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To study the effect of technical approaches for awareness to farmers and application of antagonistic microorganisms with potash against the management of charcoal rot disease of soybean with cost benefit ratio

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Abstract
Charcoal rot (*Macrophomina phaseollina*) of soybean is a disease of economic significance through out the world. Survival of promising released resistant soybean verities hampered due to uncertain change of climate in favour of dreaded charcoal rot pathogen. Availability of saprophytic beneficial microorganism in soil goes down due to continuous indiscriminate application of chemical fungicides. Level of major soil nutrients such as nitrogen and potash also decreased in soil as found during the present studied. Technological gap among the farmers also a factor for survival of the disease causing agent. Combined effect of novel technology, bio-pesticides and soil application of potash utilized during the present studied. Analysis of soil of experimental plot has been completed to known the availability of nitrogen, phosphorus and potash in experimental plot and found that soil was rich with phosphorus whereas nitrogen and potash were in medium. Total fifty farmers were selected and screened their technological knowledge before plotted the experiment and found that only 38% farmers known the proper seed and soil treatment practices. Nearly 62% farmer had knowledge about the application of electronic media in crop production of soybean. An experiment was conducted under field condition to find out the use of bio pesticides such as *Trichoderma harzianum* and *Pseudomonas fluorescens* as (seed and soil treatment) along with two dosed of potash(20kg/ha and 40kg/ha) against *Macrophomina phaseollina* pathogen during 2019-20 and 2020-21. Results of pooled data indicated that combined application of both bio pesticides and potash significantly reduced the incidence of disease in comparison to untreated control. *T. harzianum* used as soil (5kg/ha) and Seed (5g/kg seed) treatment with additional dose of basal potash (40kg/ha) in soil before sowing gave 64% disease control followed by soil treated with *P. fluroscens* plus potash (40kg/ha) 46%. Application of *T. harzianum* as seed and soil treatment with recommended dose of fertilizers (RDF) found 34% disease control which was significantly higher than T2 treatment (*P.fluroscens*+20kg/haK2O). Soil treatment with *T. harzianum*+K2O found more effective for promoting plant growth parameters and reduced charcoal rot disease of soybean. Yield in each treatment increased with bold seed and shin in compression to untreated control whereas 40kg potash with *T. harzianum* gave best performance in plant height, yield and cost benefit ratio in comparison to others treatments. Treatment 4 Yielded 32% more average yield than T2.However effect of trichoderma with 40kg/ha K2O was more effective than Pseudomonas plus K2O. In control plot, there was only 08q/ha yield with minimum net profit. Overall it might be seen that *T. harzianum*+K2O supplied plot produced significantly greater yield than *P. fluorescens +K2O* in both the years2019-20 and 2020-21. On average nearly 42-87% more yield recovered in treatments plot in comparison to control.

Keywords: soybean variety, trichoderma, pseudomonas. potash and technological approaches

Introduction
Soybean (*Glycine max* L.) is one of the most valuable dominant oil seed crop and good source of vegetable protein and oil but crop is susceptible to root and stem base rots caused by soil born pathogens at all growth stages. One of these diseases is charcoal rot of soybean caused by the polyphagous fungus *Macrophomina phaseollina is a very dangerous and important disease* infect plants from seedling stage to maturity with peculiar symptoms such as development of radish brown lesion on the hypocotyls, which become ash grey and lastly turn black. This pathogen infected a wide host rang of nearly 500 species in more than 100 crop family around the world, including other important crops such as chickpea, pea ,cotton, maize,

bean, sesame, sunflower, tobacco, safflower, sorghum and melon in addition to soybean (Singh *et al*. 2008) [12] . The fungus is not only soil born, but also seed born and infects plants from seedling stage to maturity. The presence of small, black sclerotia in the cortical tissue confers the charcoal appearance that gives the disease its name (Mengistu *et al*. 2015) [7]. *M. phaseolina* fungus enable to adopt in different environmental conditions and became widely distributed geographically with new strain/biotypes (Su *et al*. 2001) [13]. The fungus also infected mature plants with clear chlorotic lesion on the leaves, which then die but remain attached to the stem and finally the plants die prematurely in the presence of water stress and high temperature (Reznikov *et al*. 2016) [10]. High temperature and water stress condition during reproductive stage is very congenial for development of the disease. Disease severity increases as the air and soil temperature increase from 28 to 3 5ºC and when soil moisture is limited. Yield loss under field condition ranges from 20 to 40% depends upon environmental condition and prevailed soybean varieties under field condition. This disease ranked in the top six of disease among economically important soybean diseases. Causal agent of charcoal rot disease *M. phaseollina* invade the root of the host after 1-2 week of germination of plants but the symptoms appear only in mature plants. Several efforts to control of this fungus by adjusting planting dates, crop rotation, plant population, irrigation had suggested as important way of disease management. Host resistance may be practicable method to manage this destructive disease. However, soybean genotypes with high level of resistance have not been identified (Mengistu *et al* 2007) [6]. Chemical fungicides are being replaced with bio- control agents because of the emergence of resistant fungal strains against novel chemical fungicides. Bio-agents can provide an alternative ways to control certain seed and soil born plant diseases when other methods are difficult to apply. Trichoderma, Aspergillus and penicillium reported to successfully controlled *Sclerotium rolfsi*, *Rhizoctoniya solani* and *pythium* spp. Talk- based formulation of *Trichoderma viride* was widely used by farmers to treat seeds of sesame, chickpea, sunflower, mungbean and groundnut for the control of root rot disease caused by *M. phaseollina* . Aly *et al*. (2007) [1] reviewed differential antagonism of Trichoderma species against *M. phaseollina and reported that Percent* survival of melon plants in treatment applied with T. harzianum was much more than unapplied *T. herzianum* plot. Bio- control agents not only controlled the disease but also saved the human health and environment. Secondly, indiscriminate use of nitrogenous fertilizers is also responsible for incremental spread of the *M. phaseollina* disease. Farmers are not aware to utilize of major fertilizers i.e. nitrogen, phosphorus and potash at recommended dose during the crop period. Most of the farmers used only nitrogenous fertilizer which reported not to increase only the cell size of the plants but also make plant succulent to diseases. Whereas potash decrease the cell size and promoting stem / root growth, grain shining ,make plant hardy against the disease and also play a role in plant metabolism, protein synthesis and chlorophyll development . Regmi and Shrestha (2018) [9] reported that potash decrease the Alternaria leaf spot in radish and increased the root girth, plant height and yield. . Chauhan *et al*. (2000) [3] reported that increase in phosphorus nutrition in cauliflower led to an increase the incidence of damping off and stem rot. The objective of present research was to determine the role of technical approaches during the crop period along with application of bio-agents with potash as soil and seed treatment against charcoal rot disease of soybean. Treatment wise Cost benefit ratio was also calculated.

Materials and Methods

The study was conducted by the Krishi Vigyan Kendra, Narsinghpur, Madhya Pradesh at farmer's fields in two consecutive years i.e. 2019-20 and 2020-21 during kharif in village, Sivani Bandha, block -Gotegaon of the district-Narsinghpur. The farmers of this village had small and medium land holding and whole district comprised under central Narvada Valley zone. Total fifteen farmers were selected and divided in to five groups .Each group had ten farmers which considered as one replication. Soil of each replication collected and analyzed before set of the experiment in both years and data was summarized in table 1. Novel technological approaches to each experimental beneficiary on soybean production were provided during crop period through personal contact, electronic and print media. For information purposes make a Watts up group and added mobile number of each and every 50 farmers. Before going to setup the experiments, training on technical aspects such as soil sampling, type and quantity of nutrients available in soil, nutrients to be require by soybean plants, role of bio-agent and potash in disease control was organized. After completion of technical training on soybean production, a simple test was taken to know the initial technological gap at different technological aspects among the farmers. Personal profiles on Socio economic status of total 50 farmers were collected by personal contact. Field trial with variety JS20-69 in kharif 2019-20 and 2020-21crop seasons at farmer's fields was conducted as per treatments in five replications in randomized block design. Detail description of each treatment given below,

Table 1: Detail description of each treatment given below,

Treatment	Description of treatment
T1	Soil (@5kg/ha with100kg FYM) and Seed(@5g/kg) treatment with *Trichoderma harzianum* + RDF(N:P:K,20:50:20)
T2	Soil (@5kg/ha with100kg FYM) and Seed (@5g/kg) treatment with *Pseudomonas fluorescens* + RDF(N:P:K,20:50:20)
T3	Soil (@5kg/ha with100kg FYM) and Seed(@5g/kg) treatment with *Trichoderma harzianum* + Basal application of K2O@40kg/ha
T4	Soil (@5kg/ha with100kg FYM) and Seed (@5g/kg) treatment with *Pseudomonas fluorescens* + Basal Soil application of K2O@40kg/ha
T5	Untreated(Neither used bio-agent nor additional K2O)

Sowing of soybean completed in the last week of June in both crop seasons as per treatment through ridge furrow system. Recommended dose of fertilizers were supplied in the soil before sowing .Where as additional dose of potassium (40kg/ha) along with either Trichoderma or Pseudomonas applied as per treatment in the soil. Required precautions has been taken during crop period viz. drainage of excess water from the field, initial weed management with weedicide and second time with hoeing, pests management in standing crop, roughing etc. Charcoal rot disease incidence, plant height, number of pods per plant and yield were recorded timely. Cost benefit ratio was calculated to know the gain or losses in the experiment. Seed yield of each replication determined after harvesting of whole crop as per treatment.

For disease assessment, affected plants and total number of plants in each replication was counted separately as per treatment and disease incidence calculated by formula,

Disease incidence (%) = *total* affected plants x100/Total number of plants in treatment.

Results and Discussions

Available Nutrient: Soil of experimental plot collected in the last week of April as per standard norm and brought in the KVK, Narsinghpur laboratory in both the successive years 2019-20 and 2020-21. Collected soil analyzed report summarized in Table 2. Soil testing result indicated that initial average availability of both nutrients such as nitrogen (221.25Kg^{--1}) and potash(162.69Kg$_{-}^{1}$) were less while phosphorus level was high (15.34Kg/ha). Level of organic carbon was low (0.35Kg^{-1}) but range of pH was normal (Ph7.05). Farmer never applied potash in soybean crop before sowing. Recommended dose of N: P: K: for soybean crop is 20:50:20 kg/ha.

Table 2: Availability of major nutrients quantify in soil before setup of experiments.

Analyzed content	Availability kg/ha		Average of two years
	2019-20	2020-21	
N	204.8	237.71	221.25
P	14.78	15.9	15.34
K	176.10	149.28	162.69
OC	0.52	0.59	0.55
pH	7.04	7.17	7.11

Technological adoption gapes in soybean

The data present in table 3 on technological knowledge assessment showed that only 66% farmers know about the importance of soil analysis to utilized fertilizers on the basis of soil health card where as 34% farmers did not know the actual doses of recommended fertilizers for soybean crop. Nearly 54% technological gap was observed among the farmers in relation to seed and soil treatment against charcoal rot disease because farmers were not using seed and soil treatment technique through trichoderma and pseudomonas. They also did not know about the role potash in crop production and disease managements as reported by Regmi and Sheathe (2018) [9] in radish crop against Alternaria blight. Whereas seed and soil treatment is the major tool to prevent disease under field conditions. In general Farmers used insecticides instead of fungicides for disease control. Maximum technological gap (77%) noted in integrated disease management practices because farmers used partial IDM practices and not able to differentiate disease and pest symptoms in field. So this 38% gap fulfilled trough trainings, print media, electronic media and personal contact during the crop period. Partial gap (18%) was identified for use of high yielding varieties, seed rate, time of sowing, and method of sowing and weed management. The farmers were much concerned about importance of sowing time but they don't aware it escapes from appearance of disease.

Table 4: Qualitative test for Knowledge level of farmers about soybean cultivation.

Knowledge Aspect of soybean cultivation	Beneficiary farmers (n=50)		
	Frequency	Initial technological Knowledge (%)	Initial technological Gap (%)
Soil analyzed and advice nutrients application for soybean crop and use of nutrients as per soil health card	33	66.00	34.00
General knowledge about seed and soil treatments	23	46.00	54.00
General knowledge about application of IDM practices	19	23.00	77.00
General knowledge about crop geometry improvement such as sowing with ridge furrow ferity drill adjusted at three cm deep in the fourth week of June, spacing, irrigation, hoeing, roughing etc.	26	82.00	18.00
Knowledge about application of agricultural technological approaches receive through electronic & print media i.e. Watsup, KMA, News papers etc.	21	42	58.00
Knowledge about differences in insect pests and disease	31	62.00	38.00

Effect of bio-pesticides and potassium on disease severity of charcoal rot of soybean

Significant effect of bio pesticides and potassium was found on the control of charcoal rot disease in comparison to control. Incidence was found lowest (8.75%) in T3 plot receiving 40kg k_2O plus soil and seed treated with *T. harzianum* followed by T4 and T1 in the year 2019-20 (Table 4). Highest incidence was noted in T2 (19.57%) but was significantly lower than untreated control (24.75%). Treatment T4showed superior effect against charcoal rot and significantly lower incidence of disease than T2 which indicate that 40kg/ha potassium play greater role than 20kg/ha as recommendation. However doubling the rate of potassium to recommended rate either with T. *harzianum* or *P. fluorescens* decrease disease incidence 6.22-10.82% in the first year 2019-20. In the year2020-21 results showed that incidence of charcoal rot found greater on T2 treatment plot (17.23%) than T1 (16.17%) which was statistically at par with application of 20kg/ha potassium. The disease incidence was significantly decreased (7.93%) when the plot was supplied with T. *harzianum* plus 40kg/ha potassium (T3) in comparison to rest of treatments. The disease incidence increased on average from 3.44 to 9.3% among the treatments. Highest incidence recorded in *P. fluorescens plus 20kg/ha* K2O *(17.23%)* and statistically at par with trichoderma plus 20kg/ha K2O. In the second year 2020-21, treatment 3(trichoderma+40kg/ha K2O) and treatment 4 (*Pseudomonas plus 40kg/ha* K2O) had lowest disease incidence differed statistically from treatment 1 and treatment 2 (Table 4). Treatment 3 resulted to reduced 13.7% more disease incidence than treatment 5 indicated untreated control. Baired *et al* (2003) [2] reported that trichoderma directly or indirectly lowered the survival of soil born pathogens including *M. phaseolina*. Use of *T. viride* and T. *harzianum* as a seed treatment (4-5g/kg seed) has been recommended for the management of charcoal rot in soybean (Gupta and Chauhan, 2005) [4]. Khaledi and Teheri (2016) [5] reported the effect of T. viride and T. harzianum against the control of growth and development of M. phaseolina ,the causal agent of charcoal rot of soybean. It is known that the presence of phenolic compounds in plants and their synthesis in response to infection, is associated with resistance (Taheri and Tarighi 2011; Nikraftar *et al* 2013) [14, 8]. It has been found that both soil applied and foliar application of potassium decreased the Alternaria leaf spot in cotton and mustard where in low level of potassium in soil (Sharma and Kolte 1994) [11]. Potassium involved in essential cellular activity as a mobile regulator of enzymetic activity that influence the disease severity .Potassium play important role in the regulation of stomata regulation and cellular activities of crop and it also act as transporter of photosynthesis at the site of storage from production site (Regmi and Shrestha, 2018) [9]. Increased of phenolic compound after application of potassium (K) in toria plants reported by Sharma and Kolte in 1994 [11] against *A. brasssicae* ,whereas NP fertilized plants had the lowest phenolic content at each stage of plant growth .

Plant height

Result summarized in Table 5 indicated that, Significantly highest plant height (58cm) was recorded in treatment 3 provided T. harzianum for seed and soil treatment along with K2O @40kg/ha comparably to others treatments. Lowest plant highest was found in plot receiving *Pseudomonas plus* recommended dose of fertilizers in the year 2019-20. There were *no* significant differences in plant height found among T1 (49cm), T2 (46cm) and T4 (55cm). Increasing trend of average plant height was found in that plot which soil and seeds treated with bio-pesticides along with K2O in comparison to the control plot in the year 2020-21.Khaledi and Taheri (2016) [5] reported that soil treatment with T. harzianum found more effective for promoting plant growth parameters and reduced charcoal rot disease of soybean.

Effect on yield parameter and yield

Highest number of pods found in treatment 4(88) followed by T3 (87) and T1 (76) but had no significant differences among the treatment in the year 2019-20. Minimum number of pods was obtained in control treatment. Significantly greater number of pods was recorded in T3 (97) followed by T4 (92) in comparison to T1 (83) and T2 (81).It might be seen that there was no fruitful differences in number of pods between T1 and T2. Lowest number of pods (68) received in control treatment in 2020-21.Crop yield increased in all treatments in comparison to control plot. While statistically higher yield recovered in treatment 3(15.89q/ha)in which applied *T. harzianum* as soil and seed treatment along with 40kg soil based K2O before sowing. Treatment 4 led to 5.88q/ha more soybean yield than untreated control in the year 2019-20.Yield increased in all the treatment in the year 2020-21 including control and it was due to favorable environment and long duration rainfall. Treatment 3 gave more yield (17.57q/ha) and it was differed statistically from treatment 1(14.29q/ha) and treatment2 (13.63q/ha).There were no significant difference in yield between T3 (17.57) and T4 (15.34).Overall it might be seen that *T. harzianum*+K2O supplied plot produced significantly greater yield than *P. fluorescens +K2O* in both the years2019-20 and 2020-21.Nearly 42-87% more yield recovered in treatments plot in comparison to control. Role of bio-pesticides to control charcoal rot disease and increased in yield reported by Reznikov *et al*. (2016) [10].

Table 5: Effect of bio-pesticides and potassium against charcoal rot disease severity and yield attribute of soybean

Treatment	Disease incidence (%)		Plant Height(cm)		Number of Pod/Plant		Yield q/ha		Yield increased (%)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T1	14.42	16.17	49	51	76	83	12.12	14.29	42.75	46.56
T2	19.57	17.23	46	48	72	81	11.71	13.63	37.92	39.79
T3	8.75	7.93	58	59	87	97	15.89	17.57	87.16	80.20
T4	13.35	11.37	51	55	88	92	14.37	15.34	69.25	55.28
T5	24.75	21.63	45	46	62	68	8.49	9.75	-	-
P=0.05	4.18	3.27	7.13	5.33	13.63	9.97	1.71	2.31	-	-

Comparative economic analysis in production of soybean

The economics of soybean production under mentioned treatments were estimated and the results have been presented in Table 6. Different components such as Trichoderma, Pseudomonas with recommended dose of fertilizers plus additional dose of potassium have been taken along with untreated control plot kept in the present experiment. Economic indicators such as net profit and B: C ratio clearly revealed that plot supplied T. harzianum with 4okg K2O substantiation gave highest return (Rs43410) and B: C ratio (1:2.89) in comparison to *P. fluorescens* plus 40kg K2O (Rs36850). Grass return among the treatment ranges from Rs 7080.00 to 15840.Highest grass return obtained in treatment3 (Rs 66520/ha) followed by T4 (Rs59440/ha) and T1 (Rs 52840).Lowest profit and B: C ratio was received in control plot. However there were not very many differences in expenditure among the treatments. So it might be seen that charcoal rot disease of soybean which severely attacked at the time of reproductive phase of crop and caused hug damaged can be control with the application of bio-pesticides and K2O as soil and seed treatment at nominal expenses.

Table 6: Economic performance and cost benefit ratio of soybean (Average of 2019-20 and 2020-21)

Treatment	Average yield q/ha	Grass cost Rs/ha	Grass returns Rs /ha)	Net returns Rs /ha)	Benefit cost ratio
T1	13.21	22135	52840	30705	1:2.39
T2	12.67	22188	50680	28492	1:2.28
T3	16.63	23110	66520	43410	1:2.89
T4	14.86	22590	59440	36850	1: 2.63
Control	9.12	19630	36480	16850	1:1.85

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