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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 688-691

www.thepharmajournal.com
Received: 17-05-2022
Accepted: 27-06-2022

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Effect of bio fertilizers on different varieties of lentil (*Lens culinaris* L.)

Kavati Rakesh and Biswarup Mehera

Abstract
The present experiment entitled, "Effect of Bio fertilizers on Different Varieties of lentil (*Lens culinaris* L.)", which was conducted at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during *rabi* season of 2021. The experiment was carried out in a randomized block design with nine treatments and were replicated thrice. The results revealed that significantly higher plant height (41.61 cm), number of nodules per plant (6.15/plant), dry weight (38.10 g/plant), crop growth rate (19.32 g/m2/day) , relative growth rate (0.0502 g/g/day), number of pods (211.14/plant), number of seeds (1.85/plant), test weight (28.55g), seed yield (1.95t/ha), straw yield (3.91t/ha) and harvest index (%) (33.57) were recorded with application of KLS218 +PSB 20g/kg seed. Maximum gross return (INR 136733.33/ha), net return (INR 93145.33/ha) and benefit cost ratio (INR 2.14/ha) were obtained highest in the treatment combination of KLS218 +PSB 20g/kg seed.

Keywords: Biofertilizers, lentil, growth, yield

Introduction
Pulses are among the ancient food crops with evidence of their cultivation for over 8000 years. Pulses constitute an important ingredient and form an integral part of the diet of Indian population because of its high protein content (20-30 per cent). For the poor people, cereals constitute the staple food and major source of energy, however, addition of pulses will provide nutritionally balanced food. In recent years, it is gaining importance due to its hypocholesterolemic effect *i.e.* a property to lower down the blood cholesterol. Besides being a rich and cheapest source of dietary protein and a valuable animal feed, they also play a key role in improving and sustaining soil productivity on account of biological nitrogen fixation, solubilization of phosphorus in association with vesicular arbuscular mycorrhizae (VAM) and addition of huge amount of organic matter and function as mini-nitrogen factory; and also have well adaptation to marginal land and limited moisture conditions.

Pulses are also important as a compliment to carbohydrates staples such as rice and cereals. Pulse protein usually contain more than adequate levels of some of the nutritionally important amino acids such as lysine that are deficient in most cereals and pulses provides a good balance of amino acids, since cereals usually supply adequate methionine, which is deficient in pulses. But unfortunately, per capita pulse availability has come down from 69 g day-1 capita-1 in 1951 to 31 g day-1 capita-1 in 2009, whereas the need of pulses is 80 g day-1 capita-1 as per recommendation of World Health Organization while Indian Council of Medical Research recommends 65 g day-1 capita-1. The reduction in availability of pulses in India is attributed to their stagnant or marginal increase in production (12.70 million tonnes in 1960-61 to 17.57 million tonnes in 2012-13) on one hand and the numerical rise in population on the other hand. Presently, the area under pulse crops in India is around 23.86 million hectares with production of 17.57 million tonnes and productivity is 737 kg ha-1 (Anonymous, 2012-13). Therefore, there is an urgent need to increase the pulse production in the country. The production of pulsescan be increased either by bringing more area under cultivation or by enhancing their productivity. The later seems to be relevant in present day context, as the scope of increasing area under pulses is limited.

In India, lentil is grown in almost all the states as a *rabi* pulse crop, but major area lies in the Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. *Utera* cropping of lentil is common in Bihar, West Bengal and eastern parts of Uttar Pradesh. The crop is long day plant and requires low temperature for the vegetative growth and high temperature for maturity. Lentil is used as food, fodder and to sustain the fertility of the soil.

It is mostly eaten as split pulse *i.e.* 'dal'. Whole pulse grain is also used in some of the dishes. It can be cooked easily and hence preferred. It is good for patients too. The cotyledons are deep orange red or orange yellow in colour. Lentil contains about 25 per cent protein, 0.7 per cent fat, 2.1 per cent mineral, 0.7 per cent fibre and 60 per cent carbohydrate. It is also rich in calcium, iron, phosphorus, potassium, zinc and magnesium and vitamins like niacin, riboflavin, thymine and ascorbic acid (Anonymous, 2004). The protein content of lentil is highest among pulses.

In India, it is grown under irrigated as well as rainfed conditions. In Bihar, lentil is the most important pulse crop of *rabi* season and largely grown in rainfed conditions. In India, lentil is grown in about 1.60 million hectare with production of 1.07 million tonnes and average productivity of 678 kg ha-1. In Bihar, it is grown in about 2.40 lakhs hectare and produces 2.17 lakh tonnes with average productivity of about 1019 kg ha-1 (Anonymous, 2013).

Rhizobium and phosphate solubilizing bacteria are known to benefit the crop by increasing the availability of soil nitrogen and phosphorus. Considering the above said facts, the present investigation was carried out to evaluate the effect of biofertilizers and phosphorus levels on growth, yield attributes and yield of lentil under mid hill condition of Himachal Pradesh.

Lentil (*Lens culinaris*) is an important annual leguminous crop which is locally called "Masoor" belongs to the family Fabaceae. Lentil (*Lens culinaris*) is an edible pulse. It is about 40cm (16in) tall and the seeds grow in pods, usually two seeds in each. Lentils have been part of human diet since the aceramic (before pottery) Neolithic times, being one of the first crops domesticated in the near East. Archeological evidence shows they were eaten 9,500 to 13,000 years ago. Lentils colors range from yellow to red-orange to green, brown and black. Lentils also vary in size, and are in many forms, with or without the skins, whole or split (singh, K.M and singh A.K, 2014) [9].

Rhizobium offer a new eco-friendly technology which would overcome shortcomings of the conventional chemical based farming and showed positive influence on both soil sustainability and plant growth. They gradually improve the soil fertility by fixing atmospheric nitrogen. They can also help in restoring the depleted nutrients of the soil and improve plant root proliferation (Gebrekidan Feleke Mekuria, 2019) [5]. The use of phosphorous solubilizing bacteria (PSB) as an inoculant simultaneously enchances P availability to plants and crop yield. Certain micro-organisms such as phosphate solubilizing bacteria (Pseudomonas sp, Bacillus sp. Etc.), actinomycetes mostly those associated with the plant rhizosphere are known to convert insoluble inorganic P into soluble form that can be utilized by plants Vikram (2007) [14], Fankem *et al*., (2006) [4].

Although improvement of plant nutrition status and enhancement of growth are the most widely believed roles of VAM fungi in natural ecosystem but it seems that under drought stress conditions it only thrives to survival needs of plants (Varma and Hock, 1999) [13].

Materials and Methods

A field experiment was conducted during *Rabi* season of 2021-22 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) India. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (Ph 7.8), low in organic carbon (0.35%),The treatments consisted of HUL-75+Rhizobium 20g/kg seed, HUL-75+PSB20g/kg seed, HUL-75+VAM 15g/kg seed, K75+Rhizobium 20g/kg seed, k75+PSB 20g/kg seed, K75+VAM 15g/kg seed, KLS218 +Rhizobium 20g/kg seed, KLS218 +PSB 20g/kg seed, KLS218 +VAM 15g/kg seed. The experiment was laid out in Randomized Block Design, with 9 treatments replicated thrice. Data recorded on qualitative parameters were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976 [7].

Result and Discussion

Effect of Bio fertilizers and different varieties on growth parameters

Effect of Bio Fertilizers and different varieties on growth parameters of lentil are presented in Table 1.

Table 1: Effect of biofertilizers and different varieties on growth of lentil

Treatment No.	Treatment Details	At harvest		
		Plant height (cm)	Number of nodules per plant	Dry weight (g) per plant
1	HUL-75+Rhizobium 20g/kg seed	37.49	5.07	34.77
2	HUL-75+PSB20g/kg seed	38.05	5.26	35.84
3	HUL-75+VAM 15g/kg seed	36.87	5.40	33.65
4	K75+Rhizobium 20g/kg seed	37.03	4.48	34.63
5	k75+PSB 20g/kg seed	39.34	5.98	37.13
6	K75+VAM 15g/kg seed	36.19	3.84	34.15
7	KLS218 +Rhizobium 20g/kg seed	36.73	4.09	33.66
8	KLS218 +PSB 20g/kg seed	41.61	6.15	38.10
9	KLS218 +VAM 15g/kg seed	36.36	3.41	33.37
F Test		S	S	S
CD (p=0.5)		1.069	0.469	1.701
S.Ed (+)		0.54	0.221	0.803

Growth parameters

Plant height

At Harvest, significantly maximum plant height was recorded in the treatment-8 with kls-218+PSB 20 g/kg seed (31.35 cm). However, treatment combination of k75+PSB 20g/kg seed (29.39 cm), was found to be statistically at par with treatment 8. The lowest higher plant height was recorded in the treatment 6 with k75+VAM 15g/kg seed (36.19). The mechanisms for plant growth promotion by bacteria might be due to synthesis of the plant hormones indole-3-acetic acid (Barozani and Jacob, 1999), cytokinin (Timmusk *et al*., 1999), and gibberellin (Karakoc and Aksoz, 2006); breakdown of plant produced ethylene by bacterial production of laminocyclopropane-1-carboxylate deaminase (Glick, 1999); and increased minera L N and P availability of the soil (Kumar and Chandra, 2008). Similar results were also reported by Linu et al. (2009) in cowpea and Prasad et al. (2009) in wheat and singh et al. (2011)

Number of nodules/plant

At Harvest, significantly higher number of nodules per plant was recorded in treatment-8 kls-218+PSB 20 g/kg seed (14.69/plant). However, treatment-5 k75+PSB 20g/kg seed (12.65) was recorded statistically at par to the above treatment.the lowest number of nodules per plant was recorded in the treatment 9 with kls-218+ VAM 15 g/kg seed (3.41) Seed inoculation through PSB improved the availability of nutrient and also added others plant growth promoting bacteria in the soil and increased the availability of macro and micro nutrient along with greater availability of phosphorus in the soil. Phosphorus also increased the rate of photosynthesis favourably since it is directly involved in increase energy transfer reaction and essential for nitrogen fixing bacteria. The similar results were also presented by Jat and Ahlawat (2004). Dry matter is the resultant effects of growth of the plant influenced significantly more by seed inoculation through PSB than soil application and control at all the stages of crop growth during the both of experimental years (El Sayed, 1998).

Dry weight

At Harvest, significantly highest dry weight was observed in the treatment-8 kls-218+PSB 20 g/kg seed (38.10 g), whereas treatment-5 k75+PSB 20g/kg seed (37.13 g) was recorded statistically at par to the above treatment. the lowest dry weight was recorded in the treatment 9 with kls-218+ VAM 15 g/kg seed (33.37). The dry weight is the resultant effects of growth of the plant influenced significantly more by seed inoculation through PSB than soil application (EI Sayed, 1998) [3] because seed inoculation through PSB improved the availability of nutrient and also added other plant growth promoting bacteria in the soil and increased the availability of macro and micro nutrient along with greater availability of phosphorous in the soil. (Jat and Ahlawat 2004) [7].

Effect of Bio Fertilizers and varieties on yield attributes and yield

Effect of Bio Fertilizers and varieties on yield attributes and yield of lentil are presented in Table 2.

Table 2: Effect of biofertilizers and different varieties on yield attributes of lentil

Treatment No.	Treatment Details	Number of pods per plant	number of seed per pod	Test weight (g)	seed yield (t/ha)	straw yield (t /ha)	Harvest index (%)
1	HUL-75+Rhizobium20g/kg seed	200.96	1.55	23.44	1.30	3.54	26.81
2	HUL-75+PSB20g/kg seed	203.27	1.77	27.62	1.70	3.80	30.89
3	HUL-75+VAM 15g/kg seed	194.63	1.51	20.92	1.47	3.36	30.41
4	K75+Rhizobium 20g/kg seed	187.36	1.48	20.74	1.46	3.36	30.29
5	k75+PSB 20g/kg seed	200.87	1.67	25.94	1.73	3.63	32.23
6	K75+VAM 15g/kg seed	196.19	1.58	20.18	1.61	3.19	33.57
7	KLS218+Rhizobium20g/kg seed	192.19	1.45	21.73	1.41	3.27	30.09
8	KLS218 +PSB 20g/kg seed	211.14	1.85	28.55	1.95	3.91	33.33
9	KLS218 +VAM 15g/kg seed	185.57	1.41	20.31	1.32	3.30	28.51
F. Test		S	S	S	S	S	S
CD (p=0.5)		5.257	1.161	1.259	0.225	0.202	3.689
S.Ed (+)		2.480	0.076	0.594	0.106	0.092	1.740

Table 3: Effect of Bio fertilizers and different Varieties on economics of lentil

Treatment	Treatment Details	Total cost cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C
1	HUL-75+Rhizobium 20g/kg seed	43492	91000.00	47508.00	1.09
2	HUL-75+PSB20g/kg seed	43588	119000.00	75412.00	1.73
3	HUL-75+VAM 15g/kg seed	43468	102900.00	59432.00	1.37
4	K75+Rhizobium 20g/kg seed	43492	102200.00	58708.00	1.35
5	k75+PSB 20g/kg seed	43588	120866.67	77278.67	1.77
6	K75+VAM 15g/kg seed	43468	112933.33	69465.33	1.60
7	KLS218 +Rhizobium 20g/kg seed	43492	98933.33	55441.33	1.27
8	KLS218 +PSB 20g/kg seed	43588	136733.33	93145.33	2.14
9	KLS218 +VAM 15g/kg seed	43468	92400.00	48932.00	1.13

Yield attributes and Yield

Number of pods/plant (211.14), Seeds/pod (1.85), Test weight (28.55 g), Seed yield (1.95 t/ha), Stover yield (3.91 t/ha), Harvest index (33.33%) was recorded higher in treatment 8 with KLS218 +PSB 20g/kg seed. In case of Seed yield treatment 8 was recorded significantly higher, however treatment 2 is stastistically at par with treatment 8. And stover yield was recorded significantly higher in the treatment 8 however, treatment 2 is statistically at par with treatment 8. This might be due to PSB helped in increasing the availability of phosphorus through their solubilising effect and increase in dry weight of plant. Phosphorus increased the underground growth i.e. number of nodules plant-1of plant which leads to better utilization of nutrients and water in turn improved the yield attributes. Significantly highest seed yield was recorded with seed inoculation through PSB application during both the years. The seed yield behaves according to seeds and pods weight plant-1. Further the soil inoculation of PSB has facilitated a greater economic sink capacity as the yield has positive growth with significant correlation with the seed yield. The protein yield of soil per hectare was dramatically influenced by the PSB inoculation. The significantly highest protein yield was evaluated with seed inoculation by PSB during both the years than soil application and the control

(Kanwar and Paliyal, 2002). Similar findings were repeated by Mukesh Kumar Pandey 2015

Economics

The maximum gross return (136733.33 INR/ha), net return (93145.33 INR/ha) and benefit cost ratio (2.14) was recorded in the treatment 8 In which (kls-218+psb 20 g/kg seed while the lowest gross return (91000.00 INR/ha), net return (47508.00 INR/ha), benefit cost ratio (1.09).

Conclusion

From the results, it can be concluded that soil application of KLS-218 +PSB 20g/kg seed brought about significant improvement in the production of lentil and also proven economically viable.

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