Journal of Applied and Natural Science 9 (3): 1566 -1572 (2017)

Integrated nutrient management for high productivity and net returns in lentil (*Lens culinaris*)

Guriqbal Singh*, Harpreet Kaur Virk and Veena Khanna

Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana-141004 (Punjab), INDIA
*Corresponding author. E-mail: singhguriqbal@pau.edu

Received: December 2, 2016; Revised received: March 6, 2017; Accepted: August 2, 2017

Abstract: The experiment was conducted to study the integrated nutrient management for high productivity and net returns in lentil. Results revealed that nodulation was significantly (P≥0.01) enhanced in treatments comprising of *Rhizobium* and phosphate solubilizing bacteria (PSB) along with recommended dose of fertilizer (RDF), farmyard manure (FYM) and vermicompost. Treatments comprising of *Rhizobium* + PSB along with RDF, 50% RDF, FYM and vermicompost showed higher nodule dry weight as compared to the treatments without biofertilizers. Pods plant^{-1} was highest in RDF + *Rhizobium* + PSB. Combination of different organic sources with RDF resulted in significantly (P≥0.001) higher grain yield than RDF only. RDF + 5 t ha^{-1} FYM resulted in 26.3 and 6.7 per cent higher grain yield over control and RDF alone, respectively. RDF + *Rhizobium* + PSB recorded the highest net returns (Rs 40321 ha^{-1}) and B:C ratio (3.78). It can be concluded that supplementing the recommended dose of nutrients (12.5 kg N + 40 kg P_2O_5 ha^{-1}) with 5 t ha^{-1} FYM or 2 t ha^{-1} vermicompost or *Rhizobium* + PSB inoculation help in obtaining high grain yields and net returns in lentil.

Keywords: Grain yield, Lentil, Net returns, Nodulation, *Rhizobium*

INTRODUCTION

Lentil (*Lens culinaris* Medikus) is a protein-rich winter season pulse crop. The use of excessive fertilizers and pesticides are causing environmental hazards and deteriorating soil health. Judicious use of chemical fertilizers in combination with organic manures is required to improve the soil health as well as to achieve sustainable production. It is, therefore, necessary to develop a sustainable production system with maximum productivity and no/minimum environmental pollution. For sustainable production system, integrated use of chemical fertilizers, organic manures such as farmyard manure (FYM) or vermicompost or through the use of biofertilizers such as *Rhizobium* and phosphate solubilizing bacteria (PSB) helps to meet the nutrient requirement of the crop and providing high productivity (Ram *et al.,* 2013; Deshmukh *et al.,* 2015; Meena and Ram, 2016). Addition of organic manures increases organic carbon, aggregate stability, moisture retention capacity and infiltration rate of the surface soil while reducing the bulk density and also improves grain yield of lentil (Sarkar *et al.,* 2003). Application of biofertilizers (Bera and Pramanik, 2013; Singh *et al.,* 2016), nitrogen (Niri *et al*., 2010) and phosphorus (Togay *et al*., 2008; Rasheed *et al.,* 2010; Singh and Singh, 2016) is known to improve plant growth and grain yield in lentil. In this context, an experiment was planned to study the effect of integrated nutrient management (INM) with organic manures, chemical fertilizers and biofertilizers in lentil.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* (winter) 2009-10 at the research farm of Punjab Agricultural University, Ludhiana (30° 56'N, 75° 52'E, altitude 247 m), India. The soil of the experimental site was loamy sand (80.3% sand, 14.3% silt and 5.4% clay), having pH 8.7, organic carbon 0.29%, available phosphorus (P) 11.5 kg ha^{-1} and available potassium (K) 410 kg ha^{-1}. Soil pH was determined as per the Beckman's Glass Electrode pH Meter (Jackson 1967), organic carbon as per Walkley and Black's Rapid Titration Method (Jackson, 1967), available nitrogen as per Alkaline Potassium Permanganate Method (Subbiah and Asija, 1956), available phosphorus as per 0.5M sodium bicarbonate extractable method (Olsen *et al.,* 1954) and available potassium as per 1N Ammonium Acetate Extractable Method (Merwin and Peech, 1950). A total of 54.6 mm rainfall was received during the crop growing season. The weekly maximum temperature varied from 11.9 to 35.4 °C whereas the weekly minimum temperature varied from 3.8 to 17.5 °C during the crop season.

Sixteen treatments, as given in Table 1, were arranged in a randomized block design with three replications. In the treatment of recommended dose of fertilizers (RDF) as per the Punjab Agricultural University, Lu-

ISSN : 0974-9411 (Print), 2231-5209 (Online)

dhiana, 12.5 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} was applied through urea (46% N) and single superphosphate (16% P_2O_5), respectively. Seed was inoculated with *Rhizobium leguminosarum* and *Bacillus* sp. each @ 500 g ha^{-1} seed using minimum amount of water in *Rhizobium* + PSB treatments. Prior to sowing the inoculated seed was dried in shade for one hour. Chemical fertilizers and organic manures (FYM and vermicompost) were applied as per the treatments just before sowing. The sowing of cultivar LL 699 was done in rows 22.5 cm apart using a seed rate of 35 kg ha^{-1}. Each plot measured 5.0 m × 1.8 m. The crop was harvested on 7 April, 2010. Weeds were controlled by two hand weedings at 30 and 60 days after sowing (DAS). The number of nodules was recorded at 60 and 90 DAS by uprooting five plants from each plot, the roots were washed and nodules detached and counted. The nodule and plant dry weight was recorded after drying at 65°C. The chlorophyll and leghaemoglobin content was estimated using standard method of Witham *et al.* (1971) and Wilson and Reisenauer (1963), respectively.

At maturity, data on plant height, primary branches $plant^{-1}$, secondary branches $plant^{-1}$ and pods $plant^{-1}$ were recorded from randomly selected five plants from each plot, and seeds pod^{-1} from randomly selected 20 pods. Biological yield and grain yield was calculated on a plot basis and converted into kg ha^{-1}. From the produce of each plot 100 seeds were taken for 100-seed weight data. Harvest index (HI) was also calculated by dividing grain yield by total biomass production and then multiplying by 100. Gross and net returns as well as B:C ratio were also worked out. Gross returns were calculated by multiplying the grain yield with minimum support price of Rs 3100 q^{-1}. Cost of cultivation was worked out on the basis of the current prices of inputs used in various treatments. Data were subjected to analysis of variance (ANOVA) in a randomized block design as per the standard procedure using CPCS-1 software (Cheema and Singh, 1991).

RESULTS AND DISCUSSION

The application of *Rhizobium* and PSB enhanced the number of nodules as compared to uninoculated control and the organic and inorganic amendments alone (Table 1). The nodulation was significantly ($P \geq 0.01$) enhanced in treatments comprising of *Rhizobium* and PSB along with RDF, FYM and vermicompost at 90 DAS. Similarly a notable increase in the nodule dry weight was recorded in these treatments (58.3-61.6 mg $plant^{-1}$ as compared to 45.3 mg $plant^{-1}$ in the control treatment). As compared to control, the higher number and dry weight of nodules have been reported with the use of organic and inorganic sources of nutrients (Ram *et al*., 2013) and biofetilizers (Tagore *et al*., 2013). Treatments comprising of *Rhizobium* + PSB along with RDF, 50% RDF, FYM and vermicompost showed significantly ($P \geq 0.01$) higher nodule dry weight (58.3-61.6 mg $plant^{-1}$) as compared to the treatments without biofertilizers (47.6-54.0 mg $plant^{-1}$) at 90 DAS. The inoculation with PSB in greengram (Vikram and Hamzehzarghani, 2008) and *Rhizobium* + PSB in chickpea (Tagore *et al*., 2013) has also been reported to result in higher nodule number, nodule dry weight, and total dry matter. The chlorophyll content was also enhanced when organic amendments were combined with *Rhizobium* + PSB. Leghaemoglobin content, which is indicative of efficient nitrogen fixation, was at par in treatments of *Rhizobium* + PSB alone (2.87 mg g^{-1} fresh weight of nodules) or in combination with FYM, vermicompost and RDF + FYM + vermicompost (2.35-2.82 mg g^{-1} fresh weight of nodules). This may be due to the fact that the organic manures have multifarious features such as being rich in nutrients, vitamins and growth regulators. These may have enhanced symbiotic efficiency (Chauhan *et al.,* 2010). Use of co-inoculation of *Rhizobium* + *Klebsiella* with farmyard manure has been reported to enhance symbiotic parameters in dry beans (Uyanoz, 2007). Similarly, use of co-inoculation of *Rhizobium* + PSB with FYM or vermicompost enhanced nodule number and dry weight of nodules in lentil (Ram *et al*., 2013).

Different treatments involving organic manure, chemical fertilizers and biofertilizers did not influence plant height, primary branches $plant^{-1}$ and secondary branches $plant^{-1}$ significantly (Table 2). The number of pods $plant^{-1}$, a major yield attributing character, was highest in RDF + *Rhizobium* + PSB which was, however, at par with RDF + 5 t ha^{-1} FYM, RDF + 2 t ha^{-1} vermicompost, RDF and RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB. In lentil, *Rhizobium* inoculation + N + P_2O_5 (Chowdhary *et al*., 1998) and *Rhizobium* inoculation + P_2O_5 (Singh *et al*., 2001) is known to improve pods $plant^{-1}$. Integrated use of fertilizers with FYM and biofertilizers, in general, also increased seeds pod^{-1}. It was found to be highest in RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB. The treatments had non-significant effect on 100-seed weight.

The treatment with RDF + 5 t ha^{-1} FYM gave highest grain yield (1777 kg ha^{-1}) which was at par with RDF + 2 t ha^{-1} vermicompost, RDF + *Rhizobium* + PSB and RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB. This could be due to synergistic effect of various sources of nutrients as application of nutrients (Singh *et al.,* 2000), FYM (Singh *et al*., 2003) and *Rhizobium* inoculations (Singh *et al.,* 2000) is known to have beneficial effects in lentil. *Rhizobium* inoculation improves nodulation in lentil (Chowdhary *et al*., 1998) and ultimately nitrogen fixation whereas PSB solubilize the native phosphates (El-Sayed, 1999). Therefore, these biofertilizers might have helped in providing nutrients to the plants and ultimately improving the productivity of lentil. Combination of different organic

Table 1. Effect of integrated nutrient management on symbiotic parameters in lentil.

Treatment	No. of nodules plant^{-1}		Dry weight of nodules plant^{-1} (mg)		Plant dry weight (g plant^{-1})	Chlorophyll content (mg g^{-1} fresh weight of leaves)	Leghaemoglobin content (mg g^{-1} fresh weight of nodules)
	60 DAS	90 DAS	60 DAS	90 DAS			
Control (No fertilizer)	12.80	15.00	41.00	45.30	1.80	0.820	1.97
12.5 kg N + 20 kg P_2O_5 ha^{-1}	16.00	23.60	46.00	54.00	2.42	1.023	1.87
RDF (12.5 kg N + 40 kg P_2O_5 ha^{-1})	17.40	22.30	47.00	50.60	2.52	1.140	2.05
50% RDF	17.30	21.60	46.00	50.00	2.77	0.857	1.30
FYM 5 t ha^{-1}	14.60	17.30	44.00	47.60	2.80	0.924	1.97
Vermicompost 2 t ha^{-1}	15.30	18.60	45.00	49.60	2.02	0.889	1.67
RDF + 5 t ha^{-1} FYM	18.00	24.00	47.60	52.30	2.00	0.922	2.09
RDF + 2 t ha^{-1} vermicompost	17.00	22.00	48.00	54.00	1.90	0.984	2.65
50% RDF + 5 t ha^{-1} FYM	14.30	21.30	47.00	52.00	1.95	1.008	2.65
50% RDF + 2 t ha^{-1} vermicompost	18.40	24.00	48.00	53.00	2.12	0.924	2.87
Rhizobium + PSB	20.00	27.30	52.00	58.30	2.42	0.905	2.87
RDF + *Rhizobium* + PSB	22.60	28.60	51.00	61.60	1.97	1.043	1.90
50% RDF + *Rhizobium* + PSB	21.00	27.60	51.60	58.00	2.00	1.034	2.65
FYM 5 t ha^{-1} + *Rhizobium* + PSB	20.60	28.00	51.00	58.60	1.97	1.048	2.82
Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	21.60	29.60	53.00	59.60	2.65	1.355	2.55
RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	19.30	26.30	50.60	58.30	2.77	1.105	2.35
CD (p=0.05)	NS	7.1	NS	7.3	NS	NS	0.57

Table 2. Effect of INM on plant growth, yield attributes and yield of lentil

Treatment	Plant height (cm)	Primary branches $plant^{-1}$	Secondary branches $plant^{-1}$	Pods $plant^{-1}$	Seeds pod^{-1}	100- seed weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Control (No fertilizer)	57.4	4.20	9.46	107.8	1.30	2.33	5814	1407	24.2
12.5 kg N + 20 kg P_2O_5 ha^{-1}	61.1	4.40	9.59	130.0	1.50	2.46	6333	1614	25.5
RDF (12.5 kg N + 40 kg P_2O_5 ha^{-1})	58.9	4.93	10.06	136.1	1.60	2.56	6666	1666	25.0
50% RDF	58.6	4.56	9.70	125.4	1.43	2.30	6111	1583	25.9
FYM 5 t ha^{-1}	59.9	4.46	9.70	121.0	1.36	2.40	6259	1555	24.9
Vermicompost 2 t ha^{-1}	60.9	4.43	9.66	122.7	1.40	2.43	6277	1574	25.1
RDF + 5 t ha^{-1} FYM	64.3	4.60	9.93	139.7	1.50	2.46	6851	1777	25.9
RDF + 2 t ha^{-1} vermicompost	58.2	4.53	10.00	136.9	1.48	2.48	6814	1768	26.0
50% RDF + 5 t ha^{-1} FYM	57.8	4.46	9.80	131.0	1.46	2.43	6444	1592	24.7
50% RDF + 2 t ha^{-1} vermicompost	62.3	4.40	9.56	125.7	1.41	2.46	6407	1611	25.1
Rhizobium + PSB	59.5	4.36	9.59	116.8	1.40	2.35	6037	1537	25.5
RDF + *Rhizobium* + PSB	59.0	5.10	10.93	140.1	1.60	2.43	6407	1768	27.7
50% RDF + *Rhizobium* + PSB	60.3	4.53	9.59	126.1	1.46	2.36	6111	1603	26.3
FYM 5 t ha^{-1} + *Rhizobium* + PSB	61.5	4.23	9.40	121.6	1.49	2.38	6000	1581	26.3
Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	58.4	4.26	9.53	123.0	1.48	2.36	6074	1588	26.1
RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	62.7	4.56	9.93	135.0	1.63	2.53	6555	1740	26.5
CD (p=0.05)	NS	NS	NS	9.6	0.14	NS	551	94	NS

Table 3. Effect of INM on economics in lentil.

Treatment	Gross returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
Control (No fertilizer)	43617	13843	29775	3.15
12.5 kg N + 20 kg P_2O_5 ha^{-1}	50034	14205	35829	3.52
RDF (12.5 kg N + 40 kg P_2O_5 ha^{-1})	51646	14438	37209	3.58
50% RDF	49073	14140	34933	3.47
FYM 5 t ha^{-1}	48205	14843	33363	3.25
Vermicompost 2 t ha^{-1}	48794	14343	34452	3.40
RDF + 5 t ha^{-1} FYM	55087	15438	39650	3.57
RDF + 2 t ha^{-1} vermicompost	54808	14938	39871	3.67
50% RDF + 5 t ha^{-1} FYM	49352	15140	34212	3.26
50% RDF + 2 t ha^{-1} vermicompost	49941	14640	35301	3.41
Rhizobium + PSB	47647	13893	33755	3.43
RDF + *Rhizobium* + PSB	54808	14488	40321	3.78
50% RDF + *Rhizobium* + PSB	49693	14190	35503	3.50
FYM 5 t ha^{-1} + *Rhizobium* + PSB	49011	14893	34119	3.29
Vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	49228	14393	34836	3.42
RDF + FYM 5 t ha^{-1} + vermicompost 2 t ha^{-1} + *Rhizobium* + PSB	53940	15988	37953	3.37

sources with RDF resulted in significantly (P≥0.001) higher grain yield than RDF only. RDF + 5 t ha^{-1} FYM resulted in 26.3 and 6.7 per cent higher grain yield over control and RDF alone, respectively. Integrated use of chemical fertilizers along with organic manures such as FYM and vermicompost as well as biofertilizers improved the grain yield of lentil over their sole application. In the case of chemical nutrients only, use of 12.5 kg N + 40 kg P_2O_5 ha^{-1} provided higher grain yield than with 12.5 kg N + 20 kg P_2O_5 ha^{-1}, though these were statistically at par. Other researchers (Niri *et al*., 2010) advised the applications of 25 kg N + 40 kg P_2O_5 ha^{-1} for obtaining high grain yield of lentil in Iran. Optimum use of nutrients is essential for obtaining high grain yields of pulses (Singh *et al.*, 2010a, 2010b, 2011, 2012; Singh, 2013). Harvest index was not significantly influenced by different treatments.

The highest gross returns (Table 3) were obtained with the use of RDF + 5 t ha^{-1} FYM (Rs 55087 ha^{-1}), closely followed by RDF + 2 t ha^{-1} vermicompost as well as RDF + *Rhizobium* + PSB (Rs 54808 ha^{-1}). RDF + *Rhizobium* + PSB recorded the highest net returns (Rs 40321 ha^{-1}) and B:C ratio (3.78).

It can be concluded that supplementing the recommended dose of nutrients (12.5 kg N + 40 kg P_2O_5 ha^{-1}) with 5 t ha^{-1} FYM or 2 t ha^{-1} vermicompost or *Rhizobium* + PSB inoculation help in obtaining high grain yields and net returns in lentil. High grain yields of lentil were obtained with the use of RDF + 5 t FYM ha^{-1} (1777 kg ha^{-1}), RDF + 2 t vermicompost ha^{-1} (1768 kg ha^{-1}) and RDF + *Rhizobium* + PSB (1768 kg ha^{-1}), resulting in net returns of Rs 39650, 39871 and 40321 ha^{-1}, respectively. The study highlights the role of biofertilizers in lentil, which could play an important role in sustainable agriculture.

ACKNOWLEDGEMENTS

The authors are thankful to the Indian Council of Agricultural Research, New Delhi for providing financial help and Punjab Agricultural University, Ludhiana for providing facilities for the studies.

REFERENCES

Bera, A.K. and Pramanik, K. (2013) Effect of biofertilizers and homo-brassinolide on growth, chlorophyll content, yield, nutrient content and uptake of lentil (*Lens culinaris* Medik.). *International Journal of Agriculture, Environment & Biotechnology,* 6: 427-436.

Chauhan, H.S., Joshi, S.C. and Rana, D.K. (2010) Responses of vermicompost on growth and yield of pea (*Pisum sativum*). *Nature Science,* 8: 18-21.

Cheema, H.S. and Singh, B. (1991) Software Statistical Package CPCS-1. Department of Statistics, Punjab Agricultural University, Ludhiana, India

Chowdhary, A.K., Newaz, M.A., Samanta, S.C., Huda, S. and Ali, M. (1998) Response of lentil genotypes to cultural environments on nodulation, growth and yield. *Bangladesh Journal of Science and Industrial Research,* 33: 258-262.

Deshmukh, C., Singh, R.P., Singh, D. and Sharma, D.P. (2015) Effect of organic, inorganic and biofertilizers on nodulation, yield and economics of lentil (*Lens culinaris* Medik.) under rainfed conditions. *Research in Environment and Life Sciences,* 8: 625-628.

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 Journal of Soil Science,* 39: 175-186.

Jackson, M.L. (1967) *Soil Chemical Analysis*. Practice Hall of India Pvt. Ltd. New Delhi.

Meena, B.S. and Ram, B. (2016) Effect of integrated nutrient management on productivity, soil fertility and economics of blackgram (*Vigna mungo*) varieties under rainfed condition. *Legume Research,* 39: 268-273.

Merwin, H.D. and Peech, M. (1950) Exchangeability of soil potassium in the sand, silt and clay fractions as influenced by the nature of the complementary exchangeable cations. *Soil Science Society of America Proceedings,* 15: 125-128.

Niri, H.H., Tobeh, A., Gholipouri, A., Zakaria, R.A., Mostafaei, H. and Jamaati-e-Somarin, S. (2010) Effect of nitrogen and phosphorus on yield and protein content of lentil in dryland condition. *American-Eurasian Journal of Agricultural and Environmental Science,* 8: 185-188.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. (1954) Estimation of available phosphorus by extraction with sodium biocarbonate. *USDA Circular,* 939: 1-19.

Ram, B., Punia, S.S., Tetarwal, J.P., Meena, D.S. and Tomar, S.S. (2013) Effect of organic and inorganic sources of nutrients on productivity, profitability and soil health in lentil (*Lens culinaris*) under Vertisols. *Indian Journal of Agronomy,* 58: 564-569.

Rasheed, M., Jilani, G., Shah, I.A., Najeeb, U. and Iqbal, T. (2010) Improved lentil production by utilizing genetic variability in response to phosphorus fertilization. *Acta Agriculturae Scandinavica, Section B: Plant Soil Science,* 60: 485-493.

Sarkar, S., Singh, S.R. and Singh, R.P. (2003) The effect of organic and inorganic fertilizers on soil physical condition and the productivity of a rice-lentil cropping sequence in India. *Journal of Agricultural Science,* 140: 419-425.

Singh, G. (2013) Effect of phosphorus application and urea spray on growth and yield of summer urdbean [*Vigna mungo* (L.) Hepper] genotypes. *Journal of Plant Science Research,* 29: 125-128.

Singh, G., Aggarwal, N. and Khanna, V. (2010a) Integrated nutrient management in lentil with organic manures, chemical fertilizers and biofertilizers. *Journal of Food Legumes,* 23: 149-151.

Singh, G., Ram, H., Sekhon, H.S., Aggarwal, N. and Khanna, V. (2011) Effect of nutrient management on nodulation, growth and yield of lentil (*Lens culinaris* Medik.) genotypes. *American-Eurasian Journal of Agronomy,* 4: 46-49.

Singh, G., Sekhon, H.S. and Kaur, H. (2012) Effect of farmyard manure, vermicompost and chemical nutrients on growth and yield of chickpea (*Cicer arietinum* L.). *International Journal of Agricultural Research,* 7: 93-99.

Singh, G., Sekhon, H.S. and Sharma, P. (2001) Effect of *Rhizobium*, vesicular arbuscular mycorrhiza and phosphorus on the growth and yield of lentil (*Lens culinaris*) and fieldpea (*Pisum sativum*). *Environment and Ecology,* 19: 40-42.

Singh, G., Sekhon, H.S., Ram, H. and Sharma, P. (2010b) Effect of farmyard manure, phosphorus and phosphate solubilizing bacteria on nodulation, growth and yield of *kabuli* chickpea. *Journal of Food Legumes,* 23: 226-229.

Singh, N. and Singh, G. (2016) Response of lentil (*Lens culinaris* Medikus) to phosphorus - A review. *Agricultural Reviews,* 37: 27-34.

Singh, N., Singh, G. and Khanna, V. (2016) Growth of lentil (*Lens culinaris* Medikus) as influenced by phosphorus, *Rhizobium* and plant growth promoting rhizobacteria. *Indian Journal of Agricultural Research,* 50: 567-572.

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 Journal of Pulses Research,* 16: 116-118.

Singh, Y.P., Chauhan, C.P.S. and Gupta, R.K. (2000) Effect of sulphur, phosphorus and inoculation on growth, yield and sulphur utilization by lentil (*Lens culinaris*). *Indian Journal of Agricultural Sciences,* 70: 491-493.

Subbiah, B.K. and Asija, G.L. (1956) A rapid procedure for the extraction of available nitrogen in soil. *Current Science,* 25: 259-260.

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. *International Journal of Agronomy,* Vol. 2013, Article ID 581627, 8 pages (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* Medic.). *African Journal of Biotechnology,* 7: 1256-1260.

Uyanoz, R. (2007) The effects of different bio-organic, chemical fertilizers and their combination on yield, macro and micro nutrition content of dry bean (*Phaseolus vulgaris* L.). *International Journal of Agricultural Research,* 2: 115-125.

Vikram, A. and Hamzehzarghani, H. (2008) Effect of phosphate solubilizing bacteria on nodulation and growth parameters of greengram (*Vigna radiata* L. Wilczek). *Research Journal of Microbiology,* 3: 62-72.

Wilson, D.O. and Reisenauer, H.M. (1963) Determination of leghaemoglobin in legume nodules. *Annals of Biochemistry,* 6: 27-30.

Witham, F.H., Bladydes, D.F. and Delvins, R.M. (1971) Experiment in plant physiology. Van Nostrand Reinhold, New York, pp. 245.