The Pharma Innovation Journal 2022; 11(5): 238-246

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(5): 238-246

www.thepharmajournal.com
Received: 16-02-2022
Accepted: 29-03-2022

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Effect of IDM practices on growth parameters, yield and disease incidence of common scab potato caused by *Streptomyces scabies* (Thaxter) Waksman & Henrichi

Shivam Kumar, SK Biswas, Ravi Kumar, Gajendra Pratap, Bipin Verma, Saurabh Kumar, Arshad Husain, Kishan Lal and Devesh Yadav

Abstract
Integration of soil amendment, tuber treatment and foliar spray have significant role in increase growth parameters and reduce the disease incidence of common scab. The maximum germination per cent was recorded in T_2 treatments[Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing as 100% against 80% in case of control which was increase 25% germination over control. Similarly, the maximum plant height and number of leaves per plant were also recorded in T_2 treatment, representing 6.16cm, 22.50cm, 37.33cm, 50.50cm, and 63.00cm plant height at 15, 30, 45, 60, and 75 days after sowing (DAS) respectively against 2.66, 11.00, 19.16, 28.16 and 37cm in case of control & 3, 10, 16, 22, 25 in number of leaves against 2, 6, 10, 14, 16 at 15, 30, 45, 60, and 75 days after sowing (DAS), respectively. IDM practices significantly reduced the disease incidence of common scab of potato as compared to control in field condition. The minimum disease incidence of common scab of potato with the value of 1.79% was recorded in T_2treatment at the time of harvesting, followed by T_6 [Soil treatment with *Pseudomonas fluorescens*(1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)]and T_1 [Soil treated with *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)] treatmentsshowing with the value of 3.34% and 5.65% respectively, at the time of harvesting.

Keywords: *S. scabies*, germination%, growth parameters, yield, disease incidence, common scab

Introduction
Potato (*Solanum tuberosum* Linn.) is the most important and useful vegetable crop in the world. It provides a major source of nutrition and income to many population and communities. Potato is a versatile, carbohydrate-rich food, its content dry matter, edible energy and edible protein makes it of good nutritional quality. Freshly harvested potato contains about 80 percent water and 20 percent dry matter content. About 60 to 80 per cent of the dry matter is starch. The protein content in potato is similar to cereals but very high when compared with other root and tuber crops. Common scab is a major seed-soil-borne bacterial disease of potato has been reported from almost every potato growing area around the world (Lambert and Loria 1989) [6], and can cause significant economic losses (Hill and Lazarovits 2005) [4]. *Streptomyces scabies* [(Thaxter) Waksman &Henrici] can cause necrosis on all underground parts of a potato, including roots, stolons, and stems, and it can reduce growth of roots from seed tubers (Han *et al.*, 2008). Agami *et al.* (2013) reported that seed germination rate, shoot height, shoot diameter, fresh and dry weight of shoot in tomato seedlings were increased significantly by *Trichoderma* application. They also found that soil amended by *Trichoderma sp.* had marked increase in leaf number and area of leaf. Mansoor *et al.* (2001) also observed that the *Azotobacter* improved plant height and shoot dry weight significantly. Kumar and Biswas (2019) [5] found that integration of soil application of FYM @ 125gm/pot + waste of mushroom cultivation with *Trichodermaharzianum* @ 5gm/kg + tuber treatment with *Azotobacter* @ 5% + foliar spray with Ridomil @ 0.25% was the best to show minimum disease severity of late blight, representing 9.16% as against 76.40% in case of control at 21 days of observation. They also found that the treatment also exhibited increased tuber germination and plant height of potato showing the value 100 per cent and 44.5 cm at 30 days age of plant. Bansal *et al.* reported that IDM practices as Soil application of FYM + Poultry manure + Tuber treatment with *T. harzianum*+ three foliar spray with Equation Pro have

ability to increases tuber germination, growth parameters, yield of potato and reduce disease severity. Tuber treated with salicylic acid provided good protection of potato against common scab caused by *S. scabies* and also stimulate the germination of seed, growth parameter and yield (Baboo and Biswas, 2021) [1]. They also found that, all the growth parameters like covered area in cm, number of leaves per plant, number of branches per plant, stem diameter in cm etc. also found maximum in seed treatment. The pathogen both seed and soil-borne in nature and remain alive in the soil for many years. The infected tuber act as a primary source of inoculum for carrying the pathogen to new areas/fields. Once it establishes in the field, it is very difficult to reduce the pathogen population. The various control measures, such as cultural use of agrochemicals, organic, inorganic soil amendments, use of resistant variety and biocontrol have been utilized to manage the disease. Among cultural practices like irrigation, soil acidification, and crop rotation reduce the scab incidence. Laowood *et al.* (1967) reported that better control of *S. scabies* was obtained by keeping the soil moisture at field capacity by irrigation throughout the growing season of the crop. In case of chemical control, presently there are no registered chemicals for common scab control in India except for some highly toxic and expensive fumigants. Keeping all the point in view, the present study was undertaken as "Development of IDM practices for management of common scab of potato [*Streptomyces scabies* (Thaxter) Waksman and Henrici] and its effect on growth and yield" in the present investigations.

Materials and Methods

Collection of seed tuber

Truly labelled potato seed tubers of variety "Kufri Chandramukhi" was collected from Vegetable Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kalyanpur, Kanpur, to conduct the experiment research work.

Collection of organic fertilizers

Vermicompost, Neem cake, Gypsum, Manganese Sulphate, Elemental Sulphur, SSP and Boric Acid Powder was purchased from Agriculture Seed Store, Rawatpur, Kanpur**.** FYM were collected from Department of Animal Husbandry and Livestock Production Management, C.S.A.U.A&T, Kanpur to conduct the field experiments on common scab (*Streptomyces scabies*) of potato. All these bio-agents *viz.*, *Trichodermaharzianum*, *Azotobacter* and *Phosphorus Solubilizing Bacteria* (PSB) were obtained from Biocontrol Laboratory of Plant Pathology and Department of Soil Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur to conduct the present study. *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) and *Pseudomonas fluorescens* (1% W.P, Cfu count: 2x 10^8cfu/g) bacterial culture were purchased from amazon site. The experiment was conducted in Student Instructional Farm (SIF) of C.S.A.U.A&T, Kanpur during Rabi season 2019-20 and 2020-21.

Tuber treatment and soil application

Truly labelled potato seed tubers of variety "Kufri Chandramukhi" was collected from Vegetable Research Farm, CSAUAT, Kalyanpur, to conduct the experiment. Tuber seed treated with *Trichodermaharzianum*@ 5gm/kg of tubers. The seed tubers were treated by dipping the tuber in prepared solution. The treatments were given 4 hours before the sowing of tuber. Suspended 5 kg of biofertilizers (*Azotobacter* and *Phosphorus solubilizing bacteria*) in 10 liters of water and mixed thoroughly with 80-100kg of FYM for one acre of land. The mixed biofertilizer in FYM is applied in soil at the time of sowing. Soil drenching withbio-fertilizers *viz*., *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) and *Pseudomonas fluorescens* (1% W.P, Cfu count: 2x 10^8Cfu/g) was done as per following recommendation.

Effect of IDM approaches on seed tuber germination, plant height, number of leaves and disease incidence of common scab of potato (*Streptomyces scabies*)

The experiment was conducted at the experimental field area of Student Instructional Farm (SIF), C.S.A.U.A&T, Kanpur. The seed tubers of potato variety **"**Kufri Chandramukhi" were treated with *Trichodermaharzianum* and foliar spray of Copper Oxychloride with Streptocycline (3:1). The soil was treated with organic, inorganic and biological soil amendments separately. The seed tuber of potato crop was sown in 60 x 20 cm (row to row distance 60 cm and plant to plant distance 20 cm) and 15 cm deep in ridge of the plots. The plot size was 4 x 3 m (4 meters length and 3 meters bredth). The eighty (80) number of potato tuber was sown in per plot. The experiment design was laid out in RBD. Three replication per treatment and three pots were sown with untreated seed tuber serve as control. The treatments are given as follow:-

T_1= Soil treated with *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_2 = Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_3= Soil amendments with Manganese Sulphate @ 15kg/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_4= Soil amendments with Elemental Sulphur @ 5q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_5 = Soil amendments with SSP @ 10q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_6 = Soil treated with *Pseudomonas fluorescens*(1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_7 = Soil treated with *Azotobacter* @ 12.5kg/ha+ Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_8 = Soil amendments with Boric Acid Powder @ 3 kg/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_9 = Soil application with Vermicompost @ 20 t/ha + Tuber

treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_{10} = Soil application with FYM @ 25t/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_{11} = Soil application with Neem Cake @ 25q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_{12}= Soil treated with PSB @ 12.5kg/ha +Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)

T_{13} = Control

The observations were taken on tuber germination, plant height, number of leaves at 15, 30, 45, 60 and 75 days after sowing and disease incidence at harvesting time

Germination percentage

Integrated effect of organic (FYM, Vermicompost and Neem Cake), inorganic (Elemental Sulphur, Gypsum, $MnSO_4$, SSP, Boric acid powder),biofertilizers (*Pseudomonas fluorescens, Bacillus subtilis, Azotobacter, Phosphorus Solubilizing Bacteria*) for soil amendments and tuber treated with bio-agent (*Trichodermaharzianum*@ 5g/kg of tuber), on germination percent of potato were taken in the present investigation. Germination per cent was calculated by recording the number of emerging seedlings at every 24 hours up to 10 days. Germination percentage was calculated use of following formula as given by Abdul Baki and Anderson (1971).

$$\text{Germination\%} = \frac{\text{Number of germinated seed tubers}}{\text{Number of total sown seeds}} \times 100$$

Plant height

Ten plants were selected randomly from tagged plots. The shoot height was measured (in cm) from the soil surface at basal portion of flag leaf with the help of meter scale. The average of three plants height was divided by ten for obtaining their mean to consider plant height. The height of the plant was measure at 15, 30, 45, 60 and75days age of plant.

Number of leaves

The effects of IDM on number of leaves of potato plant were studied under field conditions. Ten plants were selected randomly from tagged plots. The number of leaves was counted from the soil surface at basal portion of flag leaf. Three replications were kept for each treatment. The average number of leaves of plants was obtaining by the total number of leaves of ten plant was divided by ten.

Measurement of scab incidence

Scab incidence in all the treatments was calculated by recording number of healthy and diseases tubers in each plot. Tubers were examined after the inoculation of *Streptomyces scabies*. Finally, the percentage of scab incidence was calculated by using the formula as given below:

$$\text{Scab incidence\%} = \frac{\text{Number of tuber exhibiting scab symptoms}}{\text{Total number of tuber observed}} \times 100$$

Result and Discussion

To find out their integrated effect of organic (FYM@ 25t/ha, Vermicompost@ 20t/ha and Neem Cake@ 25q/ha), inorganic (Elemental Sulphur@ 5q/ha, Gypsum@ 20q/ha, $MnSO_4$@ 15kg/ha, SSP@ 10q/ha, Boric acid powder@ 3kg/ha), biofertilizers (*Pseudomonas fluorescens, Bacillus subtilis, Azotobacter*@ 12.5kg/ha, *Phosphorus Solubilizing Bacteria*@ 12.5kg/ha)for soil amendments and tuber treated with bio-agent (*Trichodermaharzianum*@ 5g/kg of tuber), on germination per cent, growth parameter (plant height, number of leaves) and disease incidence of common scab potato.

Effect of IDM approaches on germination percent of tubers under field condition during 2019-20 and 2020-21

As the seedling began to emerge from the soil, germination percentage was calculated by recording the number of emerged seedlings from number of potato tuber sown. The result presented in table-1, showed that the highest germination per cent was eminent in treatment **T_2**[Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing 100% against 80% in case of control which was increased 25% germination over control, followed by treatment T_6 [Soil treatment with *Pseudomonas fluorescens*(1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing 98.75% against 80% in case of control which was increased 23.43% germination over control. Among all the treatments, the minimum germination per cent was recorded in treatment T_{10}[Soil application with FYM @ 25t/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing 85.00% against 80% in case of control which was increased 6.25% germination over control. Agami *et al.* (2013) reported that seed germination rate was enhanced by *Trichoderma* application and shoot height, shoot diameter, fresh and dry weight of shoot in tomato seedlings were increased significantly. They also found that soil amended by *Trichoderma sp.* had marked increase in leaf number and area of leaf. The IDM practices have ability to increases tuber germination, growth parameters, yield of potato and reduce disease severity. Total yield as 417.30 and 449.40 gm per plant was also obtained from T_9 (Soil application of FYM + Poultry manure + Tuber treatment with *T. harzianum*+ three foliar spray with Equation Pro) treated plant, against 218.78 gm and 211.68 gm in case of control in year 2016-17 and 2017-18 respectively and the minimum disease severity 1.65%, 5.28%, 9.05%, 14.92% and 1.70%, 5.35%, 9.65%, 15.10% were recorded in T_9 (Soil application of FYM + Poultry manure + Tuber treatment with *T. harzianum* + three foliar spray with Equation Pro) against 30.12%, 48.84%, 61.35%, 82.55% and 30.50, 49.05. 62.00, 82.95% in case control (pathogen inoculation) at 45, 60, 75 and 90 days after showing during 2016-17 and 2017-18 respectively. Tuber treatment with inducing agent provide good protection against common scab disease caused by S. scabies and also stimulate the germination of seed and growth parameter with application of the inducers were salicylic acid (Baboo and Biswas, 2021) [1]. They also found that, all the growth parameters like covered area in cm, number of leaves per plant, number of branches per plant, stem diameter in cm etc. also found maximum.

Effect of IDM approaches on plant height (cm) under field condition during 2019-20 and 2020-21

The effect soil amendment, tuber treatment, foliar spray of fungicide on plant height was taken at 15, 30, 45, 60 and 75 days after sowing (DAS). The data presented in the table-2 showed that the plant height was increase in all the treatment over controlled. The maximum plant height was recorded in T_2 treatment as Soil amendment with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5g/kg of tuber + Foliar spray of Copper Oxychloride with Streptocycline (3:1), representing 6.16, 22.50, 37.33, 50.50, and 63cm plant height at 15, 30, 45, 60, and 75 days after sowing (DAS) against 37cm in case of control which is increased by 70.27% over control. The T_6 treatment as soil treated with *Pseudomonas fluorescens*(1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), showing value 5.50cm, 20.66cm, 35.00cm, 50.00cm and 61.66cm plant height at 15, 30, 45, 60, and 75 days after sowing (DAS) against 37cm in case of control which is increased by 66.64% over control, representing 2nd highest among all the treatments. The T_1 treatments as soil treated with *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), showing value 4.83, 19.33, 33.83, 44.50 and 60.33 cm plant height at 15, 30, 45, 60, and 75 days after sowing (DAS) against 37cm in case of control which is increased by 63.05% over control, representing 3rd highest among the treatments. Mansoor *et al.* (2001) also observed that the *Azotobacter* improved plant height and shoot dry weight significantly. Kumar and Biswas (2019) [5] found that integration of soil application of FYM @ 125gm/pot + waste of mushroom cultivation with *Trichodermaharzianum* @ 5gm/kg + tuber treatment with *Azotobacter* @ 5% + foliar spray with Ridomil @ 0.25% was the best to show minimum disease severity of late blight, representing 9.16% as against 76.40% in case of control at 21 days of observation. They also found that the treatment also exhibited increased tuber germination and plant height of potato showing the value 100 per cent and 44.5 cm at 30 days age of plant.

Effect of IDM approaches on no. of potato plant leaves under field condition during 2019-20

The integrated effect of soil amendment, tuber treatment, foliar spray of fungicide on number of potato plant leaves were studied under field condition during 2019-20 and 2020-21. The observations of number of leaves were taken at 15, 30, 45, 60 and 75 days after sowing (DAS). The data presented in table-2, showed that the number of leaves increased in all treatments over control. The number of leaves of potato plant was found maximum in treatment T_2 where treatment was given as soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), representing 3, 10, 16, 22, 25 in number of leaves at 15, 30, 45, 60, and 75 days after sowing (DAS) against 16 in case of control which is increased by 56.25% over control at 75 DAS. The T_6 treatment as soil treated with *Pseudomonas fluorescens*(1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), showing value 3, 9, 15, 21 and 24 number of leaves at 15, 30, 45, 60, and 75 days after sowing (DAS), representing 2nd largest number of leaves among the treatments.

Agami *et al.* (2013) reported that seed germination rate was enhanced by *Trichoderma* application and shoot height, shoot diameter, fresh and dry weight of shoot in tomato seedlings were increased significantly. They also found that soil amended by *Trichoderma sp.* had marked increase in leaf number and area of leaf. Mansoor *et al.* (2001) also observed that the *Azotobacter* improved plant height and shoot dry weight significantly. Kumar and Biswas (2019) [5] found that integration of soil application of FYM @ 125gm/pot + waste of mushroom cultivation with *Trichodermaharzianum* @ 5gm/kg + tuber treatment with *Azotobacter* @ 5% + foliar spray with Ridomil @ 0.25% were increased the tuber germination and plant height of potato showing the value 100 per cent and 44.5 cm at 30 days age of plant.

Effect of IDM approach on disease incidence of common scab of potato at harvesting time under field condition during 2019-20 and 2020-21

The integrated effect of IDM practices significantly reduced the disease incidence of common scab of potato as compared to control under field condition during 2019-20 and 2020-21. The data represented in Fig: 1, showed that the minimum disease incidence of common scab of potato with the value of 1.79% was recorded in T_2 [Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], treatment at the time of harvesting, followed by T_6 treatment [Soil treated with *Pseudomonas fluorescens* (1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)] and T_1 treatments [Soil treated with *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], showing the value of 3.34% and 5.65%, respectively at the time of harvesting. Among all the treatments, the maximum disease incidence of common scab of potato with value 34.57% was recorded in T_{13} (Control). From the Fig:1, it is cleared that all IDM practices were able to reduce the scab incidence over control. Sidorevich (1981) reported that soil treatment with *Trichoderma* @ 130 kg/ha at the time of planting and tuber treatment with *Azotobactrin* for one hour reduced the scab incidence. Singh and Singh (1986) reported that tuber treatment with Streptocycline (250 ppm) for half an hour and soil amendment with gypsum @ 25 q/ha and highly significantly controlled the disease. Singh and Singh (1986), reported that soil treatment with gypsum @ 25 q/ha controlled the disease. Tuber treatment with salicylic acid provide good protection against common scab disease caused by *S. scabies* and also stimulate the germination of seed and growth parameters of potato (Baboo and Biswas, 2021) [1]. They also found that, all the growth parameters like covered area in cm, number of leaves per plant, number of branches per plant, stem diameter in cm etc. also found maximum in the same.

Effect of Integrated disease management approaches on tuber size and yield of potato under field condition during 2019-20 and 2020-21

Integrated effect of soil amendment, tuber treatment, and foliar spray on tuber size and yield was studied after

harvesting. Tubers were graded as large (>50 gm), medium (25– 49 gm) and small (<25 gm) in size. The data represented in Fig:2, showed that maximum number of large size tubers were harvested from the treatment T_2 [Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing 143 tubers each with total weight 13.845 kg per plot and 35.32% increase over control, followed by T_6 treatment [Soil treated with *Pseudomonas fluorescens* (1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], showing 139 tubers each with total weight 13.498 kg per plot which was increase by 34.41% over control. Similarly, the maximum number of medium size tuber was also obtained from T_{11}treatment [Soil application with Neem Cake @ 25q/ha + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], representing 179 numbers each with total weight 6.300 kg per plot and 13.60% increase total yield over control, which was followed by T_{10} treatment [Soil application with FYM @ 25t/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], showing 176 tubers each with total weight 5.255 kg per plot and was increase by 9.66% over control and T_7 treatment [Soil treated with *Azotobacter* @ 12.5kg/ha+ Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1)], showing 175 tubers each with total weight 6.678 kg per plot and was increase by 19.06% over control. On other hand, the maximum number of small size tuber was harvested in T_{13} **(**Control), representing 239 numbers each with total weight 5.00 kg per plot, followed by T_{11} treatment, showing 235 tubers each with total weight 4.436 kg per plot and was increase by 13.60% over control.

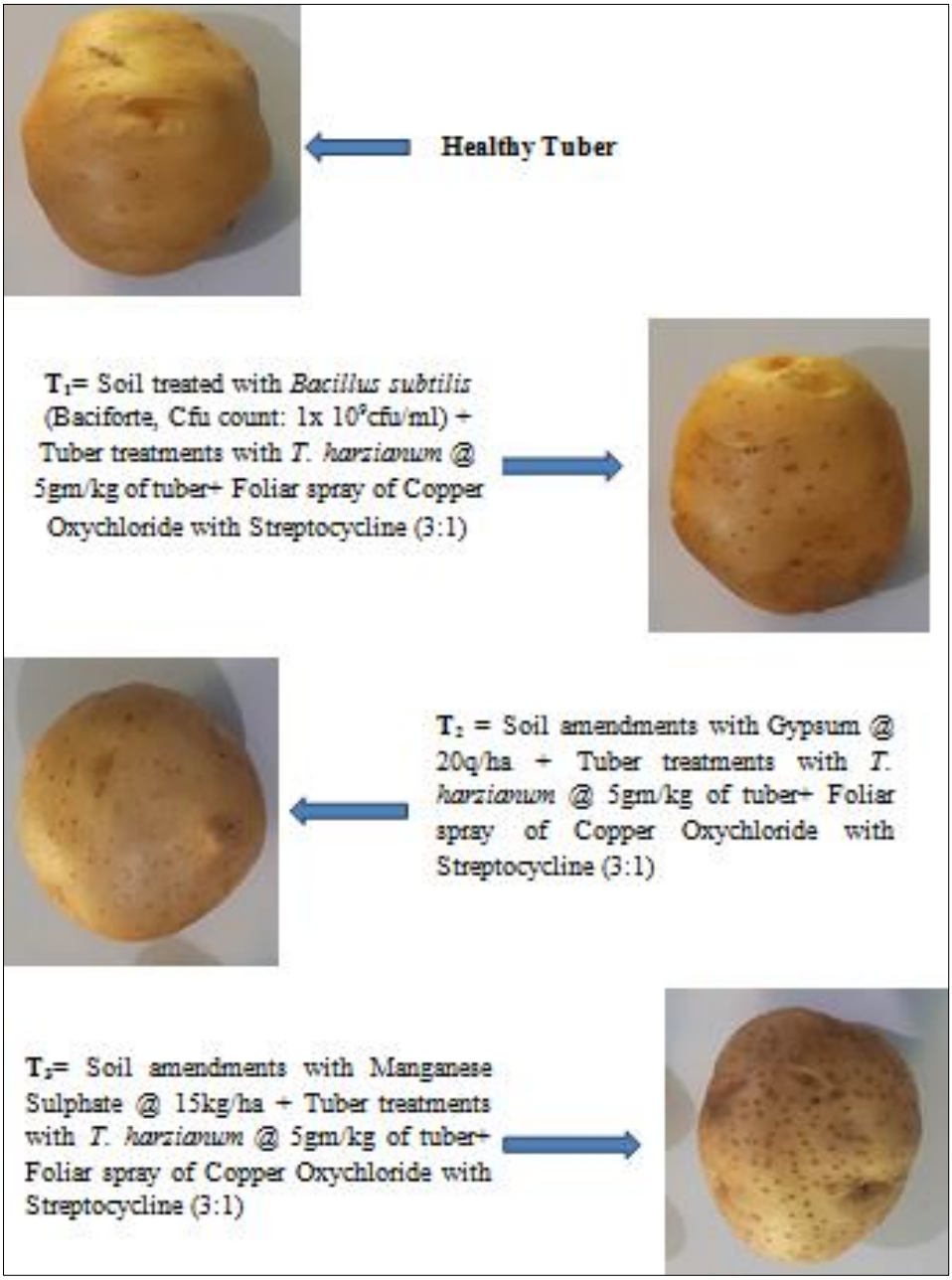


Fig 1: Effect of IDM approaches on disease severity and disease incidence of common scab of potato

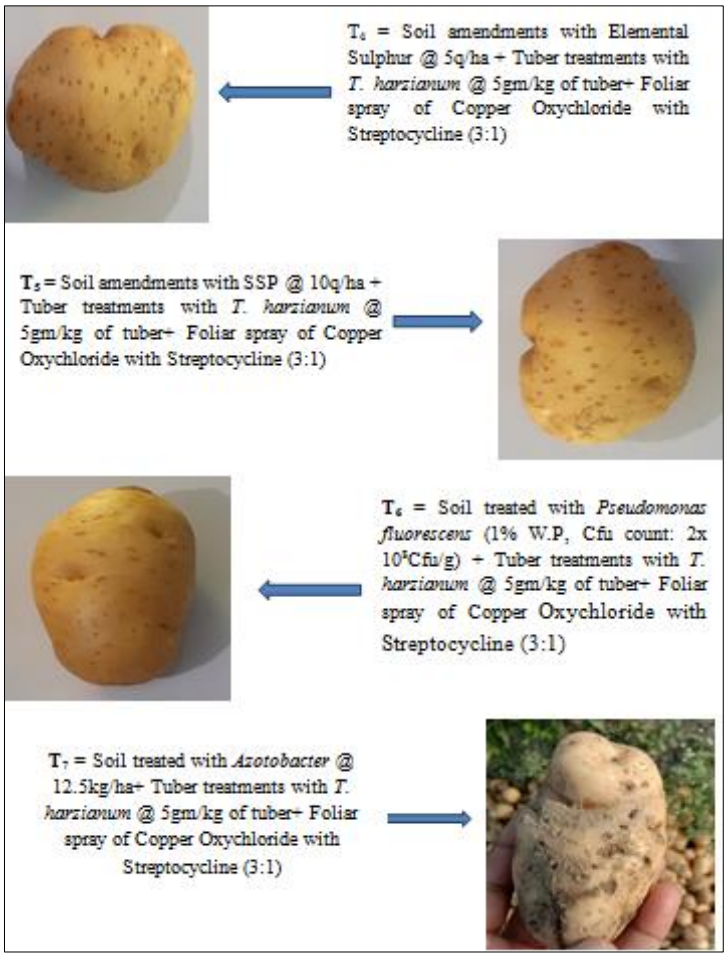


Fig 2: Effect of IDM approaches on disease severity and disease incidence of common scab of potato

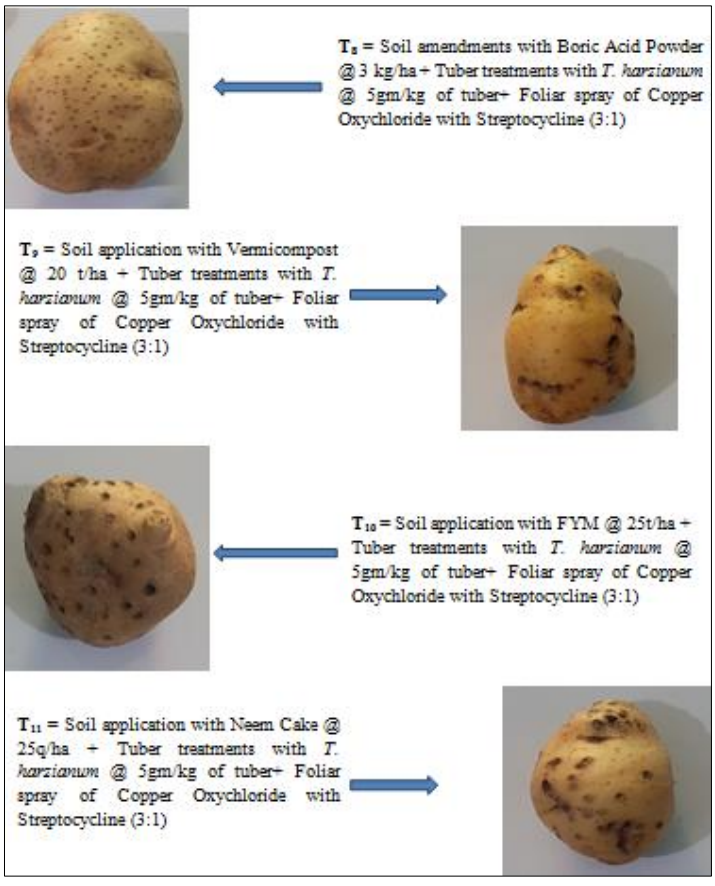


Fig 3: Effect of IDM approaches on disease severity and disease incidence of common scab of potato

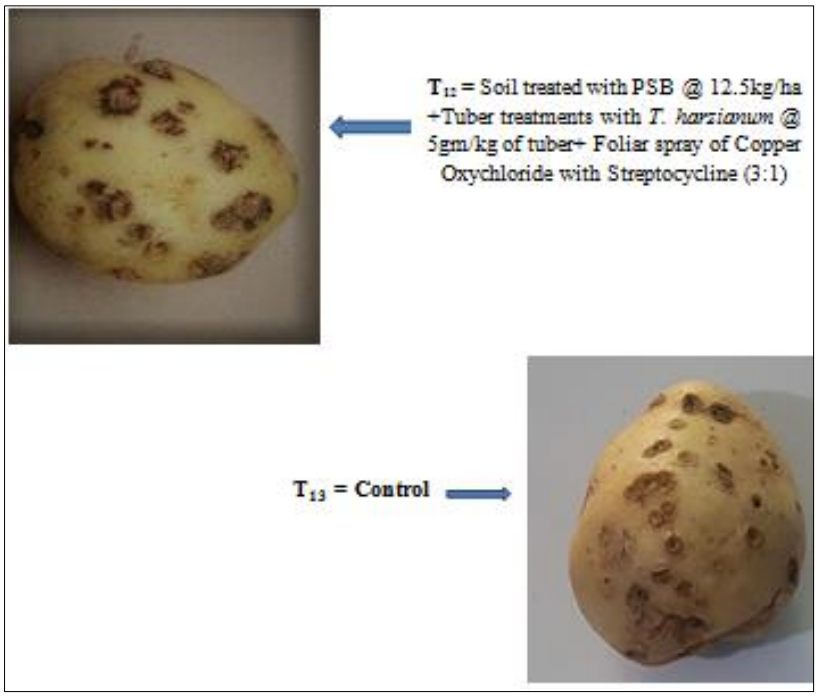
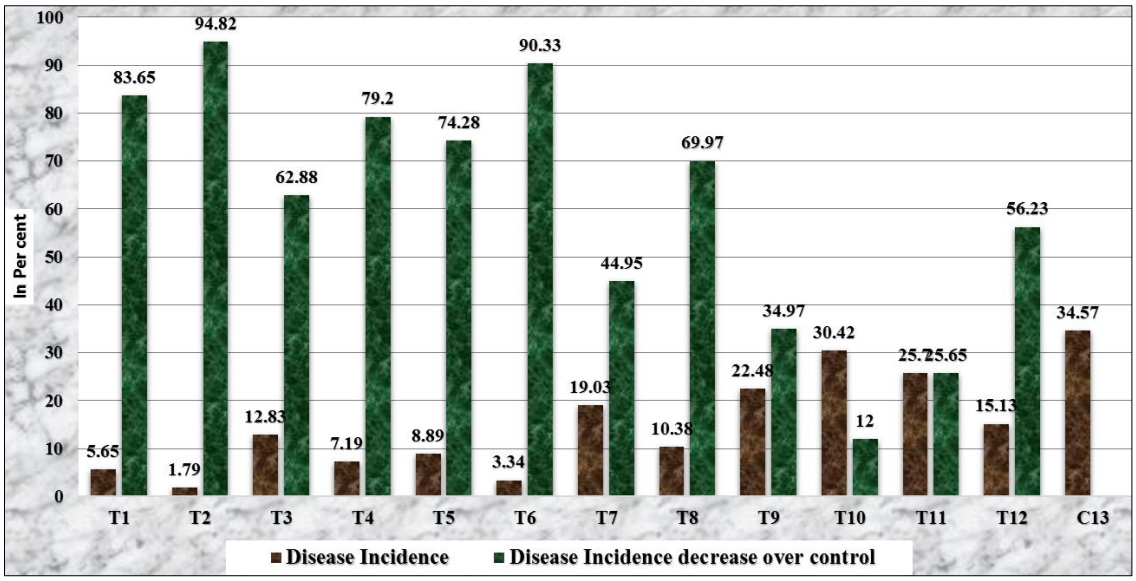


Fig 4: Effect of IDM approaches on disease severity and disease incidence of common scab of potato



T_1 = Soil treated with *Bacillus subtilis* (Baciforte, Cfu count: 1x 10^9cfu/ml) + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_2 = Soil amendments with Gypsum @ 20q/ha + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_3 = Soil amendments with Manganese Sulphate @ 15kg/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_4 = Soil amendments with Elemental Sulphur @ 5q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_5 = Soil amendments with SSP @ 10q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_6 = Soil treated with *Pseudomonas fluorescens* (1% W.P, Cfu count: 2x 10^8Cfu/g) + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_7 = Soil treated with *Azotobacter* @ 12.5kg/ha+ Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_8 = Soil amendments with Boric Acid Powder @ 3 kg/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_9 = Soil application with Vermicompost @ 20 t/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_{10} = Soil application with FYM @ 25t/ha + Tuber treatments with *T. harzianum* @ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_{11} = Soil application with Neem Cake @ 25q/ha + Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_{12} = Soil treated with PSB @ 12.5kg/ha +Tuber treatments with *T. harzianum*@ 5gm/kg of tuber+ Foliar spray of Copper Oxychloride with Streptocycline (3:1), T_{13} = Contro

Fig 5: Effect of IDM approaches on Incidence of Common Scab of Potato in field condition

Table 1: Effect of IDM approaches on germination per cent of tubers under field condition during 2019-20 and 2020-21

Treatment	Total no. of tubers sown per plot	Average no. of tubers germination per plot	Germination (%)	Germination per cent increase over control
T_1	80	78	97.50	21.87
T_2	80	80	100	25.00
T_3	80	71	91.25	14.06
T_4	80	76	95.00	11.76
T_5	80	75	93.75	17.18
T_6	80	79	98.75	23.43
T_7	80	72	90.00	12.50
T_8	80	74	92.50	15.62
T_9	80	71	88.75	10.93
T_{10}	80	68	85.00	6.25
T_{11}	80	69	86.25	7.81
T_{12}	80	72	90.00	12.50
C_{13}	80	64	80.00	

Table 2: Effect of IDM approaches on plant height at different days of interval under field condition during 2019-20 and 2020-21

Treatment	Plant height in cm					% Increase of plant height over control at 75 days after sowing
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	
T_1	4.83	19.33	33.83	44.50	60.33	63.05%
T_2	6.16	22.50	37.33	50.50	63.00	70.27%
T_3	4.00	17.50	28.33	39.83	50.83	37.37%
T_4	3.66	14.66	28.83	43.33	56.50	52.70%
T_5	3.66	13.66	25.83	40.00	54.25	46.62%
T_6	5.50	20.66	35.00	50.00	61.66	66.64%
T_7	3.33	16.00	27.16	38.33	48.00	29.72%
T_8	3.66	14.50	28.33	42.33	52.66	38.46%
T_9	4.00	14.66	24.66	35.16	46.33	25.21%
T_{10}	2.66	10.83	19.00	29.33	39.00	5.40%
T_{11}	4.33	13.16	21.50	31.33	41.50	12.16%
T_{12}	3.33	16.50	28.16	39.83	48.83	31.97%
C_{13}	2.66	11.00	19.16	28.16	37.00	
SE (m)	0.363	0.400	0.544	0.720	1.040	
SE (d)	0.514	0.565	0.769	1.018	1.471	
CD at 5%	1.062	1.168	1.589	2.103	3.038	

Table 3: Effect of IDM approaches on number of leaves at 15, 30, 45, 60 and 45 DAS under field condition during 2019-20 and 2020-21

Treatment	Number of leaves per plant					% Increase number of leaves over control at 75 days after sowing
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	
T_1	2	9	15	20	23	43.75
T_2	3	10	16	22	25	56.25
T_3	3	9	13	18	19	18.75
T_4	2	8	14	19	21	31.25
T_5	2	8	14	19	21	31.25
T_6	3	9	15	21	24	50.00
T_7	3	8	13	17	19	18.75
T_8	3	9	13	18	20	25.00
T_9	2	7	12	16	18	12.50
T_{10}	2	6	10	14	17	6.250
T_{11}	2	8	13	16	17	6.250
T_{12}	3	8	13	17	18	12.50
C_{13}	2	6	10	14	16	
SE (m)	0.160	0.320	0.480	0.640	0.800	
SE (d)	0.226	0.453	0.679	0.905	1.132	
CD at 5%	0.467	0.935	1.402	1.870	2.337	

Table 4: Effect of integrated disease management approaches on tuber size and yield of potato under field condition during 2019-20 and 2020-21

Treatments	Large (>50gm)		Medium (25-49gm)		Small (<25gm)		Mean Yield in Kg	Per cent Increase Yield After Treatment
	Mean Number of Tuber	Mean Weight in Kg	Mean Number of Tuber	Mean Weight in Kg	Mean Number of Tuber	Mean Weight in Kg		
T_1	137	13.167	167	7.324	209	5.025	25.516	33.48
T_2	143	13.845	161	7.164	198	4.854	25.863	35.32
T_3	124	12.553	174	6.585	224	4.907	24.045	25.79
T_4	135	12.990	165	7.215	214	4.925	25.130	31.46
T_5	131	13.185	169	7.600	217	4.109	24.894	30.23
T_6	139	13.498	165	7.269	204	4.926	25.693	34.41
T_7	118	11.650	175	6.678	227	4.432	22.760	19.06
T_8	127	12.818	172	7.734	221	3.873	24.425	27.77
T_9	117	11.580	168	6.075	231	4.750	22.405	17.21
T_{10}	114	10.265	176	5.255	226	5.343	20.963	9.66
T_{11}	119	10.880	179	6.300	235	4.436	21.716	13.60
T_{12}	121	11.900	175	5.771	226	5.824	23.495	22.91
T_{13}	111	10.085	159	4.029	239	5.000	19.115	
SE (m)	1.7614	0.1761	3.2025	0.2082	3.8428	0.1633	0.3204	
SE (d)	2.4907	0.2490	4.5283	0.2943	5.4338	0.2309	0.4531	
CD at 5%	5.1427	0.5140	9.3500	0.6077	11.2195	0.4769	0.9358	

Conclusion

The integrated effect of soil amendment with gypsum @ 20q/ha, tuber treated with bio-agent *T. harzianum*@ 5gm/kg of tuber and foliar spray of copper oxychloride with Streptocycline (3:1) significantly increase growth parameters *viz.*, germination per cent, plant height, number of leaves, yield and reduce the disease incidence of common scab of potato. Thus, the present IDM practices can be recommended for farmer's field against *S. scabies*, causes common scab of potato.

References

1. Baboo D, Biswas SK, Singh DR, Jatav AL, Singh R. Effect of inorganic chemicals as inducer on the growth parameters of potato (*Solanumtuberosum* L.) against common scab disease caused by *Streptomyces scabies* (Thaxter) Waksman &Henrichi. Journal of Pharmacognosy and Phytochemistry. 2021;10(2):1287-1291.
2. Bansal A, Biswas SK, Kumar S. "Effect of IDM practices on germination, growth parameters, yield and severity of late blight of potato caused by Phytophthorainfestans" (Mont.) deBary. 2021,
3. Han L, Dutilleul P, Prasher SO, Beaulieu C, Smith DL. "Assessment of common scab inducing pathogen effects on potato underground organs via computed tomography scanning". Phytopathology. 2008;98(10):1118-1125.
4. Hill J, Lazarovits G. A mail survey of growers to estimate potato common scab prevalence and economic loss in Canada". Can J Plant Pathol. 2005;27(1):46–52.
5. Kumar S, Biswas SK, Prakesh HG. "Integrated disease management approaches for control of late blight of potato and enhancing the growth of potato". Journal of Biological Control. 2019;32(4):264-2.
6. Lambert DH, Loria R. *Streptomyces scabies* species nov., nom. rev. Int. J Syst. Evol. Microbiol. 1989;39:387-392.
7. Lapwood DM, Welling LW, Rosser WR. The control of common scab of potatoes by irrigation. Ann. Appl. Boil. 1967;66(3):397-405.
8. Sidorevich NG, Golovarev VT, Silich AV, Avtushko RP. "Development of potato scab and watering". Razvitieparshikartofelya I poliv. Zaschitra Rastnii. 1981;No. 11: 27, USSR.
9. Singh NJ, Singh H. Irrigation - a cultural practice to control common scan of potato. J.I.P.A. 1981;8(1):35-36.
10. Thaxter R. The potato common scab. Connecticut Agricultural Experimental Station Report, 1890, 81-95.
11. Waksman SA, Henrici AT. Family II. Actinomycetaceae Buchanan and family *Streptomycetaceae* Waksman and Henrici.*In:* "Bergey's Manual of Determinant Microbiology." R.S. Breed, E. Murray and G.D. Hitchens (eds.), The Williams & Wilkins Co., Baltimore, Maryland. 1948, 892-980.