Effect of organic and inorganic fertilizers on productivity of lentil (*Lens esculenta* Moench)

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Abstract: A field experiment was planned and conducted during the Rabi season of 2019-2020 at Crop Research Center of Alpine Institute of Management and Technology, Dehradun (Uttarakhand). The experiment was conducted to evaluate the effect of organic and inorganic fertilizers on productivity of lentil (*Lens esculenta* Moench). The experiment was laid out in randomized block design with three replications and ten treatments. The treatments constituted viz. T_1- control, T_2- RDF, T_3- FYM, T_4- vermicompost, T_5- RDF + FYM, T_6- RDF + vermicompost, T_7- Rhizobium + PSB, T_8 RDF + Rhizobium + PSB, T_9- FYM + Rhizobium + PSB and T_{10}- vermicompost + Rhizobium + PSB. The crop variety Pant Masoor- 5 was sown on October 20, 2019 and harvested on March 01, 2020. Studies were made on growth parameters (plant height, number of branches and dry weight per plant), root nodulation, yield attributing parameters (number of pods per plant, number of seeds per pod and 100 grain weight), productivity parameters (grain yield and straw yield) and economical returns. It was concluded from the findings that integrated nutrient management having RDF + FYM increased the plant height, branches and dry weight per plant of lentil up to maximum. The application of RDF + FYM increased the root nodulation, yield attributing parameters and yield of lentil significantly higher to those of other treatments except RDF + vermicompost and RDF + Rhizobium + PSB. Amongst the integrated nutrient management treatments, RDF + FYM recorded the maximum net profit of Rs. 19,047 per hectare and B: C ratio of 1.72.

Keywords. Lentil, Organic, Inorganic, Bio-fertilizers Productivity, NPK, FYM.
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1. Introduction

Lentil (*Lens esculenta* Moench) is one of the important pulse crop grown in India. It is grown extensively during the *Rabi* season in India. It is a leguminous crop. It is grown annually on various soil types. Moderately fertile deep sandy loam soils are considered best for its growth. It requires a soil pH of around 7. Flooding and waterlogged conditions are not considered beneficial for this crop. The physical properties of soils are improved due to the cultivation of lentil.Lentil is grown under different climatic conditions across different growing regions. In the temperate climates lentil is grown in winter and spring as a result vegetative growth occurs in the summer season. In sub-tropical climate, this crop is grown at the end of the rainy season, and vegetative growth occurs during the summer season. In West Africa and North Africa, lentil is planted during winters and vegetative growth occurs during the snow melting period. This type of cultivation results in higher seed yields.Lentil is cultivated all over the world with excellent socio-economic value. In India, lentil is mostly grown in northern plains, central and eastern parts of the country. The major lentil producing states are Madhya Pradesh, Uttar Pradesh, Bihar, Uttarakhand and Bengal. It is mainly grown for its edible seed which matures between 90 to 120 days and popularly known as “Masoor” in India.Lentil plant varies from 30-50cm in height with many hairy branches having slender and angular stem. It is a diploid annual bushy herb of erect, semi-erect or spreading types with compact growth. The leaves are yellowish green to dark bluish green in color and obtuse in shape. The flowers are small, white, pink, purple, pale purple or pale blue in color which varies one to four in number. The pods are oblong, slightly inflated and about 1.5cm long, each of them contains two seeds, about 0.5cm in diameter, in the characteristic lens shape. The several cultivated varieties of lentil differ in size, hairiness and color of the leaves, flowers and seeds. Lentil is a self-pollinating crop. Its flowering is known as acropetal flowering because it begins from the lowermost buds and gradually moves upward. Flowering in lentil plant takes about two weeks on the single branch and then opens. After two-three days of the opening of the flowers the color begins to lighten with complete closing followed by setting of the pods after three to four days. **(Shyam *et al.*2007).** Importance of lentil as a pulse crop is well documented since times immemorial due to its role in food, feed and farming systems of India. Its inclusion in daily diet as dal (a popular concentrated soup) with rice provides a complete food for human nutrition. Its seeds contain high quantity and quality protein along with essential minerals and vitamins; high lysine content in its seed complements the low lysine in cereal proteins. The yield level is generally low because it is less cared crop and mostly grown in poor soils under rainfed conditions without manures and fertilizers. The beneficial effect of FYM, vermicompost, Rhizobium and PSB culture on crop yield and soil productivity is the result of its usefulness as a store house of plant nutrients.

Vermicompost is a good source of organic manure which contains relatively higher amount of plant nutrients as compared to conventional organic manures. Pulses are mainly grown in marginal land and poor productivity of the crop is mainly due to inadequate nutrient supply. Keeping in view the importance of organic manures on soil health and the inevitability of fertilizer for higher productivity, the role of different bio-fertilizers like Rhizobium, BGA, Azotobactor, PSB, VAM etc. have been established in the economical nutrition of various crops, apart from this the micro-organisms secrete the phyto-hormones and build up organic status of the soil due to which the availability of other nutrients also increases. Growing fertilizer need of the country and increasing fertilizer prices have emphasized on the use of bio-fertilizers in Indian Agriculture. Phosphate solubilizing bacteria (PSB) are known to mobilize the unavailable P in soil and make it available to crop. The research work with bio-fertilizer in combination with FYM and NPK is lacking.

2. Materials and Methods

The experiment was conducted at Alpine Institute of Management and Technology, Dehradun, Uttarakhand during Rabi season 2020. The experimental site is located at 25646ft above the mean sea level. The experiment was laid out in a randomized block design with three replications. The experiment comprised of ten treatments which include

T_1: Control
T_2: RDF
T_3: FYM
T_4: Vermicompost
T_5: RDF + FYM
T_6: RDF +vermicompost
T_7: Rhizobium culture + PSB
T_8: RDF + Rhizobium culture+ PSB
T_9: FYM + Rhizobium culture+ PSB
T_{10}: Vermicompost + Rhizobium culture+ PSB

As Dehradun of Uttrakhand is a sub-tropical zone, so the characteristics of its soil would be quite different than those of other zones due to difference in climate, topography, vegetation and rocks. The soil of experimental site was fertile alluvial soil in texture. The Lentil Variety Pant Masoor- 5 was sown at the rate of 40kg/ha. All agronomic practices were kept uniform and normal for all treatments. The data on plant height (cm), number of nodules per plant, days to maturity, number of pods per plant, number of seeds per pod, 1000- seed weight (g), seed yield and biological yield were recorded during the course of study by following standard procedure. Full dose of phosphorus and potassium and basal dose of nitrogen were applied. The observations were recorded on five randomly selected plants from each plot in each replication. The unit plot size was 4.5 m × 2.4 m The variety of lentil used for experiment was Pant Masoor- 5.

Seeds were sown in lines at a spacing of 25 cm x 10 cm inter and intra row. The chemical fertilizers viz. urea, single super phosphate and muriate of potash were used as source of nitrogen, phosphorus and potassium, respectively. The data obtained in respect of various observations were statistically analysed by the method described by Cochran *et al.,* 1967. The significance of "F" and "t" was tested at 5 per cent level of significance.

3. Results and discussion

This chapter deals with the results obtained during the course of the present investigation entitled "Effect of integrated nutrient management on productivity of lentil (*Lens esculenta* Moench)" in Dehradun valley.

The data of the various observations recorded periodically were subjected to statistical computation in a randomized block design (RBD) in order to find out the significance of different treatments by using the analysis of variance technique. The experimental findings on different aspects are integrated and presented in tables along with suitable illustrations.

Growth Parameters Plant height

An important indicator of plant growth was plant height. At different growth stages, the observations on this parameter were recorded. The data on the influence of plant height in different treatments at 30, 45, 60 days after sowing and at maturity stages are highlighted in given table.

It was clear from the data that the plant height was increased greatly with the advancement of the crop growth in all treatments and attends maximum plant height at maturity stage. The plant height was found significant in all treatments at 30 DAS. However, it raised from 10.19 cm in case of T1 control to 11.78cm in case of treatment T5 which was at par with all the treatments.

At 45 DAS the maximum plant height was recorded at T_5 (16.58 cm) which was at same with treatments T6, T8 and T10 whereas minimum plant height was recorded in treatment T1 which is 12.34 cm.

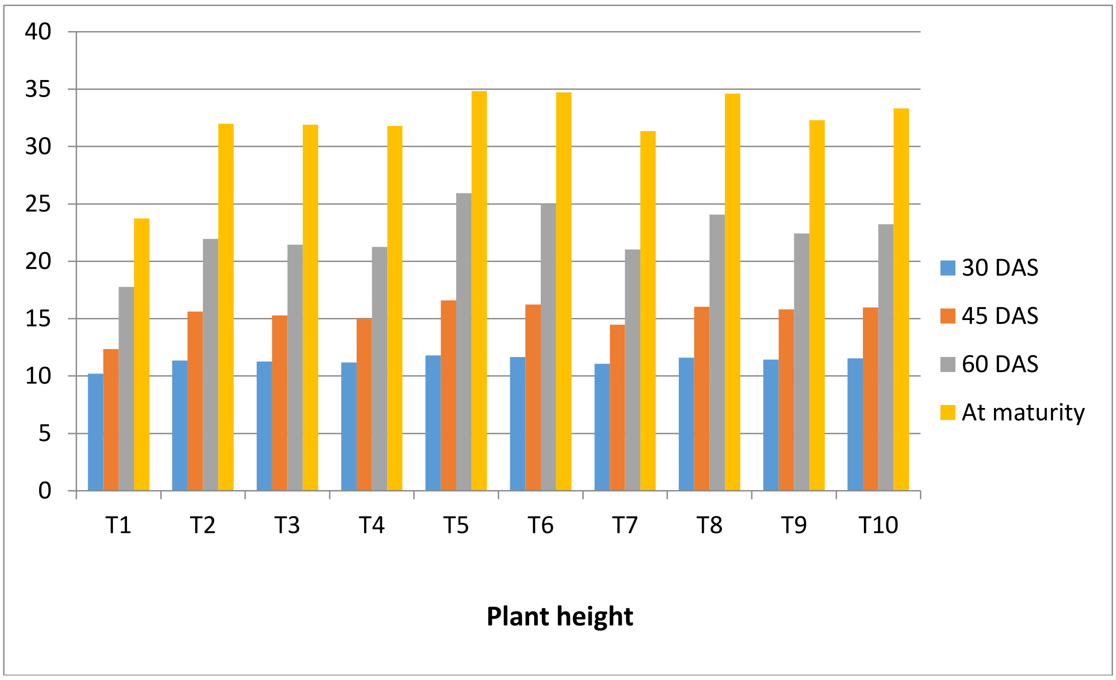
At 60 DAS the maximum plant height was recorded at T5 (25.94 cm) which was at same with treatment T6 whereas minimum plant height was recorded in treatment T1 which is 17.76 cm.

The height of plant was maximum in treatment T5 which was about 34.82 cm at maturity stage which was at par with treatments T6, T8 and T10. The minimum plant height was recorded on treatment T1 Control (23.74 cm).

Height of plant (cm) at different stages of plant growth as influenced by various treatments.

S.No.	Treatments	Plant height (cm)			
		30 DAS	45 DAS	60 DAS	At maturity
T1	Control	10.19	12.34	17.76	23.74
T2	RDF	11.34	15.62	21.96	31.98
T3	FYM	11.26	15.29	21.45	31.90
T4	Vermicompost	11.18	15.01	21.26	31.78
T5	RDF + FYM	11.78	16.58	25.94	34.82
T6	RDF + Vermicompost	11.64	16.24	24.98	34.72

T7	Rhizobium + PSB	11.06	14.46	21.02	31.36
T8	RDF + Rhizobium + PSB	11.60	16.02	24.07	34.62
T9	FYM + Rhizobium + PSB	11.43	15.82	22.42	32.30
T10	Vermicompost+Rhizobium + PSB	11.53	15.98	23.24	33.32
	S.Em ±	0.232	0.249	0.325	0.524
	C.D. at 5%	0.695	0.746	0.972	1.568
	CV	3.559	2.815	2.510	2.830



YIELD ATTRIBUTING PARAMETERS

The data on yield attributing parameters was recorded in each treatment and then statistically computed before presenting the results.

Number of pods per plant

The number of pods per plant was found to deviate significantly due to various fertility treatments as revealed from given table. The pod per plant is a very important yield attributing parameter observed, significantly influenced by various integrated nutrient management treatments. The application of RDF + FYM which was treatment T5 recorded maximum number of pods per plant (86.18). This treatment was found significantly superior than the other treatments. The application of chemical fertilizer alone or in combination with organic manures and bio-fertilizers significantly influenced the number of pods per plant whereas, the minimum number of pods per plant was reported in T1 (40.00)

Number of seeds per pod

The number of seeds per pod was found to influence significant due to different treatments was presented in given table. The effect of various integrated nutrient management treatments were found significant on increasing number of seeds per plant than the control. The maximum number of seeds per plant was recorded in treatment T5 (4.30). It was found significantly superior than all the other treatments except treatments T6 and T8. The combined application of chemical fertilizers with organic manures increased number of seeds per pod significantly. The minimum number of seeds per plant was recorded in treatment T1 (3.38)

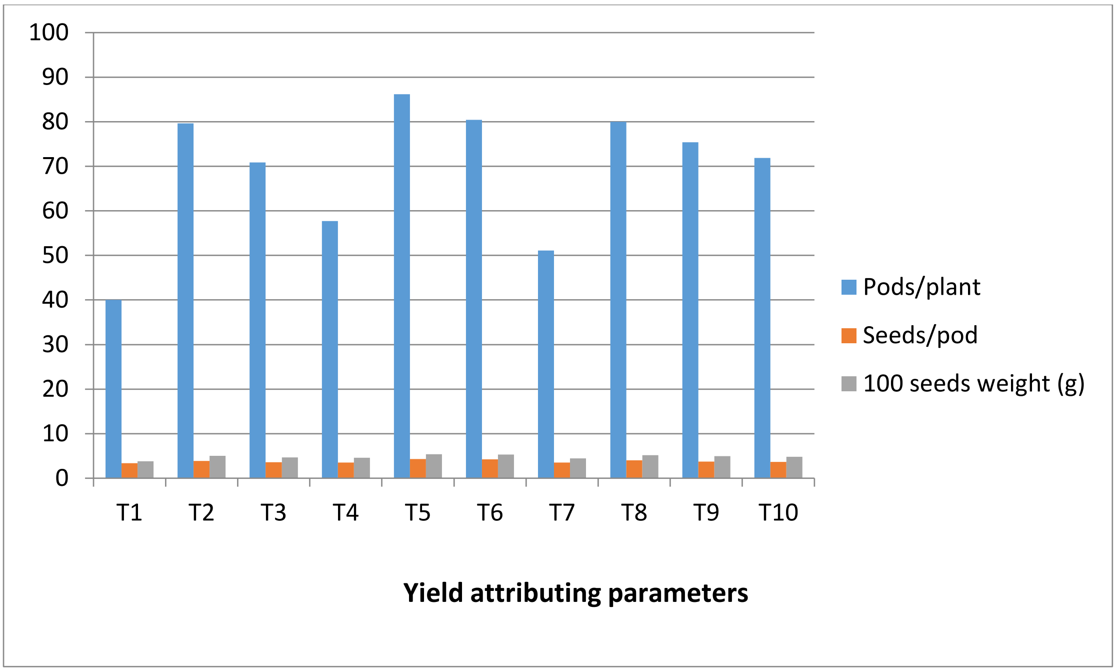
4.2.5 100 seeds weight.

The seed weight of 100 seeds was also deviated significantly due to applied fertility treatments as revealed from data in table.

The result indicated from the data that the 100 seeds weight was significantly influenced by various integrated nutrient management treatments. The maximum weight of 100 seeds (5.40 g) was recorded in treatment T5, this treatment was found significantly superior than all the treatments except treatments T2, T6 and T8. The effect of combination of organic manures and inorganic fertilizers was found significant than control. The minimum weight of 100 seeds was recorded in T1 (3.80).

Yield attributing parameters as influenced by various treatments

S.No.	Treatments	Pods/plant	Seeds/pod	100 seeds weight (g)
T1	Control	40.00	3.38	3.80
T2	RDF	79.64	3.90	5.02
T3	FYM	70.90	3.58	4.68
T4	Vermicompost	57.70	3.55	4.60
T5	RDF + FYM	86.18	4.30	5.40
T6	RDF+Vermicompost	80.44	4.22	5.28
T7	Rhizobium + PSB	51.10	3.48	4.48
T8	RDF + Rhizobium + PSB	79.98	4.05	5.14
T9	FYM + Rhizobium + PSB	75.38	3.74	4.94
T10	Vermicompost+Rhizobium + PSB	71.84	3.65	4.82
	S.Em ±	0.847	0.105	0.147
	C.D. at 5%	2.536	0.315	0.442
	CV	2.117	4.810	5.303



Yield attributes

The factors which are directly responsible for ideal grain production viz. number of pods per plant, number of seeds per pod and test weight were augmented significantly due to increased supply of nutrients from integrated nutrient management treatments having RDF + FYM. This integrated nutrient management treatment was found significantly superior to rest of the treatments except the integrated nutrient management treatment having RDF + vermicompost and RDF + Rhizobium + PSB. Thus the integrated nutrient management treatments RDF + vermicompost and then RDF + Rhizobium + PSB attained the second and third best position, respectively with respect to encouraged yield attributing parameters. The organic sources like FYM or vermicompost are not only the store house of plant nutrients but also improve the physiochemical as well as biological properties of the soil. On the other hand, for the soils applied with only chemical fertilizers are deprived of all these advantages necessary for more production of functioning leaves, greater accumulation of carbohydrates, protein and their translocation to the reproductive organs, which in turn increased the higher number of pods per plant as well as other associated yield attributing parameters. These results on lentil are exactly in accordance to the similar findings obtained by other scientists, **Gendy and Derar (1995), Naphode*et al.* (1997), Tiwari*et al.* (1997), Sayed (1998), Singh *et al.* (1999), Anonymous (2001), Bandhyopadhyay and Puste (2002), Singh *et al.* (2003)** and **Pathak*et al.* (2003).**

Productivity parameters

The combined application of RDF + FYM resulted in significantly higher grain and straw yields of lentil (10.85 and 18.52 q/ha) but was at par with trearment RDF+Vermicompost as compared to those treatments having separate application of nutrients either from RDF or FYM or vermicompost or Rhizobiium + PSB.. The trend of increase in grain and straw yield obtained due to RDF + FYM was exactly in accordance with the similar increases recorded in the yield attributing characters i.e. pods per plant, seeds per pod and 100 grain weight and the increased vegetative growth parameters up to the maximum extent. The increases in yield attributing parameters and consequently the grain yield of lentil as a result of integrated nutrient management have also been reported by many workers. **Gupta and Namdeo (1997), Chandra and Parek (2002), Pathak*et al.* (2003), Rajput and Pandey (2004), Vasanthi and Subramanian (2004),**

Rajput and Kushwah (2005), Meena*et al.* (2006).

The significant increases in straw yield due to various integrated nutrient management treatments RDF + FYM, RDF+ vermicompost and RDF + Rhizobium + PSB, may be mainly due to similar increases in vegetative growth characters viz. plant height and branches particularly only pods per plant as a result of such treatments. The harvest index did change up to significant level due to different fertility treatments. The significant differences in harvest index under these treatments might be because of the proportionately equally higher grain production over its straw.

4. Return

Cost of cultivation

The common cost of cultivation of different treatment combinations were work out, considering all operation from land preparation to harvesting and input used. The treatment cost was calculated separately and it was combined with common cost of cultivation to find out the total cost of cultivation. Data presented in table revealed that the total cost of cultivation was minimum (Rs 24,500 ha^{-1}) under the control. However, the total cost of cultivation was maximum (Rs 35,728 ha^{-1}) was recorded under the application of Vermicompost + Rhizobium + PSB.

Gross return (Rs ha^{-1})

It is evident from the data that among different fertility levels and inoculation of seed with PSB culture minimum gross return was recorded (Rs 38,010 ha^{-1}) under the control treatment. The maximum gross return of (Rs 50,112 ha^{-1}) was recorded under the application of Vermicompost + Rhizobium + PSB.

Net returns (Rs ha^{-1})

The net return was markedly influenced due to different cost incurred and yield (grain & straw) obtained under various treatments. The minimum net return of (Rs 13,510 ha^{-1}) was recorded under control. However, the maximum net return of (Rs 19,047 ha^{-1}) was recorded under the application of RDF + FYM.

Benefit: cost ratio

Data concerned with benefit: cost ratio in lentil as influenced by different fertility levels and inoculation of seed with PSB culture is presented in (Table 4.8). The minimum benefit: cost ratio in lentil (1.40) was recorded under Vermicompost + Rhizobium + PSB. However, the maximum benefit: cost ratio in lentil (1.72) was recorded under the 1application of RDF + FYM.

S.No	Treatments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net profit (Rs./ha)	B:C ratio
T1	Control	24500	38010	13510	1.55
T2	RDF	25655	39600	13945	1.54
T3	FYM	24900	40600	15700	1.63
T4	Vermicompost	25842	41820	15978	1.62
T5	RDF + FYM	26365	45412	19047	1.72
T6	RDF + Vermicompost	27512	43602	16090	1.58
T7	Rhizobium + PSB	28802	42800	13998	1.49

T8	RDF + Rhizobium + PSB	30622	46480	15858	1.52
T9	FYM +Rhizobium + PSB	34244	49000	14756	1.43
T10	Vermicompost+Rhizobium + PSB	35728	50112	14384	1.40

Net return and benefit: cost ratio from lentil as influenced by various treatments

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