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Research Article

Disease Management Approaches to Organic Farming of Chili (*Capsicum annuum* L.) in Rajasthan, India: Implications and Challenges

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ABSTRACT

Organic farming is a holistic approach that preserves natural resources, increases the biodiversity of the area, and respects the environment. Because the previous intensive agriculture has disturbed natural habitats and heterogeneity, organic or low-input farming has a less negative impact on biodiversity and naturally controls weeds and pests. Chili (Capsicum annuum L.) is highly rich in vitamins and hence antioxidant. The present study was carried out in the Jhunjhunu district of Rajasthan, where organic farming of chilli is being done on a large scale. Farmers use biofertilizers and biopesticides to manage nutrients and diseases. During the survey, various diseases in chili plants were observed and listed in the present article. Management strategies used for nutrition and controlling diseases on chilli plants are mentioned as case study in the paper.

Keywords: *Organic farming, Capsicum, Biofertilizers, Biopesticides.*

INTRODUCTION

Organic farming has higher biodiversity than conventional farming, which is between 10.5 and 30 per cent (Schneider et al., 2014). In conventional farming, rigorous use of chemical inputs like weedicides, fungicides, nematicides, and pesticides over the past few years has led to negative effects on soil microflora and decreased soil fertility (Daunde & Khandare 2020). This long-term use causes a loss of biodiversity in that area, while organic farming practices based on animal composts, crop rotations, crop remains, green manures, leguminous plants, and bio-inoculates / bio-fertilizers are safe and maintain soil health and crop yield. Organic farming limits the use of synthetic chemicals and PGR (Plant Growth Regulator) for impure soil health and enhances soil fertility by organic material or farm waste products (Sharma et al., 2019).

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Capsicum annuum L. is the world's most important vegetables as a spice crop cultivated in nearly all parts of the tropical and subtropical regions of India. Its fruits contain several important chemicals including carotenoids, flavonoids, capsaicinoids, tocopherols (vitamin E), ascorbic acid (vitamin C), vitamin A, thiamine, niacin, vitamin K, calcium, copper, iron, magnesium, manganese, phosphorus, selenium, zinc, -carotene, etc. (Votava et al., 2000). The spiciness of Chili is due to the alkaloid capsaicin, which is found in the pericarp and placenta of fruits.

Spices are important crops, especially for India, due to higher export interest and low volume storage (Sugasini et al., 2018). The family Solanaceae holds various vegetable species having excessive economic standing in agronomy. The two most significant vegetable crops in this family, which are also the richest in antioxidants and critical nutrients, are tomatoes and chillies. The most significant economic characteristic of chili is fruit output. Dry chili powder is rich source of various substances, particularly flavonoids. It can be added to food as an ingredient during food preparation to improve nutritional value (de Sa Mendes et al., 2019). Chili producing top 10 states of India (production in tonnes) is shown in Figure 1 and Chili producing top 10 states of India (% share) is shown in Figure 2.

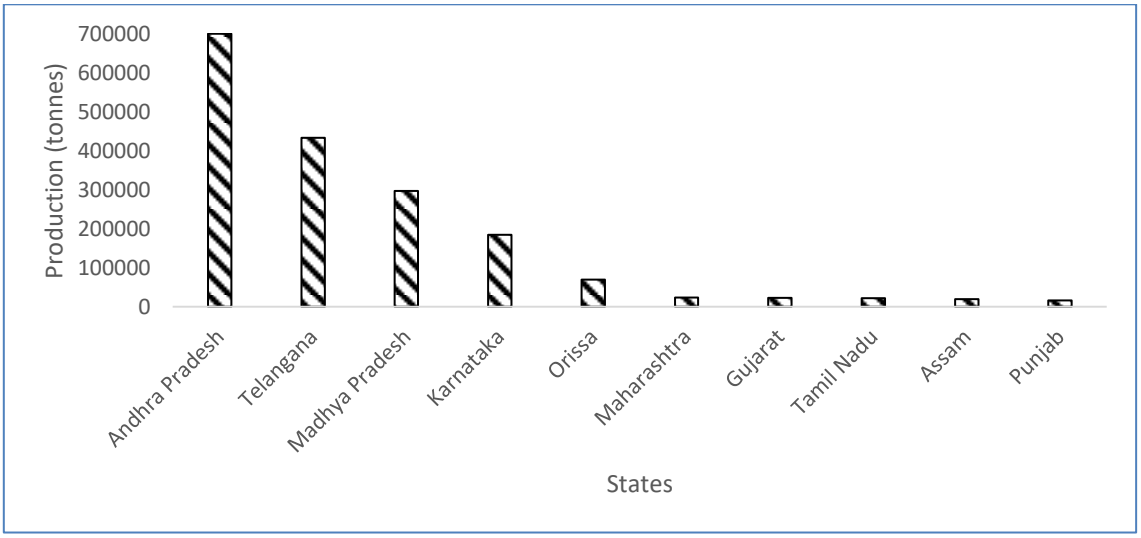

Figure 1 Chili producing top 10 states of India (production in tonnes)

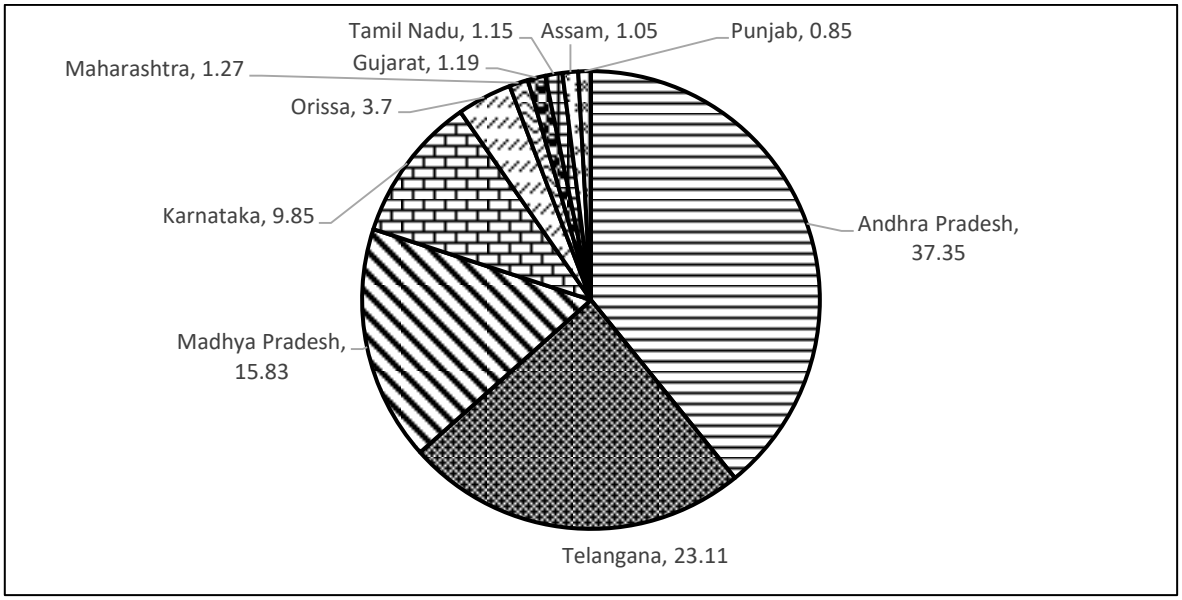

Figure 2 Chili producing top 10 states of India (% share)

The present paper will provide an insight towards the challenges farmers are facing in the applicability of organic farming. The diseases of chili need to be controlled biologically without intervention of chemicals will be identified. Jhunjhunu district is situated in the southwest of the State of Rajasthan. The geographical coordination of the area lies between 27° 38' and 28° 31' North latitudes and 75° 02' and 76° 06' East longitudes, between 300 and 450 meters are the height above sea level. The total geographical area of the district is 5928 sq. Kms. The annual precipitation rate is 459.8 mm. The region receives a hot summer, little rainfall, a cold winter, and a typically dry climate except for the short monsoon season. Winter temperatures can reach lows of 0 °C, while summer temperatures can reach highs of 50 °C. The hot wave called Loo blows in the hotter months. The normal precipitation mostly received from the southwest monsoon varies from 450 to 600 mm. According to the geological data, the area is largely determined sandy soil and semi-arid environmental conditions.

MATERIAL AND METHODS

The study area was located in the Jhunjhunu district of Rajasthan (Eastern Rajasthan), and a total of 16 farms were selected and surveyed for the study. Four farms using conventional farming methods and 12 farms using organic farming methods were approached to grow *C. annuum* at the same time. Farms that have switched from conventional to organic farming take time to adjust to changes in soil content and environmental conditions. There was a significant difference in soil fertility and retention capacity between the three types of organic farming farms. Farmers from all farms were given seeds of the *C. annuum* variety (Kharpuri) to grow. Farms were surveyed regularly to ensure proper monitoring of farming practices.

Kharpuri chili is a local high-yielding variety cultivated in Nawalgarh in the Jhunjhunu district. Kharpuri fruit size can reach 30 cm, plant height is between 106 and 108 cm, stem width is 1.5 cm, leaf span is between 2 and 3 cm, and the color of the unripe fruit is red. Both Kharpuri and Todpura varieties have high economic value.

A survey was carried out on the different farms of Jhunjhunu, Rajasthan to collect information on different forms of uses, the traditional production practices, and the storage or conservation processes. It also helped to identify the importance of chili pepper in the diet of the villager population without forgetting to identify the different techniques (traditional and modern) used to prevent and control fungal contamination of chili pepper in the field and after harvesting. The survey was carried out in 2019-20, 2020-21, and 2021-22 during the growing seasons (April to August).

In the present study during field visits of the organic farms, farmers reported various kinds of diseases in the Chili crop. Organic farming practices do not permit doses of chemical pesticides. In such conditions, farmers are using biopesticides and natural pesticides made up of neem and other plant extracts. Sometimes these are not sufficient and standing crops face different diseases. We report here various diseases caused by several pathogens. Chili plants with upward and downward leaf curling, leaf spots, and leaf yellowing due to nutrient deficiency were identified from Nawalgarh, Jhunjhunu district, Rajasthan, India, as part of a routine survey for *Begomovirus* infection (2018 to 2021). The report will help to find the solutions to these diseases in an eco-friendly manner to promote organic farming in Rajasthan.

Table 1: Chemical pesticides used to control diseases in conventional farming

S. No.	Anthracnose (*Colletotrichum spp.*),	Tebuconazole (30ml), Thiophanate methyl (30gm), Propineb (40gm), Ridomil gold (30gm), M-45 (45gm),
1.	Bacterial wilt (*Pseudomonas solanacearum*),	Kasugamycin (35ml), Copper oxychloride (40gm),
2.	Chili/pepper leaf curl virus (ChiLCV),	Rogor (45ml), Imidaachloropid (10ml), Diafenthiuron (40gm), Spiromesifen (30ml), Pyriproxyfen (50ml),
3.	Nematode (*Meloidogyne javanica*),	Carbofuran p 3% Gr (20kg/hec), Velum prime (450ml/hec), Nemetrix (40gm/hec),
4.	Powdery mildew (*Leveillula taurica*),	Imidaachloropid (10ml), Fipronil
5.	Yellow mites (*Polypagotarsonemus latus*)	Sulphur 80wdg (40gm), Dicofol (40ml), Ethion (40ml), Abamectin (20ml), Fenpyroximate (30ml)
6.	Damping off Disease in Chili (*Pythium*)	Carbendazim (2gm/kg seed), Metalaxyl (0.64gm/kg seed)
7.	Blossom end rot tomatoes/Chili (abiotic stress)	Nematoz-P, Dimethoate
8.	White gurb	1% Dimethoate or Methyl demeton (2 mL per litre of water), Monocrotophos 1.5mL, Acephate (1g in one litre of water).

OBSERVATION AND RESULTS

In the present study during field visits of the organic farms, farmers reported various kinds of diseases in the chili crop. Organic farming practices do not permit doses of chemical pesticides. In such conditions, farmers are using biopesticides and natural pesticides made up of neem and other plant extracts. Sometimes, these are not sufficient, and standing crops face different diseases. We report here various diseases caused by several pathogens. Table 1 reports all the chemical pesticides being used to manage diseases in conventional or chemical farming. Following diseases on *Capsicum annuum* L. Kharpuri variety were identified from Nawalgarh, Jhunjhunu district, Rajasthan, India.

3.1 Diseases reported on organically grown chili

3.1.1 Chili Fruit Borer (*Helicoverpamn armigera*): -

Caterpillars devour crop leaves and then enter the fruit, resulting in a significant loss in yield management. Collect and eliminate any damaged fruits or caterpillars that have grown up (Fig. 1 A).

3.1.2 Anthracnose (*Colletotrichum spp.*): -

Warm temperatures and excessive wetness stimulate the growth of the fungus *Colletotrichum piperatum* and *Colletotrichum capsici*, which cause the disease. It is characterized by the formation of black patches on affected areas. Spots are often round, wet, and depressed, with black edges. Fruits with a lot of spots drop off early, resulting in a lot of yield loss (Fig. 1 B & D).

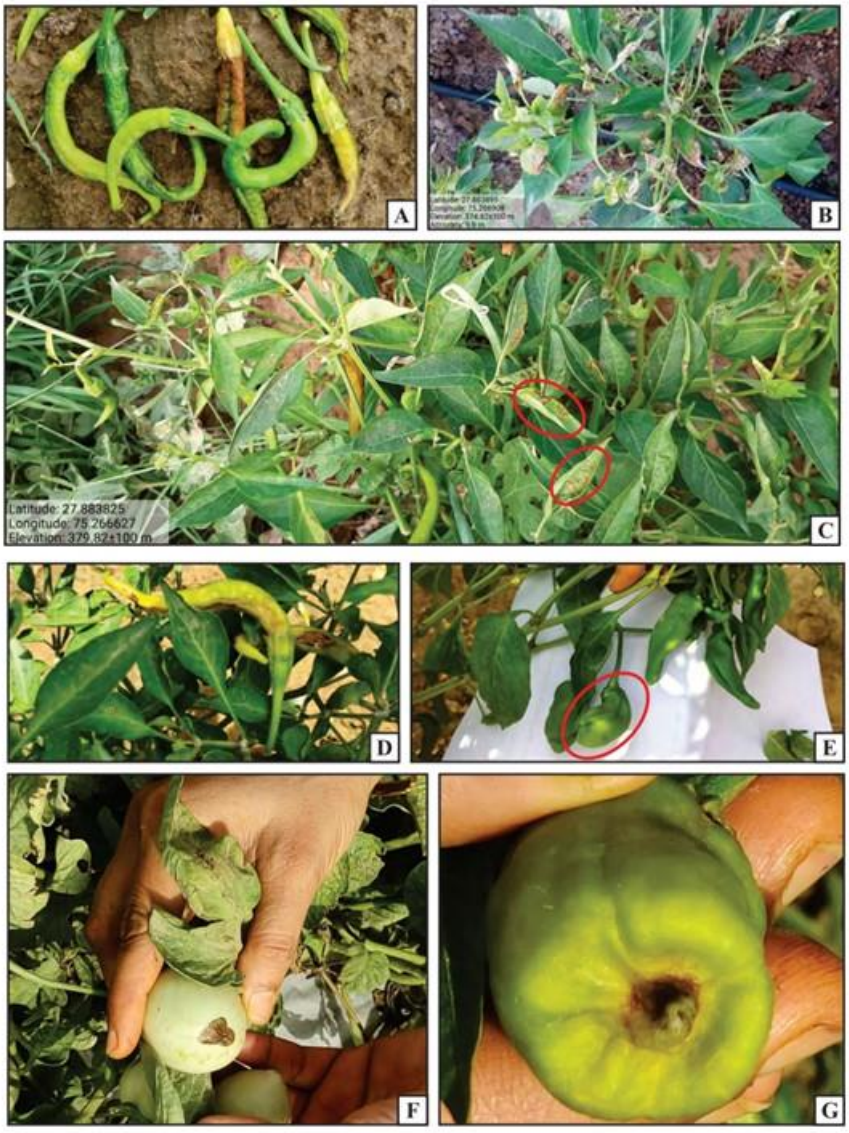

Figure 1: Various Disease Reported in Organic Chili Fields. (A) Chili Fruit Borer Disease (*Helicoverpa armigera*), (B) Anthracnose Disease (*Colletotrichum* spp.) Infected Plant, (C) *Cercospora* Leaf Spot Disease of Chili caused by *Cercospora capsica*, (D) Anthracnose Disease (*Colletotrichum* spp.) Infected Fruit, (E) Thrips Infected Fruit Comparing with Normal Fruit, (F) Blossom end rot Disease of Tomatoes (an abiotic stress), (G) Blossom end rot Disease Chili (an abiotic stress).

3.1.3 Blossom end rot tomatoes/Chili (abiotic stress): -

Blossom End Rot is a physiological problem not caused by a calcium deficiency in the plant. It's usually caused by erratic watering, which prevents calcium from being absorbed, but it can also be caused by too much nitrogen or magnesium. Keep the soil uniformly moist and well mulched to avoid the occurrence of Blossom End Rot (Fig. 1 F & G).

Figure 2: Various Disease Reported in Organic Chili Fields. (A) Nematode Infected Roots, (B) White Grubs Disease in Roots of Chili by (*Holotrichia serrata*) Insect, (C) Fusarium Wilt Disease by *Fusarism oxysporum*, (D) Fusarium Wilt by *Fusarium oxysporum* Blocks Xylem of Chilli Plant.

3.2 Nematode (*Meloidogyne javanica*)

In the nursery, *Pseudomonas fluorescens* @ 10g/m2 was applied. Use non-host or resistant crops in your crop rotation. Mix cropping with cowpea and marigold to control it. Various species of the genus *Tagetes*, such as *T. patula*, *T. erecta*, and *T. minuta*, are the most commonly used to control nematodes. These species are said to suppress plant parasitic nematodes through allelopathy (Fig. 2 A).

3.2.1 Root Knot nematodes (*Meloidogyne incognita*) in Chili

Nematodes are tiny organisms that penetrate roots and feed on nutrients present and absorbed by the roots. The roots form root knots or lesions, which are the nematode's preferred habitat. Plants gradually turn pale yellow and whiter and eventually die (Fig. 2 A).

3.2.2 White Grub in Roots of Chili (*Holotrichia serrata*) insect

Root grub feeds on the roots, causing the plants to wilt. The beetles remain in the soil inactive at a depth of about one meter until the next monsoon rains. During the rainy season (July-October), the grubs are active in their second, third, and fourth instar larval stages, feeding on organic debris until they come into contact with living plant roots. The new roots are actively fed by the second instar larvae. To control it Plough deep in the summer to expose the pupae to blistering sun radiation and bird

predation. Use of organic manures that have been well degraded is encouraged. Jowar/sorghum and bajara/pearl millet crop rotation (Fig. 2 B).

3.2.3 Fusarium Wilt by *Fusarium oxysporum*

Fusarium is a fungus that lives in the soil and spread through seeds. Adult plants initially showed modest drooping of leaves, which progressed to the drying of lower leaves, which spread from the root to the stem region, causing the plants to wilt (Fig. 2 C & D). Once a field has been infected, the disease can live for years in the soil. Farm equipment, drainage water, wind, animals, and humans can spread the fungus. To control it use raw cow milk and *Trichoderma viride* seed treatment.

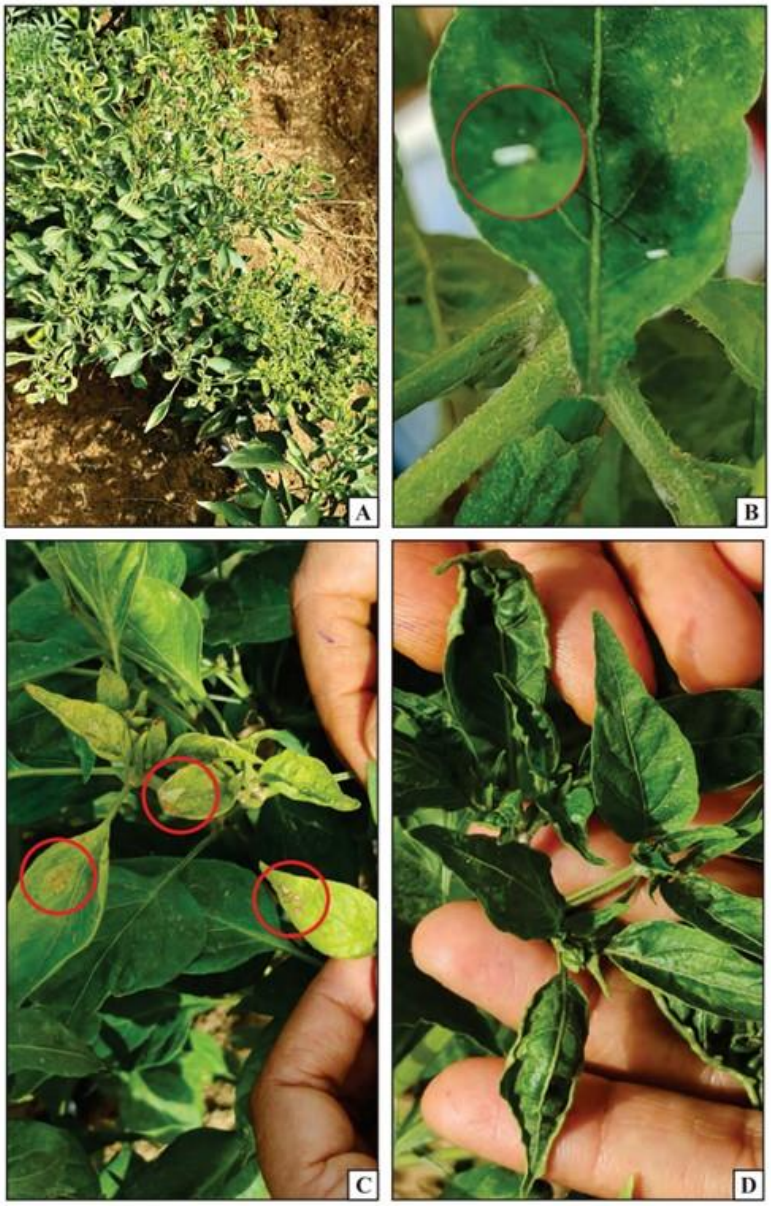

Figure 3: Various disease reported in organic chili fields. (A) Leaf curl disease (B) White fly (*Bemisia tabaci*) vector of Leaf Curl Virus, (C) Bacterial leaf spot disease, (D) Upward boat due to Thrips and inward boat due to mite

3.2.4 Chili/pepper leaf curl virus (ChiLCV)

Chili Leaf curl virus (chiLCV) is caused by *Begomovirus*. Upward curling, reduced leaf size, puckering, and stunted development with no blooms or fruits in severely damaged plants are all indications of ChiLCV disease (Thakur et al., 2018). The whitefly, *Bemisia tabaci*, transmits *Begomoviruses*. This virus can result in large yield losses, with losses as high as 90%–100% in the case of combined infections or pests like thrips or mites (Fig. 3 A).

3.2.5 Whiteflies (*Bemisia tabaci*)

Whiteflies are sucking insects that live on the underside of leaves, causing them to lose their greenness. Plants will eventually become weak due to reduced photosynthetic activity, and severe infestations will result in the growth of black sooty mould on leaves, reducing the amount of chlorophyll in the leaves (Fig. 3 B). The leaf curl disease, also known as the Gemini virus, is spread by white flies from plant to plant and field to field.

3.2.6 Thrips (*Scirtothrips dorsalis*)

Thrips are sucking insects that wreak havoc on chili plants. The sap is drained from the young fragile leaves, which coil and fold upwards, giving the leaves a boat-like appearance. The leaves change yellowish to pale green. Severe infestations can cause the edges of the leaves to develop a brownish-burnt color (Fig. 1 E; 3 D). With a high prevalence of floral deformation, symptoms such as leaf bristling, reduced plant growth, and malformation of plant parts are typical. Thrips can also spread the virus that causes leaf curl mosaic disease.

3.2.7 Aphids (*Myzus persicae*)

Aphids, both adults and nymphs, feed on the sap of plant leaves and growing shoots. The new growing tips perish, the leaves shrink, and the leaves may bend backwards. Aphids exude a sugary honey-like substance after feeding, which causes black sooty mold to grow in contaminated regions. To control aphid infection with neem-based products and follow label directions (e.g., Azatrol, 1.2% Azadirachtin. 1-part Azatrol to 1-part water, spray at 7–10-day intervals).

3.2.8 Bacterial wilt *(Ralstonia solanacearum)*

The pathogen *Ralstonia solanacearum (*formerly known as *Pseudomonas solanacearum*) is an aerobic, gram-negative bacteria with two membranous structures that area causative agent of bacterial wilt. The spots get brown and create a depression in the center where gleaming Bacterial cozen droplets may be seen (3C). Cankerous growth and withering of branches result from stem infection.

3.2.9 Phytophthora blight (*Phytophthora capsici*)

The fungus *Phytophthora capsici* is to blame. It's soil-borne, and it's most common in places with poor drainage and where suitable cultural practices haven't been followed.

3.2.10 Powdery mildew (*Leveillula taurica*)

Powdery mildew in chilies is caused by a fungus that emerges first on older plants and then moves on to younger ones. Chlorotic dots appeared on the upper surface of leaves, while the lower surface was covered with a white to grey powdery fungus growth, resulting in necrotic patches on the lower surface. Neem cake 2 q/ha + Trichoderma 2 kg/ha with 100 kg FYM + foliar spray of cow dung (20%) for Powdery mildew management.

3.2.11 Yellow mites (*Polypagotarsonemus latus*)

Yellow mites and red spider mites are two mite species that infest the chilli crop and only feed on the sap on the lower surface of the leaves, causing the leaves to become brittle and roll downward. Finally, the leaves take on a cup shape, and the undersides of the leaves become lustrous, with dark green leaves. Severe infestations result in the drying of growth tips, bud shedding, and defoliation of leaves.

3.2.12 Damping off Disease in Chili (*Pythium*)

It's a well-known soil-borne oomycete responsible for post-emergence damping-off in chili. Variables like moisture, temperature, and organic matter content, as well as pH and soil type, all have a role in causing damage ranging

from minor infections to epidemic-level damage.

3.3. Micronutrient deficiency in organic chili fields

Chemical fertilizers supply inorganic nutrients in excess to the soil. But one problem of organic farming is the nutrient deficiency in soil and afterward in produce. Iron, Nitrogen, Copper, Magnesium, Calcium, Sulphur, etc. are provided by various super compost, biowaste slurry, etc. But symptoms on chili leaves due to nutrient deficiencies in organic fields were identified.

Six elements (Cu, Fe, Mn, Zn, Mg and B) management in organic farming is mainly done by following practices like Super compost, vermicompost, biowaste slurry, Vermi wash, Azolla water, Panchgavya, Jaivik Kadha, Jeevamrut, Neem Karnel extract, Biopesticides, Panchagavya, Bizamarita, Gypsum, and Waste decomposer. These are essential ecofriendly purely organic methods to manage plant nutrients (Macro and Micro and help to enhance yield in organic farming. Biofertilizers, the most lucrative organic farms often obtain nutrients and organic wastes, scavenge residual soil nutrients, and fix nitrogen biologically.

3.3.1 Management of nutrients and diseases on chili in organic fields

The use of biocontrol agents such as *Bacillus*, *Pseudomonas*, *Penicilliums flavobacterium*, and *Trichoderma spp.* in the management of capsicum diseases is becoming increasingly popular (Segarra et al., 2013; & Torres et al., 2016). India generates a large amount of crop residues (around 500 million tons) annually, generally used as fodder and fuel for domestic and industrial purposes. Crop remains are still in abundance (140 Mt), with 92 Mt being burned annually (Bhuvaneshwari, 2019).

3.3.2 Vermicompost

Vermicompost is a procedure for preparing compost using earthworms. The farmers of the study area use the bed method to prepare vermicompost. In the concrete tank, collect the Biomass + Cow dung slurry + Earthworms + Water + Sand (at the bottom of the tank). Sprinkle water regularly to maintain the moisture content of the compost. The nutrients present in the vermicompost are N, P, K, Ca, Mg, Fe, Mn, and Zn.

3.3.3 Vermi wash

Vermi wash, vermicompost, and neem extract are three management techniques that reduced the incidence of leaf curl to certain levels compared to the untreated control. Cow urine, which has a strong pest repellent effect, was found to be the best management strategy among the strategies studied, based on data on leaf curl incidence (Mallapur & Lingappa 2005; & Anon 2000). Vermi wash was obtained from two Vermi wash units set up according to Eco science Research Foundation instructions, each containing a 50L plastic bucket with a tap near the base. Up to 20–25 cm of broken bricks and stones were placed in the lowest bucket, and on top 20–30 cm of coarse sand. A 25 cm thick layer of moist loam was placed on top of the sand layer.

The partially decomposed cow dung was covered with the dried leaves of neem, *Azadirachta indica*, which has insecticidal properties in its leaves. Around 150-200 earthworms were released to each unit. Each unit received a release of between 150 and 200 earthworms. A perforated pot suspended above the unit was used to drip water onto it throughout the night. After two weeks, the faucet was opened every morning to collect the Vermi wash, which was treated by diluting it tenfold with water. Vermi wash is a good source of hormones, vitamins, enzymes, amino acids and other micronutrients, in addition to its high NPK content. It also serves as a biopesticide.

Figure 4: Preparation of organic manure and biopesticides. (A) Biogas and water supplier tank, (B) Cow dung manure slurry, (C) cow dung manure slurry wash, (D) Fruit fly (*Drosophila melanogaster*), (E) fungicide prepared by sour buttermilk, (F) preparing biopesticide for disease management, (G) Venturi tubes to supply biopesticide in the field, (H) Azolla bed.

3.3.4 Garlic extract

The chili pepper is confronted with many phytosanitary problems during its cycle. According to some producers, the aqueous extract of garlic is the solution they use as an insecticide to control certain vectors, such as aphids and caterpillars, which are responsible for plant diseases such as anthracnose and others. The results of the survey reveal that it takes about 15 to 20 litres of the aqueous solution of garlic extract to treat 400 m2 of crop, depending on the age of the plants. Also, the best way to control most of chili pepper plants' diseases is to eliminate infection vectors such as viruses, bacteria, aphids, white flies, and especially molds from the nursery stage to the field before fruit maturity.

3.3.5 Waste decomposers

In Rajasthan fields, the waste decomposer method suggested by the National Center of Organic Farming, Ghaziabad, Utter Pradesh is used to make a new generation method in agriculture. In this method, clusters of 2 to 3 bacterial strains are obtained from cow dung. This is kept in a drum mixed in 100 Liter water and 1 Kg of jaggery. The drum is covered with a jute bag. Every morning and evening, the mixture is stirred. After 5 days water starts to convert into whitish color and air bubbles appear (4 A). After 7 days, we can spray this in organic fields. An iron rod is added to this mixture during fermentation if soil is iron deficient. To prevent leaf curl disease, 30 ml/L (15 L/Hec) solution is sprayed on the plants. The same composition effectively controls Anthracnose, powdery mildew, and thrips (sucking pests) on chili plantation. The spray is done repeatedly for 7 to 10 days starting with 15 DAS. To control nematode infestation on chili plants, 1500 L/Hec is applied by drip irrigation method. A waste decomposer is mixed with soil and broadcasted in fields. For the same composition, 4000 Kg of soil is mixed. It has microorganisms and micronutrients which increase soil fertility.

3.3.6 Bizamarita

It is prepared by keeping cow dung (10kg) + cow urine (1ltr) + cow milk (500ml) + water (7ltr) + Heng (10gm) + limestone (5kg) in a drum for 48 hours and stirring daily in the evening and morning. It is used for disease and nutrient management in organic farming and enhances yield/production (Fig. 4 B).

3.3.7 Jeevamrut

Jeevamrut is used as a fungicide and insecticide in organic farming. It is prepared using the following contents = cow dung (20kg) + cow urine (10ltr) + jaggery (2kg) + chickpea flour (2kg) + *ficus religiosa* leaves. All the ingredients in the drum and stir twice a day and keep the drum closed the enriched jeevamrut would become ready on 7days. During irrigation, it connects with venturi (4 C) by making a hole in the drum and setting it so that dripping from the drum starts and the hole field is nourished during sowing and irrigation and maintains soil fertility and soil moisture. It controls fruit fly growth (4 D) and also enhances soil micro-organisms (Fig. 4 E).

3.3.8 Neem Karnel extract

Take 5kg of neem seed kernel and grind to make powder, then put in a drum with waste decomposer and soak in 10ltr of water. Put overnight until it turns to milky white and filter through double muslin cloth to make the volume of 100ltr. Azadirachtin components come into the water, which is used as insecticide and fungicide, and have components equal to DAP (Di-ammonium phosphate) manure (Fig. 4 F).

3.3.9 Biopesticides

Organic Pesticide (Jaivik Kadha) is prepared using the following ingredients: neem kernel/leaves + Agni Mantha (arni) + Datura stramonium + Garlic paste + Chili paste + water is mixed in drum in quantity according to availability of the area. It is kept for fermentation for up to 10 to 20 days and used in two methods. Basal application is good for soil pests like nematodes and soil-borne pathogens. At the same time, the spray is applied to control Nematicide, Insecticide (white curb aphids, thrips, mites Heliothis, jassids, and different larvae ready to infect on leaves (Fig. 4 F).

3.3.10 Buttermilk (kattichach)

It is used as a fungicide in organic farming. A large quantity of buttermilk is collected in a drum and put in for 30 days and can be applied in the soil as well as spray. To control bacterial wilt and damping off on Chili by *Pythium*, this over-fermented buttermilk is applied directly in soil on 100 L/Hectare. It can be sprayed directly in the field at 100ml/liter every 7 to 10 days, and the field can be nourished during sowing and irrigation and maintain soil fertility and soil moisture. For preparing Chili plants against powdery mildew, leaf curl, and Anthracnose, 100 ml/L solution is sprayed on leaves. This is applied continuously for 7 to 10 days.it controls powdery mildew, leaf curl virus, anthracnose, bacterial wilt (initial stage), and dumping off Chili by *Pythium* (Fig. 4 E).

3.3.11 Panchagavya

It is prepared by cow dung (5kg) +cow urine (3ltr) + cow milk (2ltr) +cow curd(2ltr) +cow ghee(1kg) +coconut water (3ltr) +Gur (600gm) +ripened banana (12pcs) +beakers west (100gm) are kept in drum for 18days and stir daily. It is used for disease and nutrient management in organic farming, and it enhances yield/ production. It controls fruit fly growth and antimicrobial activity. It boosts the water-holding capacity of the soil, reduces soil pH, and fulfills the deficiency of Calcium. This controls blossom end rot in Chili.

3.3.12 Gypsum

In organic farming, it is used to improve water holding capacity and lower soil pH to compensate for Ca deficiency. Due to Ca deficiency, tomatoes/chillies cause blossom end rot.

3.3.13 Mix cropping in organic farming

The majority of organic–conventional comparisons emphasize yield. Many meta-analyses reveal a 20% reduction in average organic yield, while evidence is emerging that biologically heterogeneous cropping systems can close the gap. The majority of a crop's nitrogen needs can be met by biological nitrogen fixation, whereas Phosphorus, Potassium, and micronutrient inputs are ultimately required to prevent negative nutrient balances. If organic crops are

cultivated without cattle, getting manure or composted manure to agricultural areas could be difficult. An onion/pepper mixed cropping system can minimize parasite numbers as well as pest damage to the crops.

4. Challenges to farmers in organic farming with special reference to Rajasthan, India

Chemicals in all forms, like fertilizers, pesticides, and nutrient management in agriculture, are used, which have become an undetachable part of it. To practice farming in a purely organic manner is a bit difficult and risky in present times. But organic farming due to its extreme health and environmental benefits is highly recommended and in demand. Consumers are ready to buy products at high prices. But farmers experience different types of problems while practicing organic farming. During the survey of various organic fields, we identified challenges being faced by farmers to establish organic farming in a field where conventional farming has been practised for the last 30-40 years. Following are problems identified in the Nawalgarh area where organic farming is being done on large scale:

Organic farming where the farmer has to use eco-friendly fertilizers and pesticides is a highly laborious process. Yield is low in the initial years of organic farming. For example, in conventional farming, farmers record a yield of 100 kg/Hectare. As he converts his conventional farm into an organic farm, the yield is 50 Kg/Hectare in the I phase, 70 Kg/ Hectare in the II phase, and 90 Kg/ Hectare in the III phase. Prices of organic products are high to combat this yield loss. But still, prices in the market are competitive and not up to the mark for farmers. Rajasthan is a state facing high-temperature exposure to standing crops. Nutrient loss is high in the state due to high temperature. Green compost is not able to provide all nutrients at this high temperature to plants.

Standard biocontrol methods to combat the disease have not been provided to farmers. More research is required in pathology as organic conditions differ from conventional farming. In organic farming, the crop is facing various abiotic stress already, and it is not substantial to fight against biotic stresses under these conditions. There is no subsidy for organic fertilizers and biopesticides from the Government. On chemical fertilizers, huge subsidy is provided. For example, According to an interview done with organic farmers Vijrendra Singh Khirod, Ram Niwas Dhyal (kari), Kripal Singh Dhayal, Balbir Singh Dhayal, Mukesh Saini, and Madan Lal Dhayal, the Government provides subsidy on Urea. For example, the market value/ real price of urea is 1904 Rs of one sack according to variable weight. This area is available to farmers at 270 Rs only. This huge amount of subsidy pushes farmers to use these chemicals even knowing the negative impacts on the environment.

The government is not providing subsidies on organic farming tools as well. For example, tractors, thrashers, hoes, etc. are used in conventional farming and afterward in organic fields. This causes the transmission of various pests and pathogens. Even this transmits chemicals (present in fertilizers and pesticides). This practice needs to be stopped, but farmers don't get subsidies for buying separate tools for organic farming. Government should provide separate market places for organic produce. In competitive conventionally grown produce is much cheaper and for organic growers, it is difficult to sell their items. Resources availability is low in rural areas. Resources for organic farming are different than regular farming practices. Economic support to poor farmers is essential to survive with fewer yields in initial years of organic farming. Loans on interest rates, especially for organic growers, should be beneficial to bear the losses.

DISCUSSION

India produces around 2600 Mt of dung annually, dairy animals like cows and buffaloes (95%), while small animals like sheep, goats, pigs, and poultry account for the remaining 5% (Kaur et al., 2017). By converting the wastes into manure and compost, these vast supplies of animal waste

and plant residues could be used as sources of plant nutrients (Chatterjee et al., 2016). To control root-knot nematode on chili in organic farms: *Pseudomonas fluorescens* @ 10g/m2 was applied in the nursery. Use non-host or resistant crops in your crop rotation. Cowpea and marigold can be combined to control cropping. The three marigold species that are most frequently used for nematode control are *Tagetes patula*, *Tagetes erecta*, and *Tagetes minuta*. Marigolds primarily suppress plant-parasitic nematodes through a biochemical interaction known as allelopathy. One of the potentially bioactive substances that marigold plants produce is terthienyl, which has nematocidal, insecticidal, fungicidal, antiviral, and cytotoxic properties. It is thought to be the primary element responsible for the nematocidal activity of marigold (Wang et al., 2007). To control *Fusarium* wilt raw cow milk and *Trichoderma viride* seed treatment was used by different farmers practicing organic farming. Management of White grubs in the roots of chili is difficult. To control it Plough deep in the summer to expose the pupae to blistering sun radiation and bird predation. Farmers use organic manures that have been well degraded. Jowar/ sorghum and bajara/pearl millet crop rotation are useful to manage it. Trichoderma has previously been used to successfully manage damping-off caused by Pythium species in a variety of crops (Jayaraj et al., 2006).

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