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were peeled from top to tip flaming the knife between peeling. Carrot discs were prepared by cutting the carrot into 3mm thickness with flaming the knife between successive discs. Each disc was transferred immediately to 2.5 cm diameter Petri dish with sterilized tweezers and sealed with parafilm. All the Petri dishes with carrot discs were kept in a plastic bag arranging in rows and incubated 3 weeks at 21°C in dark. Contamination free carrot discs were then inoculated with sterilized nematodes at the rate of 30 nematodes/disc and incubated for two and half months at 21°C. Nematodes were sterilized by 4000 ppm streptomycin sulphate. Equal amount of nematode suspension and streptomycin sulphate solution were taken which reduces the streptomycin suspension to 2000ppm. The suspension was shaken well and stored overnight at 4°C. Supernatant above the settled nematodes was removed with a pipette. Afterwards, sterile water was added up to half of the tube shake well and allowed for nematodes to settle after which supernatant was removed. Washing of nematode was done 3 times.

Nematode extraction

Baermann funnel

Nematodes were extracted using baermann funnel technique for *M. chitwoodi* and baermann funnel with mistifier for *P. penetrans* based on the motility of nematodes. The funnel stem was connected with a rubber tube that was closed with a clip. Roots or carrot discs were cut into small pieces (1cm size using scissor to extract *M. chitwoodi* and carrot disc were cut using scalpel to extract *P. penetrans*) and put on a filter paper (EderolPund filter, 40g/m^2, Munketell filter AB, Sweden) lined in a 2 mm mesh sieve. The sieve was then put on top of a glass funnel filled with tap water up to a level that just covered the bottom of sieve and plant tissue. The hatched juveniles pass through the filter paper and sieve to funnel and accumulated in the bottom of the rubber tube. The nematodes were collected in a beaker by loosening the clip for few seconds as per need. The water level of the funnel was adjusted by adding water to compensate evaporation loss.

Effect of different bacterial suspensions on penetration

Two bacterial suspensions, 100% and 10% were prepared. Tomato seedlings grown in Petri dishes were taken and root systems dipped in bacterial suspensions and buffer and distilled water as control for 30 minutes. Then the seedlings were transferred to 3.9 cm diameter agar plates (prepared by autoclaving 1% bacterial agar and pouring to Petri dishes under laminar flow) at one seedling per plate for each treatment. Each treatment had five replicates. Second-stage juveniles (J2) were counted under microscope and 100 J2 were transferred to each seedling about 1 cm far from root of seedlings and kept in dark room at 20°C. Nematodes touching and 0.5 cm around the roots were counted after 24 hour, 48 hour and 5 days. After final observation, roots were stained (as described by Byrd *et al.*, 1983) to assess the nematode penetration in roots. Roots were cut into 1cm pieces in glass beakers (200 ml) and 1.5% NaOCl. Roots were kept in this solution for 4 minutes and stirred frequently. Then

the NaOCl solution was discarded and the roots were rinsed in abundant water on a sieve. 30 ml water plus 1 ml staining solution (3.5g Fuchsin acid, 250 ml acetic acid, and 750 ml distilled water) was added into a beaker with the roots and heated until boiling point for 30 seconds. After cooling to room temperature, the roots were rinsed with abundant water on a sieve. Roots were then collected in a beakers and 20 ml glycerol was added and heated till boiling point and poured into Petri dish. The nematodes inside roots were counted under microscope. Penetration experiment was carried out for both *M. chitwoodi* and *P. penetrans*.

Effect of different bacterial suspensions on hatching

M. chitwoodi

Two bacterial suspensions 10% and 100% and two controls (buffer and distilled water) were used to see the effect of *Paenibacillus*spp. on nematode egg hatching. Egg masses of *M. chitwoodi* from potato roots were separated with root pieces and transferred to small plastic tubes (1 cm diameter, 2.5 cm height) with sieve (48 µm mesh) at the bottom so that hatched juveniles can pass easily through the sieve but egg masses, root pieces and dirt remain on the sieve surface. The tubes were placed inside bigger tubes (2 cm diameter, 4.5 cm height) and 5 ml of each test solution was added. Tubes with the submerged egg masses were kept in a dark room at 20°C to allow hatching. Each treatment had four replicates. Every sixth day the hatched juveniles were counted and the test solutions were replaced by fresh test solutions. This was done during one month. After one month, egg masses were treated with 1% NaOCl solution to liberate the eggs from the gelatinous matrix using forceps and needle. Unhatched eggs were counted and cumulative hatching percentage was calculated.

P. penetrans

Eggs of *P. penetrans* were separated from the carrot discs culture. The carrots discs were chopped and macerated in a blender for 1 minute at high speed using commercial electrical blender. Eggs and vermiform stages were separated by sieving the nematode suspension through 50 µm sieve. Then the filtrate was filtered through 20 µm sieve. The eggs retained on the sieve were collected by gently rinsing with water and filter several times through 50 µm to remove vermiform nematodes. Hatching test was done in small containers (2 cm diameter, 4.5 cm height) equipped with 10 µm sieve (plastic tube having 1 cm diameter and 2.5 cm height). 500µl suspension containing 100 eggs was transferred onto the sieve of small container kept inside the big container and 5ml test solutions were added into the big containers. The container was closed with parafilm with small holes to allow air circulation. The containers were kept in incubator at 21°C. Every 6 days the hatched juveniles were counted and the test solutions were replaced by fresh test solutions. This was done during one month and cumulative hatching percentage was calculated.

Effect of different bacterial suspension on juvenile survival

Bacterial suspensions of 10% and 100% were prepared. Freshly hatched J2 of *M. chitwoodi* and mixed stages of *P. penetrans* extracted by baermann funnel methods were transferred to

the 5ml test solutions in plastic container. Buffer and distilled water were taken as control. Immobilized nematodes in test solutions were observed after 6 hour and 24 hour incubation at 20°C. Nematodes which did not move when probed with fishing needle were considered as dead. Immobile nematodes were transferred to distilled water after 6 hours of exposure to bacterial suspensions to check the recovery of nematodes.

Statistical Analysis

Computer package R studio was used to analyse data. The normal distribution and homogeneity of data were checked and log transformation done for the data which were not normally distributed. Treatment effects of the experiments were determined byanalysis of variance (One-way ANOVA) considering *P*- value.

RESULTS

Effect of bacterial suspensions on in vitro hatching of *M. chitwoodi* and *P. penetrans*

The effect of bacterial suspensions on in vitro hatching of *M. chitwoodi* from egg masses and *P. penetrans* from eggs are shown in figure1&2. Significant differences were observed in maximum hatching percentage of both *M. chitwoodi*(*P=0.01*) and *P. penetrans* (*P=0.02*). For *M. chitwoodi*almost no hatching was observed when egg masses were exposed to 100% bacterial suspensions after two weeks of exposure. The highest cumulative hatching percentage 56.85 was found in distilled water followed by 52.13 in buffer. The lowest cumulative hatching (4.56%) was found in 100% bacterial suspension followed by 42.67 in 10% bacterial suspension *in M. chitwoodi*. Likewise, the highest cumulative hatching for *P. penetrans* 45.5% was found in distilled water followed by 37.25% in buffer. The lowest cumulative hatching 15.5% was found in 100% bacterial suspension followed by 25.75% in 10% bacterial suspension in *P. penetrans*. No significant differences were found in hatching rate (b) and the time where 50% of the total hatching was reached (m) for both *M. chitwoodi* and *P. penetrans*. The highest time for 50% hatching (m) for *M. chitwoodi*was 2.08 weeks in 10% bacterial suspension followed by 1.93 weeks in distilled water and 1.78 weeks in buffer. Similarly, the highest time for 50% hatching (m) for *P. penetrans*was 1.23 weeks in buffer, 0.85 weeks in distilled water and 0.67 weeks in 100% bacterial suspension and 0.75 weeks in 10% bacterial suspension. The highest hatching rate (1.58) for *M. chitwoodi* was found in buffer, 1.53 in distilled water and 1.03 in 10% bacterial suspension. In the same way, the highest hatching rate (b) for *P. penetrans* was found highest in distilled water (1.65) followed by 1.53 in 100% bacterial suspension. The lowest hatching rate (1.18) was found in 10% bacterial suspension followed by 1.38 in buffer.

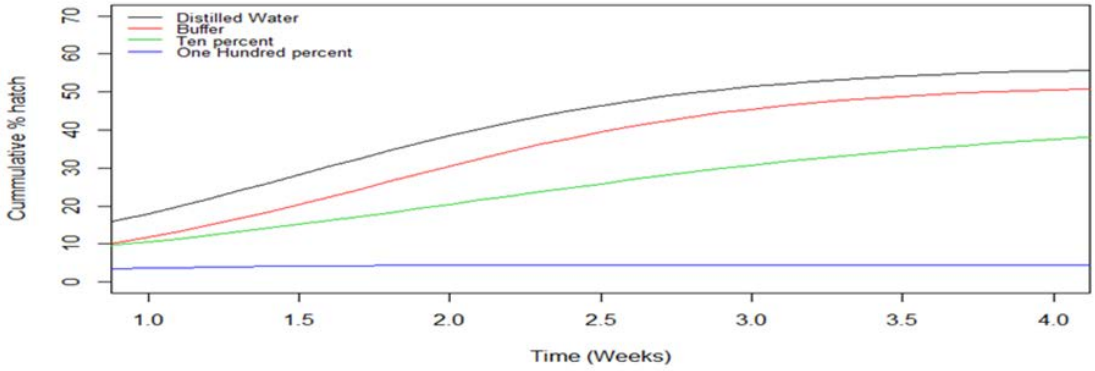

Fig. 1 : Hatching curves showing the cumulative percentage hatch of *M. chitwoodi* exposed to different bacterial suspensions (buffer and distilled water as control) with time in weeks (top line represent the distilled water, second last line for ten percent suspension and the bottom line represent the hatching at hundred percent suspension).

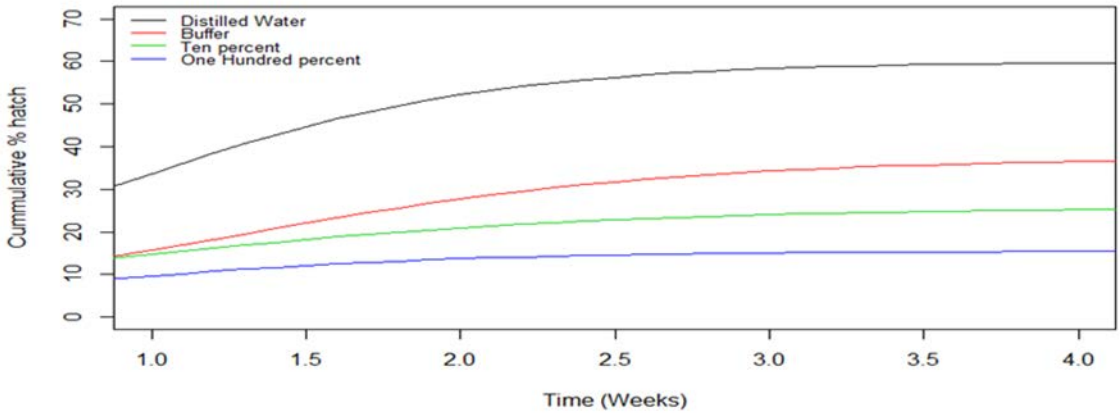

Fig. 2 : Hatching curves showing the cumulative percentage hatch of *P. penetrans* exposed to different bacterial suspensions (buffer and distilled water used as control) with time in weeks (top line represent the distilled water, second last line for ten percent suspension and the bottom line represent the hatching at hundred percent suspension).

Mortality of *M. chitwoodi* and *P. penetrans* in in vitro assay

Mortality of both *M. chitwoodi* and *P. penetrans* was found higher after exposure to bacterial suspensions. No nematodes were found dead in distilled water and negligible in buffer. Significant increase in J2 mortality of *M. chitwoodi* from 3.4% after 6 (*P=0.0003*) hours to 68.4% after 24 hours (*P=0.0008*) was observed after exposure to 10% bacterial suspension. In 100% bacterial suspension 92% and 99.2% was observed dead after 6 (*P=0.0003*) and 24 hours (*P=0.0008*) exposure, respectively (Figure 3). For *P. penetrans* a

mortality of 2.4% and 39% was observed after 6 hours and 24 hours exposure to 10% bacterial suspension. 78.2% and 100% nematodes were found dead after 6 hours (*P=0.0007*) and 24 hours (*P=0.0005*) exposure to 100% bacterial suspension, respectively (Figure 4).

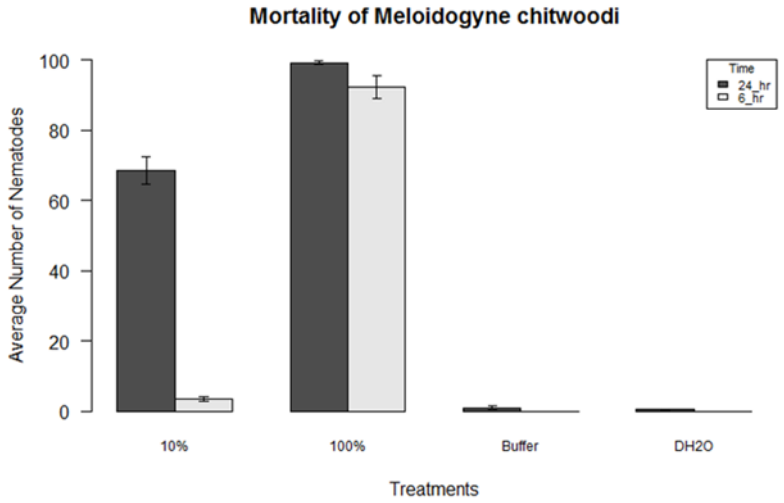

Fig. 3 : Mortality of *M. chitwoodi* juveniles after exposure during 6 hours and 24 hours to different bacterial suspensions (buffer and distilled water as control).
Number of nematodes inoculated was 100.

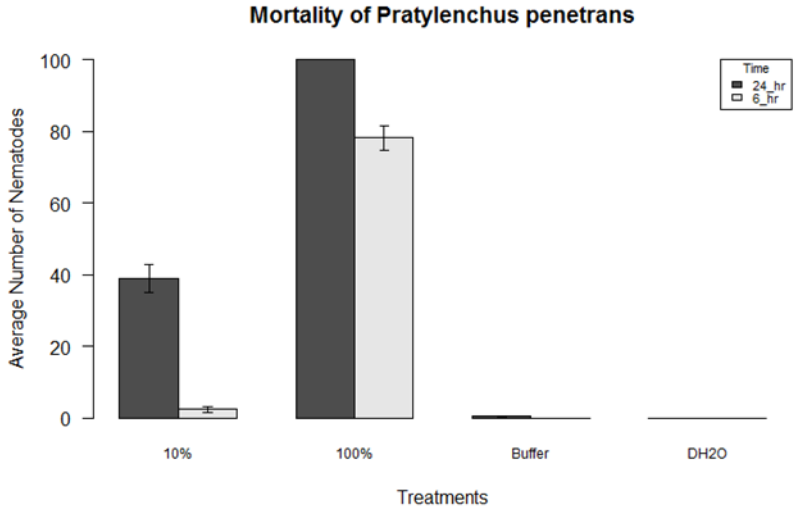

Fig. 4 : Mortality of *P. penetrans* after exposure during 6 hours and 24 hours to different suspensions (buffer and distilled water as control).
Number of nematodes inoculated was 100.

Effect of bacterial suspensions on root penetration

Effect of bacterial suspension on root penetration of *M. chitwoodi* and *P. penetrans* was observed after 24 hours, 48 hours and 120 hours. No significant difference ($P \geq 0.05$) was found between the treatments in the in vitro experiment of nematodes attraction to the root zone. Highest number of nematodes found around root zone of tomato seedlings was in buffer. On average 7.7 *P. penetrans* were found concentrated around the root zone of seedlings after 24 hours, 7.8 after 48 hours and 7.2 after 120 hours in buffer. The lowest numbers of nematodes (5.2 after 24 hours, 2.4 after 48 hours and 3.8 after 120 hours) were found in 10% bacterial suspension. The average numbers of nematodes found in 100% bacterial suspension were 4.4 after 24 hours, 6.2 after 48 hours and 5.8 after 120 hours (Figure 5). For the *M. chitwoodi*, the lowest numbers of juveniles found around root zones was in 10% bacterial suspension which was 7.4 after 24 hours, 8.2 after 48 hours and 9.2 after 120 hours. The average numbers of *M. chitwoodi* found in 100% bacterial suspension treatment were 14.4 after 24 hours, 30.6 after 48 hours and 17.4 after 120 hours. The average number found in buffer was 24.6 after 24 hours, 17.6 after 48 hours and 12 after 120 hours. The average nematode number found in distilled water treatments was 25.6 after 24 hours, 19.8 after 48 hours and 11.4 after 120 hours (Figure 7). Significant reduction in root penetration after exposure to bacterial suspensions was observed in both *M. chitwoodi* (*P=0.0007*) and *P. penetrans* (*P=0.01*). The lowest penetration was found in 100% bacterial suspension and highest in distilled water treatment for both nematode species. The average numbers of nematodes penetrated inside root 120 hours after inoculations was 4 in 10% bacterial suspension, 1.2 in 100% bacterial suspension, 8.6 in buffer and 8.8 in distilled water treatment for *M. chitwoodi* and 0.8 in 10% bacterial suspension, 0.4 in 100% bacterial suspension, 2.2 in buffer and 2.4 in distilled water treatment for *P. penetrans* (Figure 6 and 8).

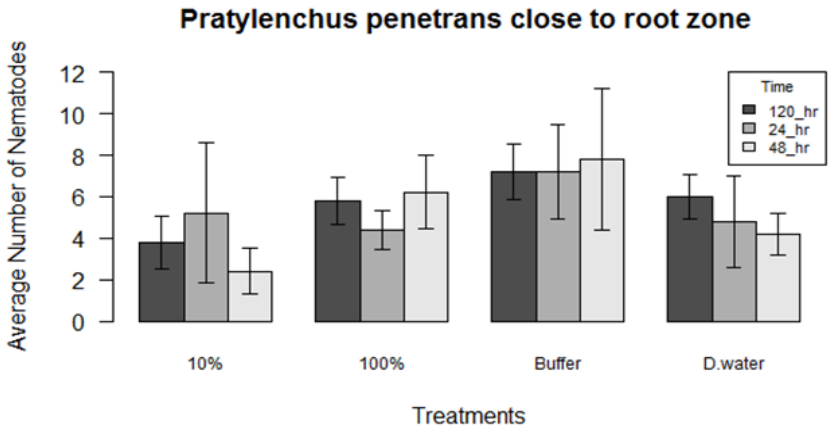

Fig. 5 : Numbers of *P. penetrans* observed at or around (0.5 cm) roots after 24, 48 and 120 hours in 10% and 100% bacterial suspensions treatment, buffer and distilled water. The number of nematode inoculated was 100.

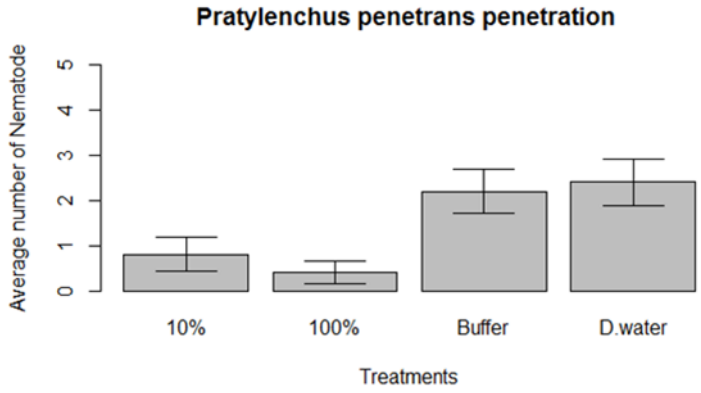

Fig. 6 : The average number of *P. penetrans* observed inside roots 120 hours after inoculation with 100 nematodes (mix of adults and juveniles) and treatment with 10% and 100% Paenibacillus suspensions, buffer and distilled water.

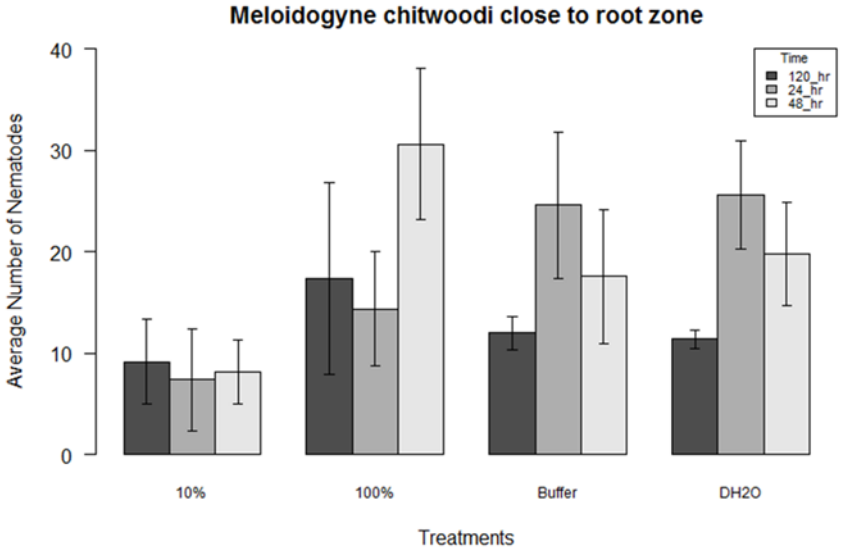

Fig. 7 : Number of *M. chitwoodi* observed at or around (0.5 cm) roots after 24, 48 and 120 hours in 10% and 100% bacterial suspension, buffer and distilled water treatment. The number of nematodes inoculated was 100.

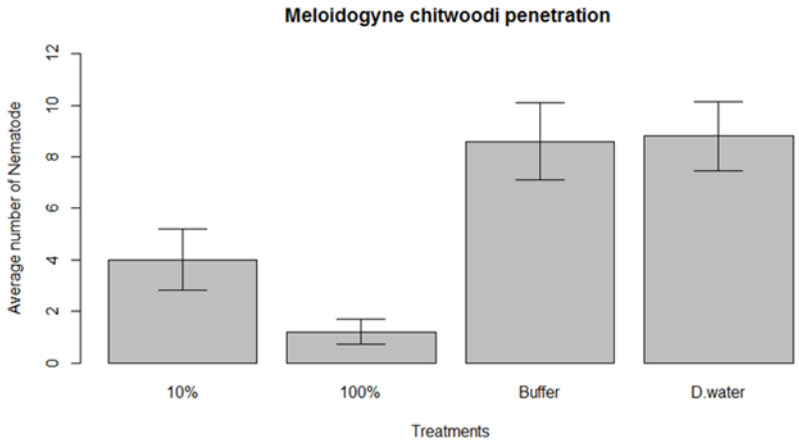

Fig. 8 : Average number of *M. chitwoodi* observed inside roots 120 days after inoculation with 100 juveniles and treatment with 10% and 100% Paenibacillus suspensions, buffer and distilled water.

DISCUSSION

Paenibacillus spp. used for these experiment was previously known as *P. polymyxa* but in molecular study some differences were noticed and suggested to write *P. spp.* until the species name confirmed. Significant reduction in hatching and increased mortality of *M. chitwoodi* and *P. penetrans* was found in bacterial suspension (*Paenibacillus* spp.) which is similar to the findings of Khan *et al.* (2008) who worked with *P. polymyxa* and *M. incognita* in tomato. The highest hatching was found during first two weeks and lowered down thereafter (Pudasaini *et al.*, 2008) for *P. penetrans* in normal condition. No hatching of *M. chitwoodi* and very few hatching of *P. penetrans* was occurred after 2 weeks in 100% bacterial suspension. The production of chitinase by *Paenibacillus illinoisensis* KJA-424 in vitro caused the lysis of egg shell in *M. incognita* resulting in the inhibition of egg hatching (Jung *et al.*, 2002). The average mortality of 68.4% in 10% bacterial suspension and 99.2% was observed in *M. chitwoodi* after 24 hours of exposure. 92% of *P. penetrans* found dead in 10% bacterial suspension and all most all nematodes found dead after 24 hours of exposure. This confirmed the findings that the bacterial suspension (CFU) and exposure duration had direct effect on nematode mortality (Khan *et al.*, 2008). The presence of toxic compounds in metabolites, lysis of egg shell and bacterial antibiotics are probably the cause of reduced hatching and increased mortality.

Significant reduction in root penetration was observed in both *M. chitwoodi* and *P. penetrans* in120 hours after inoculation. Four *M. chitwoodi* juveniles in average found penetrated inside root in 10% bacterial suspension and 1.2 in 100% bacterial suspension. Very few *P. penetrans* nematodes were observed around the root zone. They were migrated far from roots and towards shoot regions. The average of 0.8 and 0.4 nematodes penetrated inside root in 10% and 100% bacterial suspension, respectively. The less penetration of

nematodes in bacterial suspension than control is probably due to the production of Biofilms by *Paenibacillus spp*. Timmusk *et al.* (2005) have explained about formation of biofilm after invasion of *P. polymyxa*. The application of bacterial suspension (*P. polymyxa*) induced systemic resistance so that when applied to one half of the split root system caused reduced penetration of J2 in the untreated other half of the split roots and inhibited giant cell formation (Khan *et al.*, 2012).

CONCLUSION

Paenibacillus spp. was found effective against both nematode species *M. chitwoodi* and *P. penetrans* due to its toxic effectand control on eggs hatching, penetration and survival. Therefore, it can be helpful to substitute the use of synthetic chemicals.

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Research Article

PLANT DISEASE DIAGNOSIS ON VEGETABLE CROPS FROM DIFFERENT LOCATIONS OF THE COUNTRY

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ABSTRACT

Diseases are one of the major constraints on cultivation of crops and reduce production and productivity. Accurate disease diagnosis and proper identification is the first steps of disease management strategy. The activities of carrying out disease diagnosis help to know the distribution of the diseases in the country, explore new disease outbreak and its epidemiology, and provide information for disease management and support in research area prioritization. During fiscal year 2070/71, 252 different disease samples of different vegetable crops were received from various locations and sources for disease diagnosis. Examination of such samples identified 192 samples with fungal infection, 23 with bacterial infection, 28 with viral infection and 9 with nematode infection. In solanaceous crops, 70% disease caused by fungus and 11% by bacteria, 14% by virus and 5% by nematodes respectively. Likewise, in cucurbit crops, occurrence of pathogens is 61% fungal, 26% viral and 13% nematode respectively. The fugal pathogens were dominant in case of crucifer crops as well. The fungal pathogens were found in 79% of samples and followed by bacterial in 14% and viral in 7% respectively. Only fungal pathogen was detected in bulb and root crops. Fungal pathogens (76%) are the common problem in vegetable crops by followed by bacteria (9%) and virus pathogens (11%) and nematode (4%). The study revealed that management of fungal disease is prime concern to minimize the losses due to disease

Key words: bacteria, disease diagnosis, fungus, nematode, virus

INTRODUCTION

Plant disease causes significant economic loss throughout the country, but their effect is felt most severe in developing regions where most of the families obtain their livelihood from farming. Severe problems of different diseases are noticed every year on different agricultural crops from different agro ecological zones of the country. Accurate disease diagnosis and proper identification is the first steps of disease management strategy.

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Diagnosis is one of the most important aspects for proper identification of the disease and their causal agents to apply any measures for disease management. Without knowing causal agent, application of any measures for disease management will be a waste of the time and money and can lead to further plant losses. Proper disease diagnosis is therefore vital. The disease diagnosis and identification methods adopted in Nepal includes: gathering of information, visual observation, symptomatology study, incubation, microscopic examination, indicator host plant test and ELISA for virus detection, literature consultation and image study. Lack of sophisticated equipment for molecular diagnosis detection limits the plant disease diagnostic capacity in Nepal. Molecular diagnosis is now very important part of diagnosis.

The objective of the study is to find out distribution of pathogens in different vegetables in the country and to explore possibility of new disease outbreak and its epidemiology to prioritize the research area for the management of the disease problems.

MATERIALS AND METHODS

During fiscal year 2070/71, in total of 252 disease samples of different vegetable crops from various locations were received. Such samples were either collected during survey and fields visit or received from different stakeholders for disease diagnosis, proper identification and advisory services. Such information includes the crop history on field distribution, year of crop cultivation, variety, previous crop, weather condition, time of disease appearance, level of incidence and severity of disease, soil type, use of organic and inorganic manures and pesticides applied. Sign and symptoms of disease samples were observed prior to microscopic observation. The suspected disease samples were checked for its distribution pattern i.e., localize of systemic. The samples were categorized according to its causal organism viz fungal, bacterial, and viral or others by visual examination of sign and symptom of disease. Ooze test was used for bacterial disease diagnosis. Leaf blight, blast, wilt, anthracnose, scab, mosaic, leaf curl are the common symptom and mildew, mold, smut, rust, sclerotonia are common sign to diagnose the diseases (Manandhar and Amatya, 1992). Laboratory test was followed on those samples which could not be diagnosed from their sign and symptom.

The first step in the laboratory was to keep the diseased tissue in a moist chamber to induce sporulation. The moist chamber was a sterile petri dish containing a wet filter paper in the bottom of the dish and a triangle of glass tube. The sample was placed on the glass tube so that the sample could not have direct contact with the wet filter paper and get exposed to humid conditions (Mathur and Kongsdal, 2003). Plastic bags or boxes were used for larger specimens. To discourage the growth of saprophytes present on the specimen in the moist chamber, a brief surface swab with 70% isopropanol or 0.1-1% sodium hypochlorite was done. Moist chambers were generally incubated at room temperature. Direct inspection, washing test, blotter test, Agar and selected media plate test and seedling test were common method used to diagnose fungal diseases. Likewise, morphological test, biochemical test,

pathogenicity test, hypersensitive test and serological test were applied for bacterial disease diagnosis (Manandhar and Amatya, 1992). Dry seed inspection, seedling growing test, indicator plant test and serological test were used for viral disease identification. Extraction and morphological identification methods were used for charactering plant parasitic nematodes. In addition, to precise the diagnosed result with comparing the visual color pictures of internet and crop (Barnett and Hunter, 1972).

RESULT AND DISCUSSION

The disease samples collected by Plant Pathology Division (PPD) of Nepal Agriculture Research Council (NARC) during survey and field visits as well as those received from farmers, growers and other stakeholders to get advisory services for its management were diagnosed and identified. Out of received 252 samples for diagnosis, 192 (76%) was diagnosed as fungal infection, 23 (9%) as bacterial infection, 28 (11%) as viral infection and 9 (4%) as nematode infection. (Figure 1). All together 121 disease samples of five solanaceous crops were examined. Among them, 36 were pepper, 73 were tomatoes, 4 were brinjal, 7 were potatoes and 2 were okra. sclerotonia rot, collar/ crown/ fruit rot, phytopthora light, leaf spot, downy mildew, powdery mildew, early and late blight, bacterial wilt, bacterial stem rot, complex viral diseases and root knot nematodes were commonly diagnosed on pepper, tomato and brinjal. Similarly, root rot, late blight and powdery scab disease were diagnosed in potato. Root rot and leaf blight were diagnosed in okra (Table 1). Early and late blight were common in both tomato and potato. In total of 85, 17, 13 and 6 pathogen of fungi, virus, bacterial and nematodes were diagnosed in pepper, brinjal, tomato, potato and okra (Figure 2).

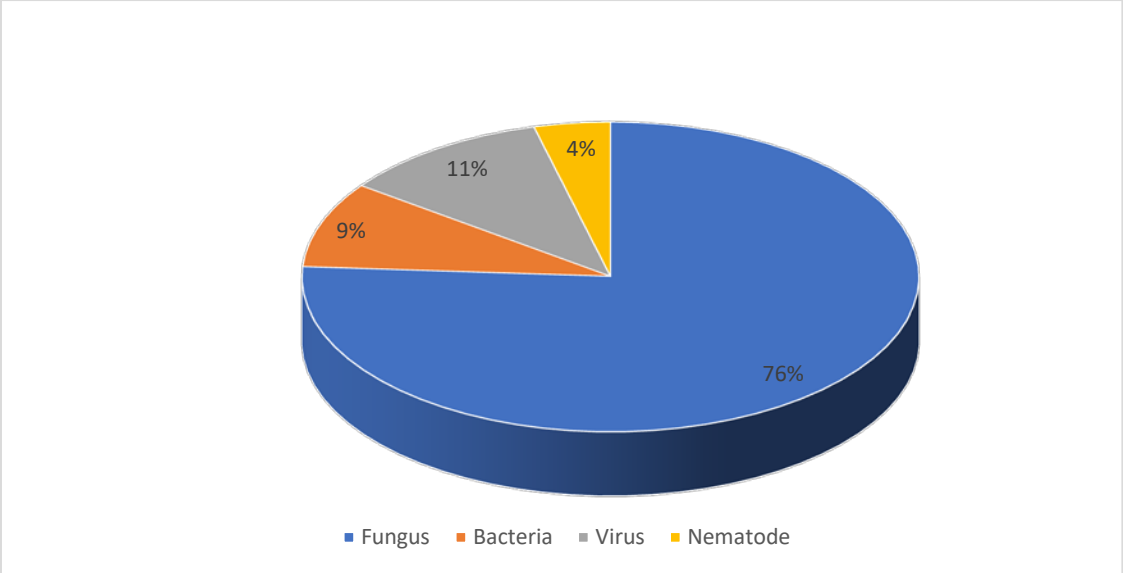

Fig. 1 : Percentage distribution of different pathogen in different vegetable crops

The fungal pathogen was recorded in higher percentage than other pathogen in the solonaceous crops (Figure 3).70 disease samples of crucifer crops were diagnosed. Among them, 20 samples were of cauliflower, 8 were of cabbage, 26 were of mustard, and 10 samples were of carrot, radish and turnip. Likewise, six diseased samples of cress, fenugreek and pakchoi were also diagnosed. Root rot, wire stem, downy mildew, collar rot, sclerotinia rot, top root bulging, leaf spot and club root were major fungal diseases, bacterial soft rot and black rot head rot were common bacterial diseases of crucifer crops. Mosaic viral diseases were also identified in turnip and radish. Clubroot as fungal and black rot as bacterial disease are getting spread over most of the crucifer growing area of the country (Annual report, 2014; Annual report 2015; Annual report, 2016; Annual report; 2017).

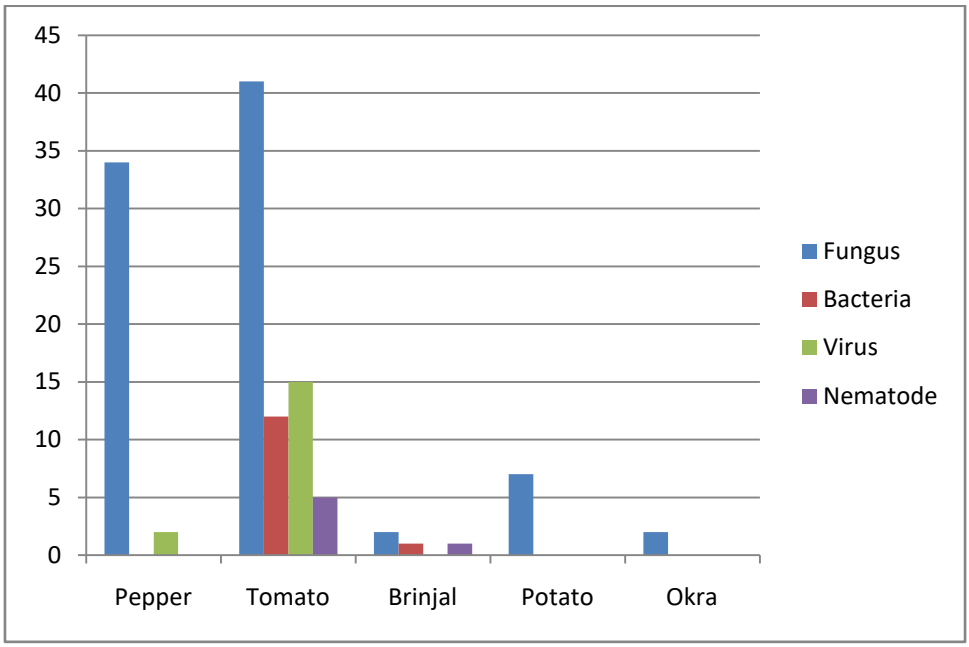

Fig. 2 : Incidence of different pathogen in various solanaceous crops

Root rot disease, downy mildew and clubroot were also observed in cress, fenugreek and pakchoi (Table 2). In total of 55, 10 and 5 samples were detected as the presence of fungi, bacteria and virus in the crucifer crops. The distribution of disease pathogens was by 79% of fungi and followed by 14% and 7% of bacterial and virus (Figure 4 and 5)

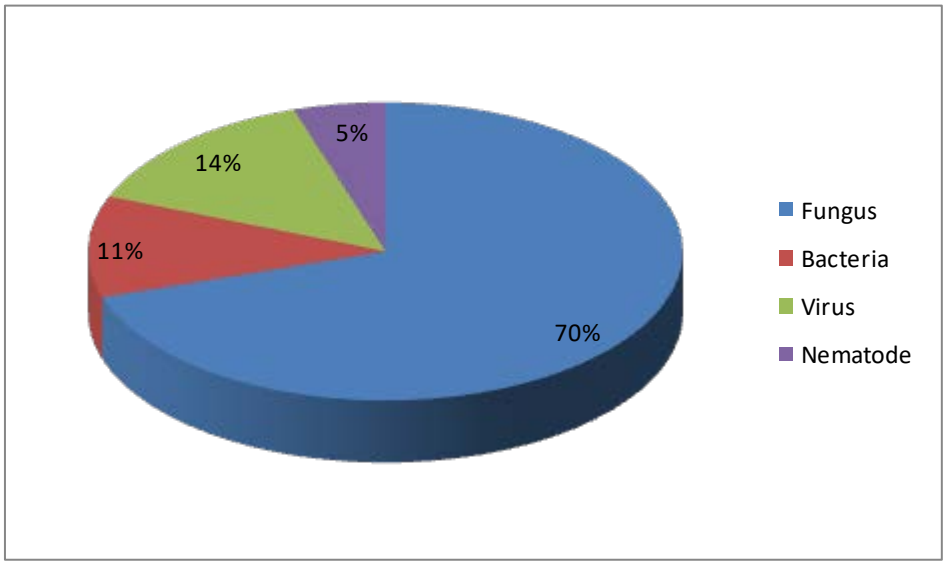

Fig. 3 : Percentage distribution of different pathogen in various solanaceous crops

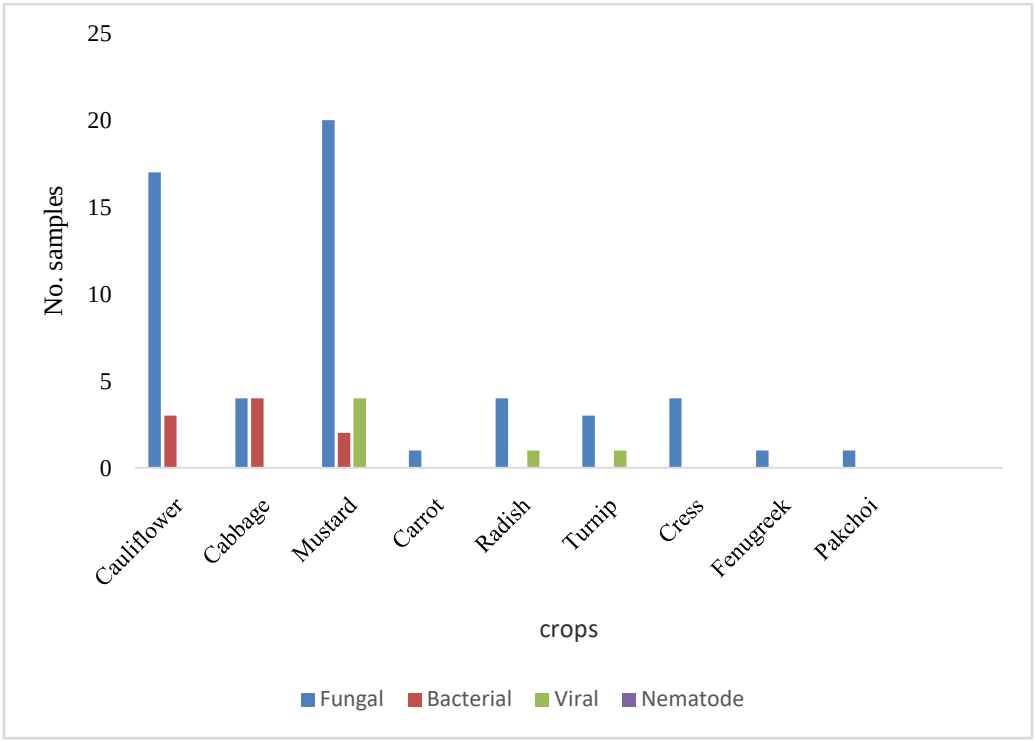

Fig. 4 : Incidence of different pathogen in various crucifer crops

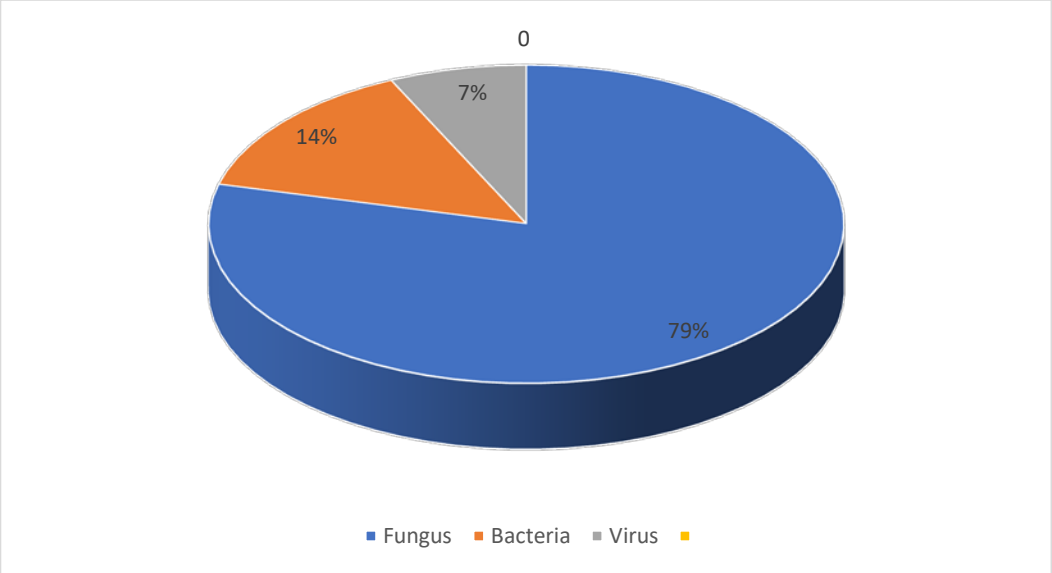

Fig. 5 : Percentage distribution of different pathogen in various crucifer crops

Likewise, in cucurbits, out of 23 disease samples diagnosed, 14 samples possessed fungal diseases such as leaf spot, powdery mildew and gummy stem blight. Gummy stem blight is the major one among them. Six samples consist of mosaic virus, vein banded mosaic virus and other virus complex. Root knot nematode was found in three samples (Table 3). In 23 samples, 14 samples had fungal pathogens, six had virus and three had nematodes but no bacterial pathogens were observed in cucurbit crops (Figure 6 and 7).

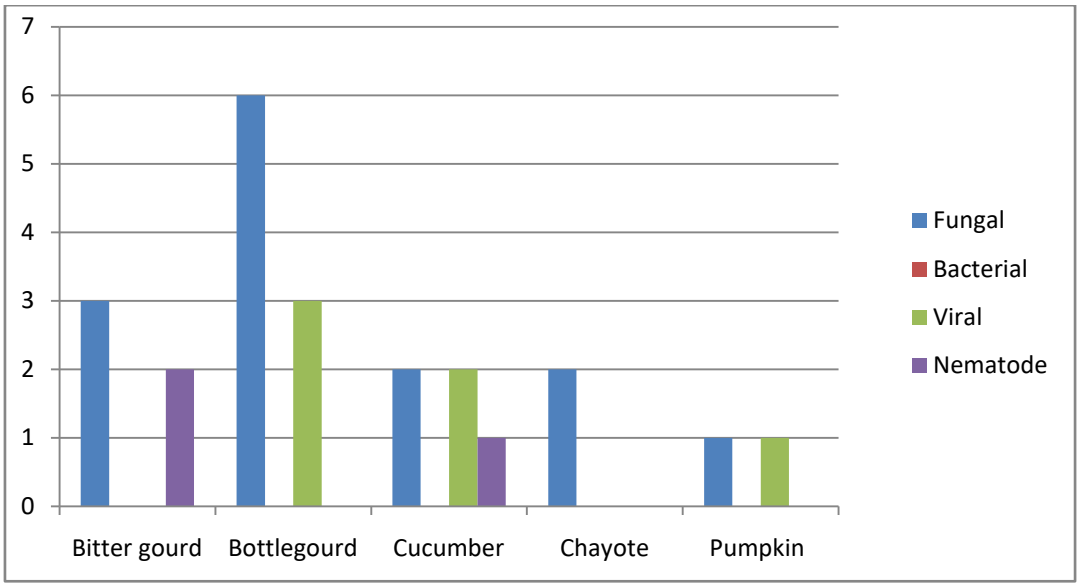

Fig. 6 : Incidence of different pathogen in various cucurbit crops

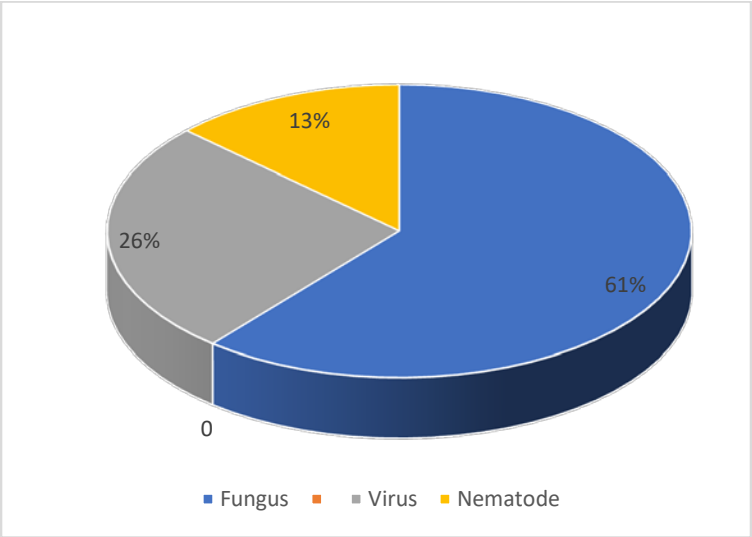

Fig. 7 : Percentage distribution of different pathogen in cucurbit crops

Similarly, out of 36 samples related to bulb and root crop, 12, 3, 18, and 3 samples of garlic, onion, ginger and turmeric were found infected with fungal pathogens respectively (Figure 8). There were no other than fungal pathogens were detected in the samples. In garlic, root tip pink, leaf blight, rust, white rot and purple blotch were identified. Downy mildew, Bulb rot and Purple blotch were found in onion (Table 4). Similarly, in ginger and turmeric Phyllosticta leaf spot, Taphrina leaf spot and leaf blight were identified.

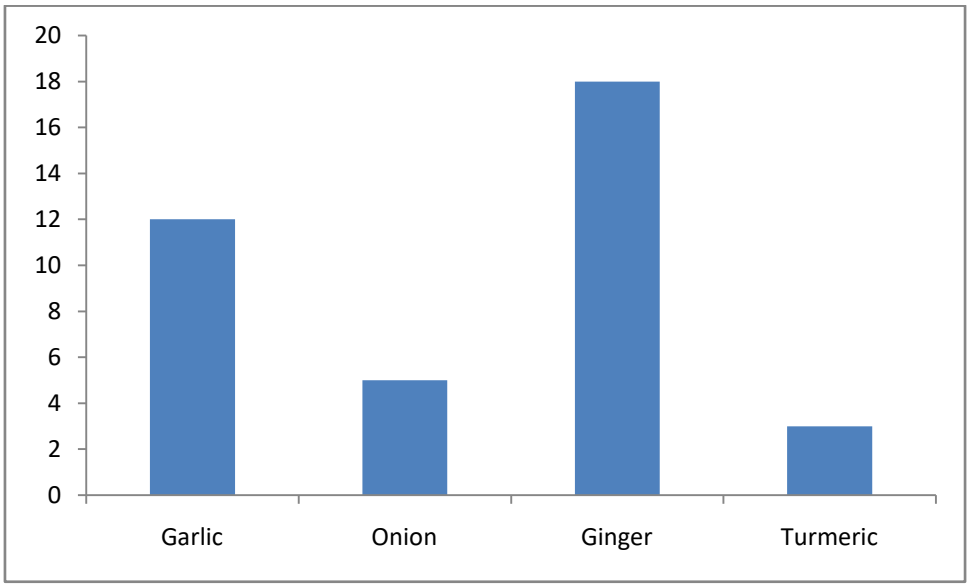

Fig. 8 : Number of fungal diseases in bulb and root crops

Vegetable disease caused by fungi, bacteria, viruses, nematodes and other pathogens are the major production constraints in the country. They are causing both qualitative and quantitative losses of crop yields every year. Direct losses are caused by both quantitative and qualitative yield reductions. Indirect losses are due to control measures and to the quarantine status. Plant Pathology Division is primarily concerned with researches on different aspects of host-pathogen interactions on various crop plants to develop appropriate and economically viable technologies for disease management. So, continued survey of diseases is prerequisite for successful planning of pathological research to know what diseases we have and what not.

CONCLUSION

Plant disease diagnosis is a knowledge-driven process and often requires specialized training for accurate diagnosis and laboratory testing may be needed. Plant diseases must be correctly identified to allow farmers, growers and other stakeholders to put in place effective integrated management strategies. The change in pathogen diversity may be caused by selection pressure due to change in cropping system, introducing new genotypes and climate change. Hence, a continual survey, monitoring, identification and prioritization of vegetables diseases are the most important part of research work for the updating the national data base in the agriculture system. Regular monitoring of pathogen is necessary for successful planning to manage the disease in vegetable crops to minimize the losses due to plant diseases.

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Table 1. Pathogens diagnosed in solanaceous crops in FY 2070-71

Pathogen	Disease	Hosts
Rhizoctonia sp.	Root/ collar rot	Pepper, Brinjal, Potato,Tomato
Fusarium solani	Root/crown rot	Okra, Pepper, Tomato
Alternaria solani	Leaf spot/early blight	Pepper, Tomato, Okra
Sclerotium rolfsii	Sclerotonia root rot	Tomato
Cercospora sp.	Leaf spot	Pepper
Leveillula taurica, L. sp	Powdery mildew	Tomato, Pepper
Septoria lycopersici	Leaf spot	Tomato
Phytopthora infestan	Late blight	Tomato, Potato
Phytopthora capasii	Phytopthora blight	Pepper
Fusarium oxysporium	Fruit rot	Pepper
Colletotrichum capsici	Anthracnose	Pepper
Cladosporium sp.	Plant/ bud dried	Tomato
Ralstonia solanacearum	Bacterial wilt	Tomato, Brinjal
Tomato Mosaic Virus	Viral disease	Tomato, Pepper
Tomato Leaf Curl Virus	Leaf Curl Virus	Tomato
Meloidogyne sp.	Root knot nematode	Tomato
Streptomyces scabies	Powdery scab	Potato

Table 2. Pathogens diagnosed in crucifer crops in FY 2070-71

Pathogen	Disease	Hosts
Rizoctonia sp.	Root rot/ wire stem	Cauliflower, Mustard, Radish, Cress, Turnip
Sclerotinia sclerotorium	Root rot/ head rot	Cauliflower, Cabbage
Alternaria sp.	Leaf spot	Cauliflower, Cabbage, Mustard, Radish, Turnip
Plasmodiophora brassicae	Clubroot	Cauliflower, Cabbage, Cress, Mustard, Turnip, Pakchoi
Phoma sp., *Culvularia* sp.	Leaf spot	Cauliflower
Cladosporium sp.	Leaf blight	Cauliflower
Fusarium sp., *Myrothecium* sp.	Root rot	Radish
Peronospora parasitica	Downy mildew	Cauliflower, Cabbage, Cress
Xanthomanas campestris pv. *campestris*	Black rot	Cauliflower, Cabbage, Rayo
Pseudomonas marginalis pv. marginalis	Bacterial soft/ root rot	Cauliflower, Rayo
Pseudomonas maculicola	Bacterial disease	Turnip
Turnip mosaic virus	Viral disease	Mustard
Thielaviopsis sp.	Root rot	Fenugreek
Alternaria dauci	Blight	Carrot
Albugo candida	White rust	Mustard

Table 3. Pathogens diagnosed in cucurbits crops in FY 2070-71

Pathogen	Disease	Hosts
Sphaerotheca fuliginea	Powdery mildew	Pumpkin, Bitter gourd
Phoma cucurbitacearum	Leaf spot	Bottle gourd, Chayote
Didymella bryoniae	Gummy stem blight	Bottle gourd
Achochyta sp.	Leaf spot	Bitter gourd, Chayote
Leveillula taurica	Powdery mildew	Cucumber
Cucumber Mosaic Virus	Viral disease	Bottle gourd, Bitter gourd, Sponge gourd, Pumpkin
Vein Banded Mosaic Virus	Viral disease	Bottle gourd
Meloidogyne sp.	Root knot nematode	Cucumber

Table 4. Pathogens diagnosed in root crops in FY 2070-71

Pathogen	Disease	Hosts
Fusarium sp.	Root tip pink	Garlic
Fusarium sp.	Bulb rot/ Rhizome rot	Onion, Ginger
Alternaria solani, *Stemphylium* sp.	Purple blotch	Garlic, Onion
Puccinia allii	Rust	Garlic
Peronospora destructor	Downy Mildew	Onion
Pythium sp.	Rhizome rot	Ginger
Phyllosticta zingiberi	Phyllosticta leaf spot	Ginger
Cercospora sp.	Leaf blight	Ginger
Colletotrichum sp.	Leaf spot	Turmeric
Cercospora sp.	Leaf spot	Turmeric
Taphrina maculans	Taphrina leaf spot	Turmeric