



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

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www.agronomyjournals.com

2024; 7(7): 639-642

Received: 25-04-2024

Accepted: 28-05-2024

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Performance of lentil (*Lens culinaris*) under various organic and inorganic sources of nutrients under sandy loam soil

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DOI: <https://doi.org/10.33545/2618060X.2024.v7.i7h.1104>

Abstract

The growth and yield of lentil were examined in a field trial using various organic and inorganic nutrient sources in sandy loam soil of Dehradun, Uttarakhand during the winter crop season of 2023-24 at the Crop Research Farm, Department of Agronomy, Dev Bhoomi Uttarakhand University, Dehradun, India. The experiment utilized a Randomized Block Design with three replications for each treatment, and the lentil seeds were planted at a rate of 20 kg ha⁻¹. Data was collected before and after harvest, and then analyzed using statistical methods. During the year of the experiment, M2 (75% RDF ha⁻¹) and O3 (5 t ha⁻¹ Vermicompost) was the best treatment out of the different organic and inorganic treatments, improvements in plant height, dry matter accumulation, and leaf area index. The highest yield attributes and yield were also documented in M2 (75% RDF ha⁻¹) in inorganic nutrient management. During the experiment year, O3 (Vermicompost 5 t ha⁻¹) showed the highest values in terms of plant height, dry matter accumulation, leaf area index, pods plant⁻¹ and seed pod⁻¹, test weight, grain yield, stover yield, and harvest index among organics. Yet, O2 (5 t ha⁻¹ Poultry manure) was observed to be on par to O3 (5 t ha⁻¹ Vermicompost) in the year of the study.

Keywords: Lentil, organic, inorganic, poultry manure, vermicompost, *Lens culinaris*

Introduction

Agricultural production is a demanding industry that is associated with higher crop yields and better quality products, resulting in a higher market value due to consumer preferences. High-quality products, including organic options, may have a significant impact on the production process. Lentil (*Lens culineris* L.) is a significant grain legume crop in India, with 2n = 14 chromosome. During the Rabi season, lentil crop is widely cultivated in India. As a leguminous crop, it uses nitrogen from the air to fulfill some of its nitrogen needs, making it a vital part of crop rotation in various regions of the country. Lentils are grown in approximately 1.38 million hectares of land in the country, resulting in a production of 0.95 million tonnes and an average yield of 688 kg per hectare. Frequent use of soil nutrients has resulted in the appearance of various nutrient deficiencies. This occurs because soil nutrients are depleted at a faster rate with higher production levels, leading to a widespread nitrogen deficiency in Indian soil. Afterwards, the lack of phosphorus emerged, impacting around 65 to 70 percent of Indian soil. Emphasizing NPK application led to secondary and micro nutrient deficiency becoming a widespread issue in soil and crops in various regions.

Extensive use of chemical fertilizers and other chemicals has caused environmental issues and raised production expenses. Increased concern about environmental issues has sparked a focus on sustainable agricultural practices that are friendly to the environment and can lower costs. Thus, maintaining a balance in nutrient management is crucial for achieving maximum yield in lentil crops across India. Evidence suggests that relying solely on chemical fertilizer does not enhance productivity in a continuous cropping system. However, incorporating farm yard manure, vermicompost, and poultry manure can enhance crop yield, soil quality, and physical condition.

The main goal is to find the most basic substrate formulas for successful lentil cultivation and this study was conducted to determine the best amount of organic and inorganic nutrient sources to enhance lentil crop yield.

Materials and procedures

During 2023-2024, a study titled "Impact of organic and inorganic nutrient sources combined with bio fertilizers on the growth and yield of lentil (*Lens culinaris*)" was conducted at Crop Research Farm, Department of Agronomy, Dev Bhoomi Uttarakhand University, Dehradun, Uttarakhand. The research farm is located in Dehradun, positioned between 78. Located at a latitude of 30.01° North and a longitude of 31.20° East, with an elevation of 450 meters above mean sea level, in the lower Himalayan area. The study was arranged using Randomized Block Design with two variables. One factor consists of inorganic nutrient sources while another factor consists of organic nutrient sources. Nine treatment combinations, each replicated three times, are created by using three organic sources. The treatments were randomly distributed within each replication, with twenty seven plots assigned to different treatments. Additionally, one plot was dedicated to the absolute control treatment, resulting in a total of thirty plots for the experiment. The growth attributes included plant height, dry matter accumulation, number of branches plant⁻¹, number of nodules plant⁻¹, crop growth rate, and relative growth rate, while yield attributes included number of pods plant⁻¹, number of seeds pod⁻¹, and test weight. The ultimate production of the crop was measured in terms of grain yield and stover yield.

Analysis of data using statistical methods

The data collected during the inquiry was organized and examined through statistical analysis in order to reach a reliable outcome. The information was evaluated following the standard method for "Analysis of Variance" (ANOVA) outlined by Gomez and Gomez (1984) [10]. The importance of treatments was assessed using an 'F' test (Variance ratio). The standard deviation of the mean was calculated in every instance. The Critical Difference (CD) was used to test the variance in treatment means at a 5% level of significance, demonstrating significant differences among means according to the 'F' test. The formula is as follows:

$$CD = \sqrt{\frac{2 \times \text{error sum of square}}{N}} \times t \text{ (error d.f. 5\%)}$$

Results and Discussion

Characteristics of growth: Plant height, dry matter accumulation, number of branches and nodules plant⁻¹, crop growth rate, and relative growth rate all showed a steady increase as the crop aged. An analysis of the data revealed that plant height, dry matter accumulation, number of branches plant⁻¹, number of nodules plant⁻¹, crop growth rate and relative growth rate were notably affected by organic and inorganic nutrient sources, with no changes in their combined effects. Examination of the mean data in table 1 and table 2 displayed significant differences in plant height, dry matter accumulation, number of branches plant⁻¹, number of nodules plant⁻¹, crop growth rate, and relative growth rate at the pre-harvest stage among various inorganic nutrient sources in the experimental year. The tallest plant height was measured with M2 using 75% RDF ha⁻¹. Yet, M1 displayed the lowest growth attribute performance with 50% RDF ha⁻¹. This could be attributed to the fact that lentil crops require a lower amount of fertilizer, particularly nitrogen-based fertilizers. Streeter and Wong (1998) [1] also found comparable results. However, the excessive use of nitrogen fertilizers and high residual levels hinder nodule formation and N2 fixation. Xuan *et al.* (2017) [2] saw similar findings in beans. O3 (Vermicompost 5 t/ha) in organic treatment showed significantly better plant height, dry matter accumulation, branches plant⁻¹, nodules plant⁻¹, crop growth rate, and relative growth rate compared to all treatments during the experiment year. O2 (Poultry manure 5 t/ha) was equivalent to O3 (Vermicompost 5 t/ha) in terms of plant height, dry matter accumulation, number of branches plant⁻¹, nodules plant⁻¹, crop growth rate, and relative growth rate. T0 (absolute control) had the lowest values of above these parameters. O3 (Vermicompost 5 t ha⁻¹) showed higher values for these parameters due to better nutrient uptake and slow decomposition of organic manures like vermicompost, making nutrients available to the plant throughout its growth, resulting in maximum growth potential. The outcome was consistent with the studies by Dhama, 2003 [3] and Sanwal *et al.*, 2007 [4]. Examination of the average data also shows that the combined impact of organic and inorganic nutrient sources remained constant on lentil plant height, dry matter accumulation, number of branches plant⁻¹ and nodules plant⁻¹, as well as crop growth rate and relative growth rates throughout the experiment year. Sanwal *et al.*, 2007 [4], also reported a comparable discovery.

Table 1: Impact of natural and artificial nutrient sources on the growth characteristics of lentil

Treatment	Plant height (cm)		Dry weight (g)		Number of branches Plant ⁻¹ (No.)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Absolute control	12.36	25.55	0.86	6.22	5.83	6.12
Inorganic source						
F1 50% RDF ha ⁻¹	13.37	28.33	1.40	8.63	6.17	6.86
F2 75% RDF ha ⁻¹	14.52	30.31	1.43	8.83	7.00	7.50
F3 100% RDF ha ⁻¹	13.63	29.77	1.54	9.54	6.72	7.02
Sem ±	0.67	1.58	0.05	0.29	0.39	0.32
C.D. at 5%	1.36	3.24	0.09	0.59	0.80	0.65
Organic Sources						
O1 FYM 10 t ha ⁻¹	18.39	38.22	1.40	8.66	6.44	6.97
O2 Poultry Manure5 t ha ⁻¹	18.07	39.88	1.44	8.90	6.72	6.90
O3 Vermicompost5 t ha ⁻¹	19.97	43.22	1.53	9.44	6.72	7.50
Sem ±	0.58	1.37	0.04	0.27	0.37	0.30
C.D. at 5%	1.18	2.80	0.09	0.56	0.76	0.62

Table 2: Impact of natural and artificial nutrient sources on the growth and growth analytic characters of lentil

Treatment	Number of nodules plant ⁻¹ (No.)		Crop Growth Rate (g m ⁻² day ⁻¹)		Relative Growth Rate (g g ⁻¹ day ⁻¹)	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Absolute control	16.53	15.26	0.76	16.85	-0.0254	0.0583
Treatment						
F1 50% RDF ha ⁻¹	19.00	19.44	1.06	19.29	-0.0332	0.0658
F2 75% RDF ha ⁻¹	19.67	19.56	1.16	21.34	-0.0285	0.0693
F3 100% RDF ha ⁻¹	19.11	19.00	1.07	19.74	-0.0332	0.0666
Sem ±	0.48	0.51	0.18	0.83	0.0061	0.0014
C.D. at 5%	0.98	1.03	0.37	1.70	0.0124	0.0029
Organic Sources						
O1 FYM 10 t ha ⁻¹	18.89	19.00	1.07	19.36	-0.0320	0.0659
O2 Poultry Manure 5 t ha ⁻¹	19.00	19.00	1.08	19.91	-0.0341	0.0668
O3 Vermicompost 5 t ha ⁻¹	19.89	20.00	1.14	21.10	-0.0287	0.0689
Sem ±	0.46	0.48	0.17	0.79	0.0058	0.0014
C.D. at 5%	0.93	0.98	0.35	1.62	0.0118	0.0028

Characteristics of production output

The crop's yield attributes were documented during the harvest stage. A brief look at the data revealed that the number of pods plant⁻¹, seeds per pod⁻¹, and test weight were greatly affected by both organic and inorganic nutrient sources, with no changes for their combined effects. Examination of the average data in table 3 displayed substantial differences in pod number, seed number, and test weight during the harvest stage across various inorganic nutrient sources. The highest number of pods on each plant, seed pod⁻¹, and test weight were measured at M2 (75% RDF ha⁻¹). Nevertheless, M1 (50% RDF ha⁻¹) showed the lowest yield performance. M1 (50% RDF ha⁻¹) results in minimal yield characteristics. Pod initiation and seed setting are considerably lower in comparison to M2 (75% RDF ha⁻¹), leading to a decrease in these processes. This could be because a balanced diet supports healthy growth and development in lentil plants. Gedam *et al.* (2008)^[5] and Singh *et al.* (2013)^[6] also reported comparable findings. During the year of the study, O3

(Vermicompost 5 t/ha) showed a notable increase in pods plant⁻¹, seed pod⁻¹, and test weight compared to all other treatments. Conversely, O2 (Poultry manure 5 t ha⁻¹) had similar results to O3 (Vermicompost 5 t ha⁻¹). T0 (absolute control) had the lowest number of pods plant⁻¹, seed pod⁻¹, and test weight. Examination of the average data also shows that the interaction effect of various organic and inorganic nutrient sources remained unchanged in relation to the number of pods plant⁻¹, number of seeds pod⁻¹, and test weight of lentil at harvest. Similar results were also documented Tiwari *et al.* (2006)^[7]. Patel *et al.* (2012)^[9] suggests that the improved availability of nutrients, enhanced plant establishment, and enhanced growth attributes in O3 (Vermicompost 5 t ha⁻¹) may contribute to this outcome. Tiwari *et al.* (2006)^[7] suggest that the improved availability of nutrients, enhanced plant establishment, and enhanced growth attributes in O3 (Vermicompost 5 t ha⁻¹) may contribute to this outcome.

Table 3: Shows how organic and inorganic nutrient sources impact the yield attributes and overall yield of lentils.

Treatment	No. of pod plant ⁻¹ (No.)	No. of seeds pod ⁻¹ (No.)	Test weight (g)	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)	Harvest index
Absolute control	28.14	0.81	20.12	22.12	24.55	47.39
Inorganic source						
F1 50% RDF ha ⁻¹	32.69	1.47	20.20	30.40	27.18	47.20
F2 75% RDF ha ⁻¹	36.02	1.62	22.26	33.09	29.71	47.50
F3 100% RDF ha ⁻¹	33.33	1.50	20.59	31.56	27.95	47.16
Sem ±	1.07	0.05	0.66	1.01	0.89	1.41
C.D. at 5%	2.19	0.10	1.35	2.05	1.82	-
Organic Sources						
O1 FYM 10 t ha ⁻¹	32.81	1.47	20.28	30.52	27.28	47.32
O2 Poultry Manure 5 t ha ⁻¹	32.81	1.51	20.77	31.27	27.94	47.20
O3 Vermicompost 5 t ha ⁻¹	33.60	1.60	22.01	33.27	29.62	47.34
Sem ±	1.02	0.05	0.63	0.95	0.85	1.34
C.D. at 5%	2.08	0.09	1.28	1.95	1.73	-

Index of yield and harvest

Yield is a intricate trait that emerges from the interplay between the plant's inherent traits and how it interacts with its surroundings and how it is managed. The ecological situation, genetic potential, and agronomic management systems are crucial for achieving high crop yields. If both requirements are widely held, the outcome of the crop will be naturally influenced by agricultural practices. Out of all agronomic practices, the ways in which nutrients are administered are extremely crucial. Yet, achieving a balance between crop growth during the vegetative and reproductive stages is necessary to increase grain yield. The increased proportion of grain weight compared to

total dry matter produced is a measure of balanced growth and is utilized to assess the effectiveness of agronomic treatments. The harvest index (HI) is the term used to describe this ratio. Different sources of inorganic nutrients caused considerable differences in grain yield and stover yield. Treatment M2 (75% RDF ha⁻¹) showed significantly higher grain yield, stover yield, and harvest index compared to all other treatments. This finding is consistent with previous studies by Kumar, Singh, and Aziz. Over-fertilization negatively impacts the performance of lentil crops. Excessive nutrition can also decrease productivity by affecting the crop's performance, leading to lower growth rates delayed maturity and ultimately reducing the yield. Shah and

Namdeo (2013) ^[6] stated that the most optimal nutrient management for lentil crops in the Indian Himalayan region is the application of 75% RDF.

There was a notable increase in lentil grain yield and stover yield when using O3 (Vermicompost 5 t/ha) in the experiment year. Conversely, O2 (Poultry manure 5 t ha⁻¹) showed similar results to O3 (Vermicompost 5 t ha⁻¹). This outcome was in agreement with the findings of Patel *et al.* (2012) ^[9] and Singh *et al.* (2013) ^[6]. The increased grain production from O3 (Vermicompost 5 t ha⁻¹) could be a result of efficient nutrient utilization. During the later stages of crop growth, the increase in nutrient availability results in maximum growth characteristics, leading to higher plant growth and ultimately increased yield. This rise in straw yield can be attributed to the significant boost in plant height and dry matter production with 5 t ha⁻¹ of vermicompost application under O3 conditions. This finding supported the findings of Singh *et al.* (2013) ^[6]. The harvest index for grain crops is the proportion of harvested grain compared to the total shoot dry matter. This can serve as an indicator of how efficient reproduction is. The index can also help in calculating crop carbon balance by using it with grain yield data to figure out total shoot dry matter, and then determining crop residue as the gap between shoot carbon and grain carbon. The reason for the highest harvest index in O3 (Vermicompost 5 t/ha) is likely the highest grain yield in O3.

Conclusion

According to the results, it can be inferred from the current study that using M2 (75% RDF ha⁻¹) combined with O3 (Vermicompost 5 t ha⁻¹) is the most effective combination of organic and inorganic nutrients for growing lentils in the experimental year.

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