

Original Research Article

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## Effect of Chemical Fertilizer, Organic Manure and Biofertilizer on Nodulation, Yield and Economics of Lentil (*Lens culinaris* L. Medik.)

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### ABSTRACT

A field experiment was conducted during the *rabi* season of 2019-2020 to study the “Influence of Integrated Phosphorus Management on the Growth, Yield and Quality of Lentil (*Lens culinaris* L. Medik.)”. The soil of the experimental field was clay in texture with pH of 5.54 and organic carbon content of 0.8%. The minimum and maximum temperatures recorded during the period under review were 10.3 and 24.5°C with a total rainfall of 246.4 mm and average sunshine of 8.6 hours respectively. The experiment was laid out in Randomized Block Design with three replications. There were nine treatments which consisted of different sole and combined application of phosphorus, organic manure and Biophos. It was observed that application of 75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed (T<sub>4</sub>) proved significantly superior to all the treatments in terms of all parameters viz nodule number (61.0), fresh and dry weight of nodule (36.0 and 26.0 mg), number of pods per plant (164.30), number of seeds per pod (2.57), seed and stover yield (15.50 and 19.03 q/ha). The highest gross income (Rs. 118500 /ha) and net return (Rs. 82510 /ha) were also associated with the treatment T<sub>4</sub>. However, T<sub>4</sub> and T<sub>1</sub> exhibited similar B:C ratio of 3.29. The treatment T<sub>4</sub> showed significant enhancement of post-harvest soil nutrient status.

#### Keywords

Lentil, Phosphorus, Organic manure, Biofertilizer, Yield, Economics

#### Article Info

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### Introduction

Lentil (*Lens culinaris* L. Medik.), locally known as Masoor, is one of the most important *rabi* season legumes grown in India. It occupies about 2.22 million hectares with an average productivity of 7312 kg/ha (FAOSTAT, 2018). Lentil is one of the most nutritious cool season legumes and ranks next only to Chickpea in India. The seed of lentil contains about 24% - 26% protein, 1.3% fat,

2.1% minerals, 3.2% fibre and 57% carbohydrate (Ali *et al.*, 2012 and Singh *et al.*, 2013).

Low productivity of lentil may be ascribed to many reasons such as inadequate and imbalanced fertilization and prevalence of suboptimum soil moisture condition. The lentil crop shows good response to phosphorus fertilization (Muhammad *et al.*, 2002). Rhizobium and phosphate solubilizing

bacteria are known to enhance the productivity of the crop as they increase the availability of soil nitrogen and phosphorus (El Sayed, 1999). Phosphorus is one of the macronutrients required for biological growth and development. Among the major nutrients phosphorus is considered to be one of the major limiting nutrient elements in pulse production in India, particularly in acid soils of North Eastern India, including Manipur. Phosphorus plays a vital role in cultivation of legumes as it directly enhances grain formation, stimulates early formation and growth of roots, improves nodulation, seed yield and seed crude protein content (Singh *et al.*, 2014).

Phosphorus availability in the soil is highly affected by the pH and temperature of the soil. Only a minute portion of the phosphorus added through synthetic or chemical fertilizer is utilized by the plants, but a large quantity of it is transformed into insoluble fixed forms, rendering them unavailable for crop uptake. Phosphorus recovery efficiency by crops is only about 10-30 % (Swarup, 2002). However, biofertilizer like phosphate solubilising bacteria (PSB) can transform fixed or unavailable phosphorus into available form through the process of mineralization thereby supplying it to plants in the required form for growth and development of the crop (Khan *et al.*, 2007). With the increase in available phosphorus, the overall growth and yield of the crop can be increased.

Fertilizers are becoming costlier and the resource poor farmers cannot afford to apply the recommended dose of fertilizers. Further, it is now well realized that to protect the soil health, use of judicious combination of organic and inorganic sources of nutrients is essential. Vermicompost is one good form of organic manure which contains relatively higher amount of plant nutrients compared to other conventional organic manures.

However, non-judicious use of chemical fertilizer as well as reduction in the use of organic manures has resulted in the deterioration of soil physical and chemical properties and its productivity. Use of farm yard manure and vermicompost are some of the best options for maintaining of soil health as well as productivity and replacement of mineral fertilizers.

No one source of fertilizer is entirely adequate to fulfil the nutrient requirement of a crop and one does not serve as a substitute for another, but they complement each other. Therefore, the combination of chemical fertilizer, farmyard manure, vermicompost and biophos in the right dosage will not only prove efficient but also improve the health of the soil which plays a vital role in nutrient and moisture retention (Venkateswarlu and Wani, 1999). Therefore, the present investigation was carried out with the objectives to find out the best Integrated phosphorus Management practices for lentil and also their economics.

### **Materials and Methods**

The experiment was conducted at the Agronomy field, College of Agriculture, Central Agricultural University, Imphal during the *rabi* season of 2019-2020. Before sowing of the crop initial soil samples were collected for analysis and it was found that the soil of the experimental field was clay in texture having pH of 5.54, medium in available nitrogen (262.3 kg/ha) and potassium (243.7 kg/ha), low in available phosphorus (18.45 kg/ha) and organic carbon content (0.8%). The minimum and maximum temperatures recorded during the period under review were 10.3 and 24.5°C with a total rainfall of 246.4 mm and average sunshine of 8.6 hours respectively.

The experiment was laid out in Randomized Block Design (RBD) with three replications.

There were nine treatments which consisted of 100 % RDP (40 kg P<sub>2</sub>O<sub>5</sub>/ha) (T<sub>1</sub>), 75% RDP + FYM @ 5 t/ha (T<sub>2</sub>), 75% RDP + Vermicompost @ 2 t/ha (T<sub>3</sub>), 75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed (T<sub>4</sub>), 75% RDP + Vermicompost @ 2 t/ha + Biophos @ 20 ml/kg seed (T<sub>5</sub>), FYM @ 5 t/ha (T<sub>6</sub>), Vermicompost @ 2 t/ha (T<sub>7</sub>), Biophos @ 20 ml/kg seed (T<sub>8</sub>) and Control (T<sub>9</sub>). A uniform dose of 20 kg/ha each of nitrogen and potash were applied to all the plots in furrows a day before sowing was done. The lentil variety used for the study was HUL-57. The source of chemical phosphorus was single superphosphate (SSP) while organic manures were supplied through farm yard manure (FYM) and vermicompost (VC) and phosphate solubilising bacteria through biophos. The nitrogen was supplied through urea and potash through muriate of potash (MOP).

Observations regarding nodule number, nodule fresh and dry weight were manually recorded from five randomly selected representative plants from individual plots and the values were averaged. Data on yield attributes and yield such as number of pods per plant, number of seeds per pod, seed and stover yield as well as harvest index were recorded at harvest. Soil samples were collected after harvest of the crop and analyzed for postharvest soil nutrient status.

## Results and Discussion

### Nodulation

Data in Table 1 revealed that the different phosphorus treatments either solely or in combination exerted significant influence on the number, fresh and dry weight of nodules. The maximum number of nodules, fresh and dry weight of nodules (61.0, 36.0 mg and 26.0 mg) were associated with the application of 75% RDP + FYM at 5 t/ha + Biophos at 20

ml/kg seed (T<sub>4</sub>) and it showed significant superiority in this characters over all the rest of the treatments. This was followed by addition of 75% RDP + VC at 2 t/ha + Biophos at 20 ml/kg seed (T<sub>5</sub>). This could be the result of balanced nutrition achieved through integration of inorganic, organic and biofertilizers which induced maximum number of nodulation and consequently enhanced the fresh and dry weight of the nodules. Adequate supply of phosphorus promotes early development and growth of roots, improves the photosynthetic capacity of the crop, energy transformation and translocation which influences fixation of nitrogen that ultimately increase nodule development in lentil. There was no significant difference among sole application of 100% RDP (T<sub>1</sub>), FYM (T<sub>6</sub>) and VC (T<sub>7</sub>) in respect of number of nodules, fresh and dry weight of nodules. The lowest number of nodules, fresh and dry weight of nodule was recorded in the control. Singh *et al.*, (2003), Gahoonia *et al.*, (2006), Singh *et al.*, (2010), Tagore *et al.*, (2013) and Dashrath and Singh (2014) whose results conform with that of this study.

### Yield attributes and yield

The number of pods per plant and seeds per pod was significantly increased with different phosphorus management practices either sole or in combinations with organic manure and biofertilizer as compared to control (Table 2). Treatment receiving 75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed (T<sub>4</sub>) recorded the maximum number of pods per plant (164.30) and seeds per pod (2.57) which remained at par to 75% RDP + VC at 2 t/ha + Biophos at 20 ml/kg seed (T<sub>5</sub>) in respect of pods per plant only but significantly higher to all the rest of the treatments for this two yield attributing characters. This might be due to supply of adequate dose of phosphorus through chemical fertilizer and organic

manure as well as biofertilizer which led to development of more number of pods and development of more seeds per pod as phosphorus encourages flowering and fruiting in lentil. The findings of Sarkar *et al.*, (1997), Kumawat *et al.*, (2010), Tagore *et al.*, (2013) and Saket *et al.*, (2014) are in agreement with the findings of the present study. Though variation in test weight of the seed was recorded among the integrated phosphorus management practices but the differences were found to be not significant. This finding is in agreement with those of Deol *et al.*, (2005) and Dashrath and Singh *et al.*, (2014).

The significantly highest seed yield (15.80 q/ha) and stover yield (19.03 q/ha) was recorded through the application of 75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed (T<sub>4</sub>) followed by 75% RDP + VC at 2 t/ha + Biophos at 20 ml/kg seed (T<sub>5</sub>). Further integration of 75% RDP + organic manures (T<sub>2</sub> and T<sub>3</sub>) also recorded significantly higher seed yield than that of sole application of 100% RDP, FYM, VC and biophos. Such increment in yield may be due to increase in photosynthesis and translocation of assimilates or photosynthates to different plant parts as observed in improvement of nodulation resulting in increased number of pods per plant and seeds per pod that were recorded through application of 75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed (T<sub>4</sub>). In addition balanced phosphorus nutrition from both organic and inorganic source leads to improved seed yield of lentil as it influences early flowering and pod formation as well as regulation of many plant metabolic activities. The continuous and slow release of nutrients to the crop through integration of organic manures and chemical fertilizer also ensured that optimum yield potential of the crop is expressed. Such impact of balanced integrated phosphorus nutrition on yield has also been reported by Choubey *et al.*, (2013), Singh *et al.*, (2013),

Tagore *et al.*, (2013), Dashrath and Singh (2014), Saket *et al.*, (2014), Singh *et al.*, (2017), Singh *et al.*, (2018) and Yadav *et al.*, (2018) respectively. The lowest seed yield (3.93 q/ha) was recorded in the control.

Harvest index is a measure of the physiological potential of a crop regarding its ability to convert photosynthates into economically relevant parts. According to the findings of the present research displayed in Table 2, the highest harvest index (0.46) was associated with application of 75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed (T<sub>4</sub>) and the lowest (0.40) was recorded in the control. This shows that T<sub>4</sub> has more physiological efficiency and it might be a result of the synergistic benefits from chemical fertilizer, organic manures and biofertilizer. The finding of Zike *et al.*, (2017) is also in agreement with this study.

### **Postharvest soil status**

The postharvest nutrient status of the soil was also found to be influence by the different integrated phosphorus treatments as shown in Table 3. After analysis of the postharvest soil samples, T<sub>4</sub> (75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed) was found to remarkably improve soil available nitrogen (282.43 kg N /ha), phosphorus (21.30 kg P<sub>2</sub>O<sub>5</sub>/ha) and potassium (263.11 kg K<sub>2</sub>O/ha). The improvement in soil fertility as recorded in this treatment may be the result of synergistic and beneficial effect of chemical fertilizer, organic manures and biofertilizer. This result is supported by Sahu *et al.*, (2017).

### **Economics**

The findings of this study revealed that there was significant impact of different integrated phosphorus treatments on the economics of the crop.

**Table.1** Number of nodules, fresh and dry weight of nodules of lentil as influenced by integrated phosphorus management

Treatment	60 DAS			90 DAS		
	Number of nodules	Nodule fresh weight (mg)	Nodule dry weight (mg)	Number of nodules	Nodule fresh weight (mg)	Nodule dry weight (mg)
<b>T<sub>1</sub>:100% RDP (40 kg P<sub>2</sub>O<sub>5</sub>)</b>	37.17	23.80	14.00	21.23	18.52	11.53
<b>T<sub>2</sub>:75% RDP + FYM @ 5 t/ha</b>	41.67	24.53	15.00	22.00	19.63	12.63
<b>T<sub>3</sub>:75% RDP + VC @ 2 t/ha</b>	38.33	24.15	14.13	21.33	19.51	12.50
<b>T<sub>4</sub>:75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed</b>	61.00	36.05	26.00	41.33	26.65	19.67
<b>T<sub>5</sub>:75% RDP + VC @ 2 t/ha + Biophos @ 20 ml/kg seed</b>	50.67	29.92	20.67	31.33	24.00	17.00
<b>T<sub>6</sub>:FYM @ 5 t/ha</b>	37.00	23.48	13.73	20.83	17.56	10.60
<b>T<sub>7</sub>: VC @ 2 t/ha</b>	36.67	23.11	13.13	20.80	17.33	10.33
<b>T<sub>8</sub>: Biophos @ 20 ml/kg seed</b>	36.33	22.22	12.23	20.67	15.00	8.00
<b>T<sub>9</sub>: Control (No P applied)</b>	25.67	18.42	8.43	13.33	13.17	6.17
<b>SE d(±)</b>	2.79	0.31	0.95	1.77	0.16	0.90
<b>CD (P = 0.05)</b>	5.90	0.69	2.01	3.74	0.34	1.89

**Table.2** Yield attributes and yield and quality of lentil as influenced by integrated phosphorus management

TREATMENT	Yield attributes and yield						Quality	
	Pods per plant	Seeds per pod	Test weight (g)	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index	Crude protein yield (kg/ha)	Crude protein yield (kg/ha)
<b>T<sub>1</sub>:100% RDP (40 kg P<sub>2</sub>O<sub>5</sub>)</b>	106.20	1.87	18.25	11.43	13.43	0.45	22.40	256.03
<b>T<sub>2</sub>:75% RDP + FYM @ 5 t/ha</b>	129.87	1.90	18.31	12.77	15.33	0.45	22.75	290.53
<b>T<sub>3</sub>:75% RDP + VC @ 2 t/ha</b>	117.94	1.88	18.29	12.23	14.77	0.45	22.58	276.15
<b>T<sub>4</sub>:75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed</b>	164.30	2.57	18.56	15.80	19.03	0.46	23.28	367.83
<b>T<sub>5</sub>:75% RDP + VC @ 2 t/ha + Biophos @ 20 ml/kg seed</b>	158.93	2.27	18.33	13.80	17.97	0.43	23.10	318.77
<b>T<sub>6</sub>:FYM @ 5 t/ha</b>	87.84	1.83	18.23	8.77	10.23	0.45	22.05	193.37
<b>T<sub>7</sub>: VC @ 2 t/ha</b>	85.47	1.80	18.23	7.80	9.17	0.44	22.05	171.97
<b>T<sub>8</sub>: Biophos @ 20 ml/kg seed</b>	77.06	1.78	18.20	5.60	8.03	0.41	22.05	123.47
<b>T<sub>9</sub>: Control (No P applied)</b>	60.87	1.48	17.78	3.93	5.77	0.40	21.70	85.30
SE d(±)	2.70	0.12	0.49	0.37	0.61	0.02	0.05	0.37
CD (P = 0.05)	5.72	0.26	NS	0.79	1.29	0.04	0.11	0.78

**Table.3** Economics and postharvest soil nutrient status as influenced by integrated phosphorus management

Treatment	Economics				Postharvest soil status		
	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
<b>T<sub>1</sub>:100% RDP (40 kg P<sub>2</sub>O<sub>5</sub>)</b>	26050	85725	59675	3.29	260.50	19.51	244.10
<b>T<sub>2</sub>:75% RDP + FYM @ 5 t/ha</b>	35900	95775	59875	2.67	270.55	19.82	257.41
<b>T<sub>3</sub>:75% RDP + VC @ 2 t/ha</b>	65900	91725	25825	1.39	267.78	19.76	254.44
<b>T<sub>4</sub>:75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed</b>	35990	118500	82510	3.29	282.52	21.30	263.20
<b>T<sub>5</sub>:75% RDP + VC @ 2 t/ha + Biophos @ 20 ml/kg seed</b>	65990	103500	37510	1.57	279.06	20.00	260.05
<b>T<sub>6</sub>:FYM @ 5 t/ha</b>	35450	65775	30325	1.86	265.38	19.65	252.33
<b>T<sub>7</sub>: VC @ 2 t/ha</b>	65450	58500	-6950	0.89	263.13	19.60	250.05
<b>T<sub>8</sub>: Biophos @ 20 ml/kg seed</b>	25540	42000	16460	1.64	262.27	19.51	246.03
<b>T<sub>9</sub>: Control (No P applied)</b>	25450	29475	4025	1.16	256.07	18.32	243.13
<b>SE d(±)</b>					0.27	0.04	0.05
<b>CD (P = 0.05)</b>					0.58	0.07	0.10



The maximum cost of cultivation (Rs. 65 990 /ha) was found in T<sub>5</sub> (75% RDP + VC at 2 t/ha + Biophos at 20 ml/kg seed). The highest gross income (Rs. 118 500 /ha) and net income (Rs. 82 510 /ha) were recorded through application of 75% RDP + FYM at 5 t/ha + Biophos at 20 ml/kg seed (T<sub>4</sub>). This is due to the fact that the highest economic produce (seed yield) was acquired through application of this treatment. However, the B:C ratio of T<sub>4</sub> remain the same with that of the T<sub>1</sub>(100 % chemical fertilizer) which may be due to lower cost of the fertilizer as compared when used with organic manure which is costlier input. Goud *et al.*, (2010), Choubey *et al.*, (2013), Patel *et al.*, (2017) and Singh *et al.*, (2017) all supported this result in their respective investigations.

Based on the findings of the present research, it can be concluded that integrated application of organic (FYM) and inorganic sources of phosphorus along with biofertilizers (Biophos) is the most ideal and economically feasible nutrient management practice for optimum yield realization in lentil production as the maximum seed yield, stover yield, gross income, net income and benefit-cost ratio were achieved through the application of 75% RDP + FYM @ 5 t/ha + Biophos @ 20 ml/kg seed.

## References

- Ali, M. O., Zuberi, M. I. and Sarker, A. (2012). Lentil relay cropping in the rice-based cropping system: An innovative technology for lentil production, sustainability and nutritional security in changing climate of Bangladesh. *J. Food Sci. Engineering*, 2(9): 52.
- Campbell, W. R., and Hanna, M. I. (1937). The determination of nitrogen by modified Kjeldahl methods. *J. Biol. Chem.*, 119: 1-7.
- Choubey, S.K., Dwivedi, V.P. and Srivastava, N.K. (2013). Effect of different levels of phosphorus and sulphur on growth, yield and quality of lentil (*Lens culinaris* Medik.). *Indian J. Sci. Res.*, 4(2): 149-150.
- Dashrath, S. and Singh, R. P. (2014). Effect of integrated nutrient management on growth, physiological parameters and productivity of lentil (*Lens culinaris* Medik.). *Int. J. Agric. Sci.*, 10(1): 175-178.
- Deol, M. S., Kahlon, C. S. and Kaur, K. (2005). Effect of phosphate solubilizing bacteria, farmyard manure and phosphorous on growth and yield of lentil (*Lens culinaris* Medik.). *Dept. Agron., GB Pant Univ. Agri. and Tech. Pantnagar*, 5: 78.
- Deshmukh, C. and Jain, A. (2014). Effect of integrated nutrient management on protein content of lentil seeds under rainfed condition. *Int. J. Pl. Sci.*, 9(1): 193-195.
- El Sayed, S.A.M. (1999). Influence of *Rhizobium* and phosphate solubilizing bacteria on nutrient uptake and yield of lentil in the New Valley (Egypt). *Egyptian J. Soil Sci.*, 39(2): 175-186.
- Erman, M., Yildirim, B., Togay, N. and Cig, F. (2009). Effect of phosphorus application and rhizobium inoculation on the yield, nodulation and nutrient uptake in field pea (*Pisum sativum* sp. arvense L.). *J. Anim. Vet. Adv.*, 8(2): 301-304.
- FAOSTAT (2018) Agricultural Data: Agriculture and Food Trade. Rome, Italy: FAO. Available at <http://faostat.fao.org> (Accessed 18 July 2020).
- Gahoonia, T.S., Ali, O., Sarker, A., Nielsen, N.E. and Rahman, M.M. (2006). Genetic variation in root traits and nutrient acquisition of lentil genotypes. *J. Plant Nutrition*, 29: 643-655.
- Goud, V.V., Kale, H.B. and Patil, A.N.



- (2010). Performance of organically grown mung bean under rainfed condition in vertisol. *J. Food Legumes*, 23(3 and 4): 218-222.
- Khan, M.S., Zaidi, A and Wani, P.A. (2007). Role of phosphate –solubilising microorganisms in sustainable agriculture- A Review. *Agron. sustainable Dev.*, 27:29-43.
- Kumari, M., Vasu, D., Ul-Hasan, Z., and Dhurwe, U. K. (2009). Effects of PSB (Phosphate Solubilizing Bacteria) on morphological characters of *Lens culinaris* Medic. *Biol. Forum*, 1(2): 5-7.
- Kumawat, N., Sharma, O.P., Kumar, R. and Kumari, A. (2010). Yield and yield attributes of mung bean (*Vigna radiata* L. Wilczek) as affected by organic manures, PSB and phosphorus fertilization. *Environ. Ecol.*, 28(1A): 332-335.
- Muhammad, H., Shah, SH. and Nazir, SM. (2002). Differential genotypic response to phosphorus application in lentil (*Lens culinaris* Medik). *Int. J. Agri. Bio.*, 4(1): 61-63.
- Patel, H.B., Shah, K.A., Barvaliya, M.M. and Patel, S.A. (2017). Response of green gram (*Vigna radiata* L.) to different levels of phosphorus and organic liquid fertilizer. *Int. J. Curr. Microbiol. Appl. Sci.*, 6(10): 3443-3451.
- Sahu, G., Chatterjee, N., and Ghosh, G. K. (2017). Integrated nutrient management in lentil (*Lens culinaris* Medikus) in red and lateritic soils of West Bengal. *Bull. Env. Pharmacol. Life Sci*, 6(4): 55-62.
- Saket, S., Singh, S. B., Namdeo, K. N. and Parihar, S. S. (2014). Effect of organic and inorganic fertilizers on yield, quality and nutrients uptake of lentil. *Ann. Pl. Soil Res.*, 16(3): 238-241.
- Sarkar, R. K.; Shit, D. and Chakraborty, A. (1997). Effect of levels and sources of phosphorus with and without farmyard manure on pigeon pea under rainfed condition. *Indian J. Agric.*, 42(1): 120-123.
- Singh, A. K., Bhatt, B. P., Singh, K. M. and Upadhyaya, A. (2013). An Analysis of Oilseeds and Pulses Scenario in Eastern India during 2050-51. *J. Agril. Sci.*, 5(1): 241- 249.
- Singh, D., Khare, A., and Singh, S. (2017). Effect of phosphorus and molybdenum nutrition on yield and nutrient uptake in lentil (*Lens culinaris* L.). *Ann. Pl. Soil Res.*, 19(1): 37-41.
- Singh, G., Sekhon, H. S., Ram, H. and Sharma, P. (2010). Effect of farmyard manure, phosphorus and phosphate solubilizing bacteria on nodulation, growth and yield of kabuli chickpea. *J. Food Legume*, 23(3 & 4): 226-229.
- Singh, G., Virk, H. K., & Khanna, V. (2017). Integrated nutrient management for high productivity and net returns in lentil (*Lens culinaris*). *J. Appl. Nat. Sci.*, 9(3):1566-1572.
- Singh, O.N., Sharma, M. and Dash, R. (2003). Effect of seed rate, phosphorus and FYM application on growth and yield of bold seeded lentil. *Indian J. Pulses Res.*, 16(2):116-118.
- Singh, S., Singh, H., Singh, J and Sharma, V.K. (2014) Effect of integrated use of rock phosphate, molybdenum and phosphate solubilizing bacteria on lentil (*Lens culinaris* Medik) in an alluvial soil. *Indian J. Agron.*, 59(3): 433-438.
- Singh, S. R., Kundu, D. K., Dey, P., Singh, P., and Mahapatra, B. S. (2018). Effect of balanced fertilizers on soil quality and lentil yield in Gangetic alluvial soils of India. *J. Agril. Sci.*, 156(2): 225-240.
- Singh, U., Saad, A. A. and Singh, S. R. (2008). Influence of genotypes and inoculation method on productivity of lentil (*Lens culinaris* Medik) under dryland temperate conditions of Kashmir valley. *Indian J. Agri. Sci.*, 78(8), 671-675.

- Singh, Y., Singh, P., Sharma, R. D., Marko, G. S. and Namdeo, K. N. (2013). Effect of organic sources of nutrients on growth, yield and quality of lentil genotypes. *Ann. Plant Soil Res.*, 15(2), 134-137.
- Sital, J.S., Kaur, K., Sharma, S., Sandhu, J.S. and Singh, S. (2011). Effect of Rhizobium inoculation, phosphorus and nitrogen supplements on protein quality in developing lentil (*Lens culinaris* Medik) seeds. *Indian J. Agri. Biochem.*, 24: 17-22.
- Swarup, A. (2002). Lessons from long term fertilizer experiments in improving fertilizer use efficiency and crop yields. *Fertilizer news*, 47(12):59-73.
- Tagore, G. S., Namdeo, S. L., Sharma, S. K., and Kumar, N. (2013). Effect of Rhizobium and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghemoglobin, and yield of chickpea genotypes. *Int. J. Agron.*, 2013. <http://dx.doi.org/10.1155/2013/581627>
- Togay, Y., Togay, N. and Dogan, Y. (2008). Research on the effect of phosphorus and molybdenum applications on the yield and yield parameters in lentil (*Lens culinaris* Medik). *Afr. J. Biotech.*, 7: 1256-1260.
- Venkateswarlu, B. and Wani, S. P. (1999). Bio-fertilizers: An important component of integrated plant nutrient supply (IPNS) in dry lands. *Fifty years Dryland Agril. Res. India, CRIDA, Hyderabad*, 379-394.
- Yadav, G.S., Datta, M., Babu, S., Das, A., Meena, R.S., Sarkar, M., Debbarma, C. and Tahashildar, M. (2018). Enhancing lentil productivity through sustainable nutrient management practices in rice fallow. *Indian J. Hill Farming*, 31(2): 231-235.
- Zike, T., Abera, T. and Hamza, I. (2017) Response of Improved Lentil (*Lens culinaris* L. Medik.) Varieties to Phosphorus Nutrition on Vertisols of West Showa, Central Highlands of Ethiopia. *Adv. Crop Sci. Tech.*, 5: 315. doi:10.4172/23298863.1000315

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