, are parasites and predators of pests and their eggs. These biopesticides and bio-control agents are briefly described below:

– *Bacillus thuringiensis (Bt). Bacillus thuringiensis* is the most commonly used biopesticides globally. It is primarily a pathogen of lepidopterous pests which are some of the most damaging. These include American bollworm in cotton and stem borers in rice. When ingested by pest larvae, Bt releases toxins which damage the mid gut of the pest, eventually killing it.

– *Baculoviruses*: These are target specific viruses which can infect and destroy a number of important plant pests. They are particularly effective against the lepidopterous pests of cotton, rice and vegetables. Their large-scale production poses certain difficulties,so their use has been limited to small areas. They are not available commerciallyin India, but are being produced on a small scale by various IPM centres and state agricultural departments.

– *Beauvaria bassiana:* This bio pesticide is prepared from entomopathogenic fungus *B. bassiana* that infects insect pests. It is most effective against lepidopteron caterpillar pest of vegetables and fruit plants and sucking pests like mites and spiders of vegetables and flowers, borer, white flies on cotton andvegetables, aphids, scale insect, Colorado beetle of potato.

– *Neem*: Derived from the neem tree *(Azadirachta indica)*, this contains several chemicals, including 'azadirachtin', which affects the reproductive and digestive process of a number of important pests. Recent research carried out in India and abroad has led to the development of effective formulations of neem, which are being commercially produced. As neem is non-toxic to birds and mammals and is non-carcinogenic, its demand is likely to increase.

– *Trichoderma: Trichoderma* is a fungicide

Sr. No.	Crop	Trap crop/Decoy crop	Pest controlled
1.	Cabbage	Mustard, cauliflower	*Plutella xylostella*
2.	Tomato	Maize, Mariglod	*Helicoverpa armigera*
3.	Tomato	Pumpkin	White fly
4.	Chilli	Marigold	*Helicoverpa armigera*
5.	Brinjal	Marigold	*Meloidogyne incognita, M. javanica*
6.	Tomato	Marigold	*M. incognita*
7.	Okra	Marigold	*Meloidogyne* spp.

effective against soil borne diseases such as root rot. It is particularly relevant for dryland crops such as groundnut, black gram, green gram and chickpea, which are susceptible to these diseases. *Trichoderma* spp. *viz., Trichoderma viride, T. harzianum, T. koningii, T. hamatum*, etc. have been in use to produce various biopesticides under different trade or commercial names. It is highly active on root rot, foot rot, collar rot, stem rot, damping off, wilt, blight/leaf spot, of crops like patchouli, coleus, melissa and pulses, oil seeds, cucurbitaceous crops like cucumber, pumpkin, bottle gourds, ridge gourds: Solanaceous crops like tomato, brinjal, chillies, capsicum, cole crops *i.e.* cabbage, cauliflower: root crops diseases like tuber, rhizome rot of potato, ginger, turmeric along with rotten diseases of garlic, flowers etc, the product is also effective against sheath rot, sheath blight and bacterial leaf blight (BLB) of rice.

– *Trichogramma: Trichogramma* are minute wasps which are exclusively egg-parasites. They lay eggs in the eggs of various lepidopteran pests. After hatching, the *Trichogramma* larvae feed on and destroy the host egg. *Trichogramma* is particularly effective against lepidopteran pests like the sugarcane internode borer, pink bollwormand sooted bollworms in cotton and stem borers in rice. They are also used against vegetable and fruit pests. *Trichogramma* is the most popular bio-control agent in India, mainly because it kills the pest in the egg stage, ensuring that the parasite is destroyed before any damage is done to the crop.

– Nicotine Sulfate:Nicotine is extracted from tobacco or related *Nicotiana* species and is one of the oldest botanical insecticide in use today. It is also one *of* the most toxic to warm-blooded animals and readily absorbed through the skin. It breaks down quickly,however, so it lega1ly acceptable to use on organically grown crops. Nicotine sulfate is sold as a 40 per cent nicotine sulfate concentrate under trade names that include black leaf 40or tender leaf plant insect spray. Nicotine kills insects by interefering with the transmitter substance between nerves and muscles. It is commonly used to control aphids, thrips, spider mites and other sucking insecticides on most of the vegetables. Nicotine sulfate has a danger warning.

– Sabadilla: It is another botanical insecticide, is derived from the seeds of the sabailla lily. The active ingredient is an alkaloid known as veratrine. Sabadilla is considered among the least toxic of botanical insecticides, No residue is left after application of sabadilla because it breaks down rapidly in the sunlight. Sabadilla is effective against caterpillars, leaf hoppers, thrips, stink bugs and squash bugs. The insecticide is labeled for use on many vegetables. It has been assigned a caution rating.

– Rotenone: Rotenone is a resinous compound produced by the roots of two members of the leguminosae family. Its common use is to control various leaves feeding caterpillars, beetles, aphids and thrips on a wide variety of vegetables and small fruits. A slow acting chemical, rotenone requires several days to kill most susceptible insects, but insect feeding stops shortly after exposure. Rotenone is moderately toxic to mammals but is extremely toxic to fish. It has been assigned a caution rating.

– Pyrethrum/Pyrethrin: Pyrethrum is the most widely used botanical insecticide in the United States. The active ingredient pyrethrin is extracted from a chrysanthemum plant, grown primarily in Kenya, Rwanda, Tanzania and Ecuador. Pyrethrum is non-toxic to most mammals, making it among the safest insecticides in use. The environmental protection agency has approved it for more uses than any other insecticides.

Trap crops:

Growing of susceptible or preferred hosts along with the main crop which attracts the pests in large numbers and thus can be killed selectively.

Crop rotations:

Crop rotations are fundamental to sustainable cropping systems. A well-designed crop rotation creates farm diversity and improves soil conditions and fertility. A simple definition of crop rotation is the planting of different crops in recurring succession in the same field. The benefits usually associated with good crop rotations are:

– Maintains good soil physical condition and organic matter

– Improves distribution of plant nutrients in the soil by varying the feeding range of roots

– Improves fertility with legume nitrogen and, when using green manure crops, makes other plant nutrients more available

– Fosters the most effective use of manure and fertilizer

– Helps control weeds, some plant diseases and insect pests

– Reduces need for purchased herbicides and fertilizer

– Can enhance soil moisture management

– Promotes income diversity and stability through increased marketing options

– Better allocates farmer's labor and equipment usage through the year

– Improves crop quality and yields by 10 - 15 per cent

– Provides low cost forages for livestock with return of manure on cropland

– Reduces the cost of conservation compliance

– Improves diversification and soil quality to reduce drought impact

– Reduces soil erosion. Increases flora, fauna and wildlife diversity and numbers

– Improves water quality through reduction in loss of agricultural chemical off-field

Intercropping:

Intercropping is defined as the growing of more than one crop species or cultivar simultaneously in the same field during a growing season. It is the practical application of ecological principles such as diversity, crop interaction and other natural regulation mechanisms. Intercropping has many advantages, mainly related to the complementary use of environmental resources by the component crops which results in increased and more stable yields, better nutrient recycling in the soil, better control of weeds, pests and diseases and an increased biodiversity.

Mulching:

Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production. Mulch technical term means 'covering of soil'. While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the methods and benefits of mulching. Mulching with organic or artificial materials is very useful methods in and will probably be used more in the future. Mulching serves several purposes in organic production including reducing weed growth, conserving soil moisture and nutrients, regulating soil temperature, helping prevent soil erosion, and reducing water splashing on plants (which keeps them cleaner and reduces the spread of disease). An added benefit comes from organic mulch: As it decomposes, it increases the amount of organic matter in the soil. Almost any organic matter can be used successfully as mulch. This can include things such as old hay, straw, leaves, sawdust, paper, or bark.

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