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Effect of Phosphate and Zinc Solubilizing microbes on Growth, Yield and Economics of Fieldpea (*Pisum sativum L.*) under Conditions of Chhattisgarh

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A B S T R A C T

The new research work was conducted at Instructional Cum Research Farm, College of Agriculture, Department of Agronomy, IGKV, Raipur during *rabi* season of 2019-20. The experiment was assessed with three replication in Randomized Block Design. The experiment consist of 11 different treatments. Fieldpea as a test crop and variety was Indira matar-1. Recommended dose of nitrogen, potassium and sulphur @ 20 kg ha^{-1} and Rhizobium culture applied common to all treatments. The result revealed that use of recommended dose of phosphorus @ 50 kg ha^{-1} and nutrient mobilizer (LNm 43a) was found to be effective and significantly increase the growth and yield attributes of fieldpea rest of the treatments in terms of plant height (cm), number of branches $plant^{-1}$, number of leaves $plant^{-1}$ and number of pods $plant^{-1}$. Significantly, higher seed yield (1700 kg ha^{-1}) and stover yield (3950 kg ha^{-1}) were also obtained. Inoculation of phosphate and zinc solubilizing microbes in fieldpea have proven to be the best treatment for achieving the maximum gross realization (Rs 80450 ha^{-1}), net realization (Rs 58234 ha^{-1}) and benefit cost ratio (3.62) under RDP and nutrient mobilizers (LNm 43a). Owing to improved growth efficiency and yield attributes, yield increases and result in higher economic returns considered as cost effective integration of RDP and microbes.

Introduction

Pulses are 2nd important cultivated crops after cereals**.** A variety of pulse crops grown in India and world. Fieldpea (*Pisum sativum L.)* is the most popular pulse crop of India. The important fieldpea growing states are Uttar Pradesh, Punjab, Haryana, Rajasthan, Chhattisgarh and Madhya Pradesh. Fieldpea is the most significant annual cool season pulse crop. It contains rich source of protein (22%), carbohydrates (62.1%), fat (1.8%), minerals (calcium - 64 mg $100g^{-1}$, iron - 4.8 mg $100g^{-1}$) and vitamins (Riboflavin, Thiamine**).** Fieldpea contain high level of amino acid lysine and tryptophan

India is the largest producer and importer of pulses. It is also grown for forage crop for cattle. Besides this, fieldpea can be grown as green manure crop which protect the soil from erosion and improves the physical, chemical

and biological properties of soil. It is one of the potentially high yielding crop grown in wide varieties of soil types from light sandy to heavy clay. It require cool growing season for its better growth and development. Phosphate solubilizing microbes include various bacterial, fungal and actinomycetes forms which help to convert insoluble inorganic phosphate into simple and soluble form make it available to plants for the proper growth and development of the plant. Phosphorus play significant role in the transformation of energy in carbohydrate metabolism, fat metabolism and also help in respiration of plants. It increase plant tolerance to root rot disease and also responsible for early maturity of seed and fruit. Zinc solubizing microbes have high potential in transforming fixed zinc into available forms for proper growth of plant. Zinc is constituent of carbonic anhydrase, RNA polymerase enzymes, important in synthesis of IAA (Indole Acetic Acid) and essential for water uptake. It help in production of SOD (Super oxide dismutases) which control oxidative stress in plants.

Materials and Methods

The experiment was conducted at Instructional Cum Research Farm, IGKV, Raipur during rabi season of 2019-20. Geographically, Raipur is located near a large plain and situated at 21°.25' N latitude and 81°.62' E longitude. Its height from mean sea level at 298.15 m. The experiment soil was vertisols. The experiment was conducted in randomized block design with three replication. The experiment consist of 11 different treatments. Test crop was fieldpea and variety taken was Indira Matar -1. 80 Kg ha^{-1} seed was sowned manually with a spacing of 30 cm X10 cm row to row and plant to plant in the depth of 4-5 cm in soil for proper nitrogen fixation. Sowing was done on 11-11-2019. Recommended dose of nitrogen, potassium and sulphur @ 20 kg ha^{-1} respectively, applied as basal dose and seed was treated with 5 gm rhizobium culture kg^{-1} seed at the time of sowing common to all treatment. Harvesting was done manually on 15-03-2020 by rooting the plant. Several observation was taken from each plot randomly during entire growth period of fieldpea. Observed plants were tagged properly for further days. Observation was recorded at 30, 60, 90 DAS and at harvesting of crop. The following observation were taken on growth and yield attributes of fieldpea are plant population (m^{-2}), plant height (cm), number of branches $plant^{-1}$, number of leaves $plant^{-1}$, number of nodules $plant^{-1}$, Leaf area index (LAI), Leaf area duration (LAD), Dry matter accumulation $plant^{-1}$ (g), Crop growth rate (CGR), Relative growth rate (RGR), number of pods $plant^{-1}$, number of seeds pod^{-1}, 100 seed weight (seed index), stover yield (kg ha^{-1}), seed yield (kg ha^{-1}). Five place was randomly selected from each plot for counting the plant population $meter^{-2}$ with the help of quadrates and counted the each plant which are in inside the quadrate. Mean value was taken. Randomly five plant were selected for measuring height (cm) with the help of meter scale, number of branches $plant^{-1}$, number of leaves $plant^{-1}$, number of nodules $plant^{-1}$, number of pods $plant^{-}$ and mean value was calculated. For counting the number of nodules $plant^{1}$. The selected plant sample was uprooted carefully and wash with water for removing the soil mass adhered in roots and counted the pink coloured nodules. Mean value was recorded. For analysis of the growth and development of crop plant, most common parameters were used *i.e* Leaf area index (LAI), Leaf area duration (LAD), Crop growth rate (CGR) and Relative growth rate (RGR). To evaluate the best treatment for fieldpea, economics evaluation was done. Several economic indices are used to evaluate the profitability of plots *viz.* cost of cultivation, gross realization, net realization and benefit cost ratio.

Results and Discussion

Growth parameters

In the table. 1 the observation of plant height was recorded at 60 and 90 DAS. The result revealed that plant height was minimum upto 30 DAS but it was increased during 60 and 90 DAS due to increase in the age of crop. The plant height value ranges from 35.8 to 50.7 at 60 DAS and 42.3 to 63.1 at 90 DAS under different treatment. Significantly, maximum plant height value was 50.7 recorded at 60 DAS and 63.1 at 90 DAS under T_{11}: RDP + nutrient mobilizer (LNm 43a) and found superior among the treatments. This finding was confirmed by Ganie *et al.,* (2009) in gardenpea and Kant *et al.,* (2016) in urdbean recorded highest plant height. Number of branches plant^{-1} was recorded at 30 and 60 DAS and found that number of branches plant^{-1} significantly influenced at all the growth stage of fieldpea. The result revealed that number of branches plant^{-1} value ranges from 2.18 to 3.12 recorded at 60 DAS under different treatment. Due to the positive interaction between microorganism gave superior result on promoting number of branches plant^{-1}. Significantly, maximum numbers of branches was (3.12) recorded at 60DAS under T_{11}: RDP + nutrient mobilizer (LNm 43a) treatment as compared to other treatments. Similar finding were also reported by Kalayu (2019). Dry matter accumulation plant^{-1} at all the growth stages due to phosphate and zinc solubilizing microbes in field pea. The data was recorded at 60, 90 DAS and at harvest. The pre-requisite for high yields was a high production of total dry matter per unit area.The amount of dry matter produced depend on photosynthesis which in turns depends on large and efficient assimilating area, adequate supply of solar radiation, CO_2 and favourable environment condition. Significantly maximum dry matter accumulation plant^{-1} at 60, 90 DAS and at harvest. was 6.90, 10 and 14.07 recorded under T_{11}: RDP + nutrient mobilizer (LNm 43a) among the treatments. It was at par to$T_{10:}$ 50% RDP + 12.5 kg $ZnSO_4$ + Biophos + Biozinc (6.77, 9.77 and 13.80), $T_{9:}$ 50% RDP + Biophos + Biozinc (6.57, 9.47 and 13.37),T_2: RDP application (@ 50 kg ha^{-1}) (6.32, 9.43 and 13.13) and $T_{7:}$ 50 % RDP + Biophos (9.17 and 13.05) (at 90 DAS and harvest).While, minimum dry matter accumulation plant^{-1} was (1.49, 4.99, 6.90 and 10.20). recorded under T_1: control plot. Tagore *et al.,* (2013) and Meena *et al.,* (2015) also reported that inoculation of phosphorus solubilizing microbes significantly increase the dry matter yield plant^{-1}

Yield attributes and yield

The data was presented regarding number of pods plant^{-1} in Table 2. recorded after the harvesting of crop. The result show that inoculation of phosphate and zinc solubilizing microbes significantly increase the number of pods plant^{-1} in fieldpea. The result indicates the positive effect of phosphate and zinc solubilizing microbes on number of pods plant^{-1} ranges from 10 to 29 among different treatment. The result revealed significantly maximum number of pods plant^{-1} 29 was recorded under T_{11}: RDP + nutrient mobilizer (LNm43a) due to positive effect of nutrients, increase the flower formation and fruit setting. This finding was confirmed by Meena *et al.,* (2015) and Oteino *et al.,* (2015) recorded maximum number of pods plant^{-1}. Grain yield in presented in Table 2. The data revealed that there was significant variation in grain yield among different treatments due to presence of phosphate and zinc solubilizing microbes. Yield is the result of final plant population, number of pods plant^{-1}, no of seeds pod^{-1} and seed index etc. The amount of economic yield depends on the manner in which the net dry matter is produced among different parts of the plant.

Table.1 Effect of phosphate and zinc solubilizing microbes on growth attributes

	Plant height (cm)		No of branches plant^{-1}	Dry matter accumulation plant^{-1}(g)		
Treatments	**60 DAS**	**90 DAS**	**60 DAS**	**60 DAS**	**90 DAS**	**At Harvest**
Absolute Control (Without P)	35.8	42.3	2.18	4.99	6.9	10.2
RDP application (@ 50 kg/ha)	46.5	57.4	2.82	6.32	9.43	13.13
Soil Appli. of 25 kg $ZnSO_4$/ha	43.9	46.6	2.23	5.3	7.89	11.02
Application of Biophos	41.1	48.6	2.35	5.57	8.19	12.55
Application of Biozinc	41.4	51.7	2.24	5.8	7.89	12.2
Application of Biophos + Biozinc	45.2	53.5	2.35	5.9	8.67	12.7
50 % RDP + Biophos	45.7	55.6	2.3	6.17	9.17	13.05
12.5 kg $ZnSO_4$+ Biozinc	43.3	57.3	2.34	5.97	8.3	12.65
50 % RDP + Biophos + Biozinc	47.2	59.4	2.92	6.57	9.47	13.37
50 % RDP+12.5 kg $ZnSO_4$+Biophos + Biozinc	47.8	60.2	2.96	6.77	9.77	13.8
RDP + nutrient mobilizer {LNm 43a	50.7	63.1	3.12	6.9	10	14.07
C.D.	1.5	1.9	0.08	0.2	0.2	0.43
SE(m)	4.5	5.5	0.26	0.61	0.88	1.28

Table.2 Effect of phosphate and zinc solubilizing microbes on yield attributes, seed yield, stover yield and harvest index

	Pods plant^{-1}	Seed yield	Stover yield	Harvest
Treatments		(kg ha^{-1})	(kg ha^{-1})	Index(%)
Absolute Control (Without P)	10	900	2700	25
RDP application (@ 50 kg/ha)	25	1527	3710	29.15
Soil Appli. of 25 kg $ZnSO_4$/ha	11	940	2978	24
Application of Biophos	13	1090	2957	27
Application of Biozinc	12	990	2834	26
Application of Biophos + Biozinc	17	1240	3008	29.1
50 % RDP + Biophos	21	1490	3630	28.54
12.5 kg $ZnSO_4$+ Biozinc	14	1140	2983	27.7
50 % RDP + Biophos + Biozinc	25	1533	3709	29.24
50 % RDP+12.5 kg $ZnSO_4$+Biophos + Biozinc	4.4	1547	3748	29.21
RDP + nutrient mobilizer {LNm 43a	29	1700	3950	30
C.D.	0.66	72	112	0.9
SE(m)	1.97	213	333	2.7

Table.3 Effect of phosphate and zinc solubilizing microbes on economics

Treatments	Cost of cultivation (Rs ha^{-1})	Gross realization (Rs ha^{-1})	Net realization (Rs ha^{-1})	B: C ratio
Absolute Control (Without P)	20800	43200	22400	2.08
RDP application (@ 50 kg ha^{-1})	21458	74425	52967	3.47
Soil application of 25 kg $ZnSO_4$ha^{-1}	21675	45278	23603	2.09
Application of Biophos	20900	52007	31107	2.49
Application of Biozinc	20900	47384	26484	2.27
Application of Biophos + Biozinc	21000	58808	37808	2.80
50 % RDP + Biophos	21558	70680	49122	3.28
12.5 kg $ZnSO_4$ + Biozinc	21338	54283	32945	2.54
50 % RDP + Biophos + Biozinc	21658	72694	51036	3.36
50 % RDP + 12.5 kg $ZnSO_4$+Biophos + Biozinc	22096	73363	51267	3.32
RDP + nutrient mobilizer (LNm 43a)	22216	80450	58234	3.62

The data revealed that inoculation of phosphate and zinc solubilizing microbes in fieldpea significantly produce higher grain yield. The result revealed that value of grain yield ranges from 900 kg ha^{-1} to 1700 kg ha^{-1} under different treatments plots. The result showed that highest grain yield was (1700 kg ha^{-1}) obtained under $T_{11:}$ RDP + nutrient mobilizer (LNm43a). It was at par to T_{11}: 50 % RDP+12.5 kg $ZnSO_4$+ Biophos + Biozinc (1547 kg ha^{-1}), $T_{9:}$ 50 % RDP + Biophos + Biozinc (1533 kg ha^{-1}), $T_{2:}$ RDP application (50 kg ha^{-1}) (1527 kg ha^{-1}) and T_7: 50 % RDP and Biophos (1490 kg ha^{-1}).While lowest grain yield was 900 kg ha^{-1} obtained under T_1: control plot. Singh *et al.*, (2012) found that application of single super phosphate and phosphate solubilizing bacteria recorded highest seed yield (1.70 tonnes ha^{-1}) in fieldpea. Highest stover yield 3950 kg^{-1} ha under $T_{11:}$ RDP + nutrient mobilizer (LNm 43a). It was at par with $T_{10:}$ 50 % RDP + 12.5 kg $ZnSO_4$ + Biophos + Biozinc (3748 kg ha^{-1}), $T_{9:}$ 50 % RDP + Biophos + Biozinc (3709 kg ha^{-1}), T_7: 50 % RDP and Biophos (3630 kg ha^{-1}) and $T_{2:}$ RDP application (50 kg ha^{-1}) (3710 kg ha^{-1}). While, minimum stover yield was 2700 kg ha^{-1}recorded under control plot. Bhat *et al.*, (2013) found that combined inoculation of rhizobium and PSB in field pea recorded maximum stover yield(15.85 q ha^{-1}). Highest harvest index was (30%) also obtained under $T_{11:}$ RDP + nutrient mobilizer (LNm 43a). It was at par withT_9: 50 % RDP + Biophos + Biozinc (29.24 %),$T_{10:}$ 50 % RDP + 12.5 kg $ZnSO_4$ + Biophos + Biozinc (29.21 %). $T_{2:}$ RDP application (50 kg ha^{-1}) (29.15%), $T_{6:}$ Application of Biophos + Biozinc (29.10 %), T_7: 50 % RDP and Biophos (28.54 %) and $T_{8:}$ 12.5 kg $ZnSO_4$+ Biozinc(27.70 %). While, minimum harvest index was recorded (20 %) under $T_{1:}$ control plot.

Economics

The data present in Table 3. regarding economic of fieldpea. Several economic indices are available to evaluate the profitability of particular treatments like cost of cultivation, gross realization, net realization and benefit cost ratio. The cost of cultivation varies according to different treatments. It includes value of seed, manures, fertilizers, pesticides, herbicides and labour etc. Due to inoculation of phosphate and zinc solubilzing microbes maximum gross realization value (Rs 80450 ha-1), net

realization value (Rs 58234 ha-1) and benefit cost ratio (3.62) was recorded under T11: RDP + nutrient mobilizer (LNm 43a). While, lowest gross realization value (Rs 43200 ha^{-1}), net realization value (Rs 22400 ha^{-1}) and benefit cost ratio (2.08) recorded under T1: control plot due to low level of nutrients which was directly responsible for the growth and yield attributes of fieldpea. RDP + nutrient mobilizer (LN m 43a) show perfect combination of inorganic nutrient and organic nutrient for achieving higher gross realization, net realization value and benefit cost ratio, found superior among all the treatment. Singh *et al.*, (2008) recorded highest net return (Rs 2624 ha^{-1}) in black gram under treatment having optimum level of phosphorus (40 kg P_2O_5 ha^{-1}) along with phosphorus solubilizing bacteria and recommended for medium black soil of Madhya Pradesh. Similar finding were also reported by Mishra *et al.*, (2010) in fieldpea.

In conclusion the RDP + nutrient mobilizer (LNm 43a) resulted in highest growth and yield attributes and consequently maximum benefit cost ratio. Therefore, integrated management with RDP and nutrient mobilizer can be used to boost the production of field pea (*Pisum sativum* L.).

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