

Effect of levels of nitrogen and phosphorus on growth, yield and economics of lentil (*Lens culinaris* L.)

ABSTRACT

The present investigation was carried out in *Rabi* (winter) season 2022-23 at Agronomy Research Farm of Chandra Bhanu Gupta Post Graduate College, Bakshi ka Talab, Lucknow (U.P). The treatments comprised of four nitrogen levels viz., 0, 15, 30 and 45 kg N ha⁻¹ with four phosphorus levels viz., 0, 20, 40 and 60 kg P₂O₅ were tried in Factorial Randomized Block Design. The soil was silty-loam texture with slightly alkaline pH 8.1, organic carbon 0.70 %, available nitrogen 270.00 kg ha⁻¹, available phosphorus 27.0 kg ha⁻¹, and available potash 262.0 kg ha⁻¹ during 2022- 2023. The rainfall received during the crop period was 0.00 and 0.02 mm, respectively. The relative humidity was recorded maximum during month of December study while, the sunshine ranged from 2.3 to 9.1 during crop period. Increasing levels of nitrogen and phosphorus significantly increased most of the growth and yield attributing characters viz., plant height, number of branches, dry matter accumulation and yield attributes viz., number of pods plant⁻¹, number of grains pod⁻¹, grain weight and test weight were significantly higher with 45 kg N ha⁻¹ and 60 kg P₂O₅ ha⁻¹ and superior to other doses of nitrogen and phosphorus. Yield studies viz., Grain yield, straw yield and biological yield were significantly higher with 45 kg N ha⁻¹ and 60 kg P₂O₅ ha⁻¹ and superior to other doses of nitrogen and phosphorus. The N and P content % and uptake increased with increasing levels of nitrogen and phosphorus. The highest nutrient content and uptake were recorded with 45 kg N ha⁻¹ with 60 kg P₂O₅ ha⁻¹. Economics analysis viz., gross return, net return and benefit cost ratio was recorded highest with 45 kg N ha⁻¹ + 60 kg P₂O₅ while lowest with control. Thus for obtaining better yield and profit apply 45 kg N ha⁻¹ in combination with 60 kg P₂O₅ ha⁻¹ for lentil.

KEYWORDS: Nitrogen, phosphorus, Growth, Yield, Economics lentil.

INTRODUCTION

“Lentil (*Lens culinaris* L.) is a herbaceous annual plant which originated from Middle East and a rich source of protein. The genus *Lens* is part of the subfamily Faboideae which is contained in the flowering plant family Fabaceae or commonly known as legume or bean family, of the order Fabales in the kingdom Plantae. As food crop, the majority of world production comes from Canada and India, producing 58% together. India ranked first in area and second in the production with 39.79% and 22.79% of world area and production respectively. Canada rank first in production (41.16%) due to very high level of productivity (1633 kg ha⁻¹) as compared to India (611 kg ha⁻¹). (FAO state, 2014). “The major lentil producing states are Uttar Pradesh, Madhya Pradesh and Bihar. Uttar Pradesh alone occupies 0.58 million hectares area with 0.44 million tons production and productivity of 701 kg ha⁻¹. Nitrogen is critical element for increasing the quality of food crops. Nitrogen deficiency occurred frequently in every where, therefore, these elements should be comprised as a fertilizer. Application of optimum amount of nitrogen in legumes increased pod number, seed number and seed weight. Studies have shown that nitrogen fertilizer application rate of 20 to 25 kilograms of fertilizer per hectare as a starter is necessary to achieve maximum plant growth. The abundant N supply through N₂ fixation is thought to exacerbate the indeterminate growth habit of lentil. In addition, when a legume crop like lentil has access to N fertilizer, the crop favours fertilizer N uptake instead of nitrogen fixation, due to nitrate or ammonium uptake being a less energy consuming process for the plant. Inhibiting effects of nitrate on legume N₂ fixation have also been described in the literature” (Bremer *et al.*, 1989). “Therefore, the N supply to lentil particularly due to N₂ fixation could play a role in delayed maturity”. (Togay *et al.*, 2005), (Deol, 2007).

“Phosphorus is an important macro element for growth of legumes. It has important role in formation of root nodules and this opinion has an important role in nitrogen fixation. Phosphorus (P) is a non-renewable and second most important macronutrient which is required for young tissues and performs several functions related

to growth, development, and metabolism of the plant and also regulates many metabolic activities of the plant life. Application of 20-80 kg P ha⁻¹ in combination with 40 kg N ha⁻¹ increased the number of filled pod lentil" (Sharma and Singh, 2004). Determining the appropriate amount and mix of fertilizer nitrogen and phosphorus is important because that have a large role in increasing the performance of crops. Other studies showed that percentage of lentil seed protein was increased by applying 40 - 60 kg P ha⁻¹.

METHODS AND MATERIALS

A field experiment was conducted at Shradhay Bhagwati Singh Agriculture Research Farm (Hajipur), Chandra Bhanu Gupta Krishi Satakottar Mahavidyalaya, Bakshi-Ka-Talab, Lucknow University, Lucknow (U.P.) during Rabi season 2022-2023. The experimental site is situated at 26.50° North latitude and 80.50° East longitude with an altitude of 123 meters above mean sea level. The soil of experimental field was silty-loam texture, slightly alkaline in reaction (8.0 p^H), medium in organic carbon (0.70%) and available nitrogen (270 kg ha⁻¹) phosphorus (27 kg ha⁻¹) and potassium (262 kg ha⁻¹). Sixteen treatments comprised of four levels of Nitrogen (0, 15, 30 and 45 N ha⁻¹) and four levels of phosphorus (0, 20, 40 and 60 P₂O₅ ha⁻¹) were tested in Factorial Randomized Block Design. Nitrogen and phosphorus were applied through urea and SSP, respectively. A full dose of nitrogen and phosphorus as per treatment was applied at the time of sowing. A common dose of potassium (20 kg K₂O ha⁻¹) was applied at sowing time to all plots through single super phosphate and muriate of potash, respectively. The Lentil variety (DPL-62) was sown third week of November 2022, using 45 kg ha⁻¹ seed at 25 cm apart rows and harvested in second week of March 2023. All improved packages of practices were followed to raise the crop. The data on plant height and branches were recorded from the area already marked by tagged. Sample for dry matter accumulation was recorded by cutting of plants from ground level. The fresh samples were first sun dried and then kept in electric oven at 65-70°C till the constant dry weight attained. Yield attributes were recorded from 10 pod selected randomly from each plot. Grain and straw yields of lentil were recorded at harvest the harvest index was calculated as grain yield divided by total biological yield and multiplied by hundred. The uptake of nutrients was calculated as nutrient content in grain and straw multiplied by respective yield. Economics of different treatments was worked out on the basis of prevailing market prices. The data so obtained on various parameters were analysed as per standard statistical procedures. The content of N, P, and K in grain and straw was determined using standard laboratory procedures.

RESULTS AND DISCUSSION

Growth attributes

Plant height, number of branches, and dry matter accumulation of lentil were affected significantly due to application of different levels of Nitrogen and phosphorus (Table 1). Increasing levels of nitrogen up to 45 kg N ha⁻¹ increased the number of branches, and dry matter accumulation significantly over rest of the nitrogen levels. The maximum plant height (34.47 cm), number of branches (12.20) and dry matter accumulation (13.16 q ha⁻¹) was recorded significantly with 45 kg N ha⁻¹ over rest of nitrogen levels but being at par with 30 kg N ha⁻¹. Significant improvement in growth parameters with increasing the levels of nitrogen might be due to increased availability of nitrogen and its uptake by plant increased the metabolic activity and formation of meristematic tissues which improved the cell elongation and cell division which in turn improved the number of branches, and dry matter accumulation of crop. These results are supported by the findings of (Khare *et al.*, 2017; Methew *et al.*, 2002). Plant height increased significantly with increase in phosphorus dose up to 40 kg P₂O₅ ha⁻¹. This may be because of the fact that phosphorus encourages the cell division and root development thereby resulting in improved growth and development of the plant. The results are in close conformity with the findings of Verma *et al.*, 1983; Niri *et al.*, 2010; Rabbi *et al.*, 2011.

Application of phosphorus @ 40 kg P₂O₅ ha⁻¹ being at par with 60 kg P₂O₅ ha⁻¹ but recorded significantly taller plant, higher number of branches, and dry matter accumulation as compared to without phosphorus treatment. The highest plant height (33.37 cm), number of branches (10.68) and dry matter accumulation (9.76 q ha⁻¹) was recorded with the application of 60 kg P₂O₅ ha⁻¹. The favourable influence of phosphorus application on growth may be due to its role in various enzymatic reactions, growth processes, hormone production and protein

synthesis and also translocation of photosynthates in various plant parts leading to higher growth of crop. Similar results were obtained by (Gan *et al.*, 2005; Joudi *et al.*, 2008).

Yield attributes

Yield attributing characters like number of pod plant⁻¹, number of grains pod⁻¹, grain weight (g) and test weight (g) were affected significantly due to application of nitrogen and phosphorus (Table 2). Crop fertilized with 45 kg N ha⁻¹ produced significantly the highest number of pod plant⁻¹(57.13), number of grains pod⁻¹ (2.80), grain weight (4.74 g) and test weight (21.80 g) over rest of the nitrogen levels, however the difference between 60 kg N ha⁻¹ and 40 kg N ha⁻¹ was recorded non-significant except in number of pods. Similar findings were reported by (Kumar *et al.*, 1993; Hoque *et al.*, 1994). Increase in number of pod plant⁻¹ with increasing level of nitrogen might be due to increased availability of nitrogen which enhanced the cell division. The higher availability of nitrogen with supply of N-levels enhance the meristematic tissue activity located at initiation of branching point which improved with supply of nitrogen and recorded higher no. of pod plant⁻¹ with increasing levels of nitrogen resulted more branches with increasing levels of N. Similar results were also reported by (Verma and Kalra, 1983)

The increase supply of nitrogen leads to improve pod. The higher values of yield attributes with application of N was mainly due to increase availability of nitrogen to plant which enhanced the photosynthetic activity and its translocation to since resulted in improved yield attributes. These results are in agreement with the findings of (Kumar and Agarwal, 1993), (Methew *et al.*, 2002) However, (Joudi *et al.*, 2008) reported non-significant effect of N fertilizers on grain number plant⁻¹, grain number/pod and filled pod number.

Application of phosphorus had remarkable effects on yield attributes of lentil (Table 2). The maximum values of yield attributes like number of pod plant⁻¹ (58.10), number of grains pod⁻¹ (2.65), grain weight pod⁻¹ (4.11 g) and test weight (21.83g) was obtained with application of phosphorus @ 60 kg P₂O₅ ha⁻¹, however being on par with 40 kg ha⁻¹ phosphorus. Significant response of phosphorus application on yield attributes of lentil was due to its favourable influence on various enzymatic reactions, growth processes, hormone production, protein synthesis and also the translocation of photosynthates to reproductive parts there by leading to higher growth and yield attributes.

Application of Nitrogen up to 45 kg N ha⁻¹ improved significantly the grain and straw yield rest levels of nitrogen (Table 2) However, the difference between 45 kg ha⁻¹ and 30 kg/ha was recorded significant. Crop fertilized with 45 kg N ha⁻¹ produced significantly highest grain yield (8.74q ha⁻¹) and straw yield (12.37 q ha⁻¹) over rest of the Nitrogen levels except 30 kg N ha⁻¹. Application of Nitrogen to crop enhanced the growth and yield attributes of wheat thus resulted higher yield.

Application of phosphorus from 0 to 60 kg P₂O₅ ha⁻¹ increased significantly the grain yield and straw yield. The highest grain yield (8.74 q ha⁻¹) and straw yield (11.60 q ha⁻¹) was recorded with application of 60 kg P₂O₅ ha⁻¹, however the difference between 60 kg P₂O₅ ha⁻¹ and 40 kg P₂O₅ ha⁻¹ was found significant regarding to grain yield and straw yield. The seed yield was also increased significantly up to 40 kg P₂O₅ ha⁻¹ as the seed yield is directly dependent on the yield attributing characters (Table 2). The straw yield also showed the same trend like the seed yield. These results are in conformity with the findings of (Sharma and Singh, 2004), (Mandal and Majumdar, 2001), [Gan *et al.*, 2005], (Sharma and Singh, 1999), (Rabbi *et al.*, 2011).

Table1. Growth attributes of lentil as affected by levels of nitrogen and phosphorus

Treatments	Plant height (cm)	Number of Branches plant ⁻¹	Dry matter accumulation (q ha ⁻¹)
Levels of Nitrogen (Kg ha⁻¹)			
N0-0	28.98	8.34	10.39
N1-15	30.29	9.10	12.05
N2-30	33.54	10.84	12.87
N3-45	34.47	12.20	13.16
SEm±	1.20	0.48	0.10
CD at 5%	NS	1.34	0.30
Levels of phosphorus (Kg ha⁻¹)			
P0-0	30.34	8.10	9.22
P1-20	32.99	9.30	9.32
P2-40	33.02	10.51	9.60
P3-60	33.37	10.68	9.76
SEm±	0.94	0.48	0.10
CD at 5%	2.83	1.34	0.30
Interaction			
SEm±	2.03	0.97	0.21
CD at 5%	-	-	-

Table 2. Yield attributes characters and yield of lentil as affected by levels of nitrogen and Phosphorus

Treatments	No. of pod/plant(g/m)	No. of grain/pod	Grain weight/plant (g)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
Levels of Nitrogen (Kg ha⁻¹)						
N0-0	30.90	1.61	2.50	16.76	5.30	7.55
N1-15	53.71	2.04	3.11	18.79	7.42	10.21
N2-30	56.87	2.76	4.31	21.71	9.28	11.35
N3-45	57.13	2.80	4.74	21.80	9.30	12.37
SEm±	0.08	0.018	0.16	0.037	0.86	1.14
CD at 5%	0.25	0.053	0.48	0.107	2.52	3.31
Levels of phosphorus (Kg ha⁻¹)						
P0-0	34.95	1.41	2.57	16.90	5.70	7.36
P1-20	26.03	2.34	3.56	18.16	7.04	9.03
P2-40	57.93	2.51	3.85	21.79	8.72	11.58
P3-60	58.10	2.65	4.11	21.83	8.74	11.60
SEm±	0.089	0.01	0.09	0.037	0.86	1.14
CD at 5%	0.30	0.30	0.27	0.107	2.52	5.31
Interaction						
SEm±	0.17	0.02	0.24	0.05	1.50	2.23
CD at 5%	-	-	-	-	-	-

Nutrient Content and uptake-

Data revealed that crop fertilized with 45 kg N ha⁻¹ being at par with 30 kg N ha⁻¹ but recorded significantly the maximum uptake (kg ha⁻¹) of N, P, in grain (19.62 kg ha⁻¹, 4.60 kg ha⁻¹,) and in straw (21.23 kg ha⁻¹, 5.65 kg ha⁻¹), respectively over rest of phosphorus levels (Table 3) The uptake of nitrogen and phosphorus by seed and straw increased significantly at higher levels of nitrogen. This could be attributed to better fixation of nitrogen by the rhizobium at higher nitrogen levels. Earlier (Singh *et al.*, 2005), also reported similar findings. They further reported that there was an increase in root growth and development distributed widely up to different depths and thus creating a proper gradient for N absorption at the root soil interface.

Economics

The economics of different treatment combinations was worked out on the basis of input- output analysis. The data pertaining to economics have been presented in Table 4 various components of economics are being described here as under.

The data presented in table 4 regarding the cost of cultivation make it clear that the highest cost of cultivation (Rs. 20254.58), Gross return (Rs. 56256), Net return (Rs. 36001.42) and Benefitcost ratio (1.77) was recorded in treatment combination where 45 kg N ha⁻¹ was applied with 60 kg P₂O₅ ha⁻¹.

The lowest cost of cultivation (Rs. 19435.58), Gross return (26422), Net return (6986.42) and Benefit cost ratio (0.35) was recorded in treatment combination where 0 kg N ha⁻¹ was applied with 0 kg P₂O₅ ha⁻¹.

Table 3 N and P uptake by lentil crop was affected by different levels of nitrogen and phosphorus				
Treatment	N Uptake (kg ha ⁻¹) by grain	N Uptake (kg ha ⁻¹) by straw	P Uptake (kg ha ⁻¹) by grain	P Uptake (kg ha ⁻¹) by Straw
Levels of Nitrogen (Kg ha⁻¹)				
N ₀ -0	18.03	16.42	2.48	4.34
N ₁ -15	18.29	19.03	3.91	4.03
N ₂ -30	18.56	20.20	4.29	4.25
N ₃ -45	19.62	21.23	4.60	5.65
Sem±	0.53	0.51	0.17	0.20
CD at 5 %	1.10	1.05	0.35	0.42
Levels of Phosphorus (Kg ha⁻¹)				
P ₀ -0	18.01	17.31	3.38	3.61
P ₁ -20	18.38	19.08	4.09	4.80
P ₂ -40	18.52	20.12	5.36	5.45
P ₃ -60	19.05	20.31	6.67	5.64
Sem±	0.53	0.51	0.17	0.20
CD at 5 %	1.10	1.05	0.35	0.42
Interaction				
SEm±	1.04	1.01	0.35	0.39
CD at 5%	-	-	-	-

Table 4 Economics was affected by different treatment combination of lentil crop

Treatments	Total cost of cultivation (Rs. ha ⁻¹)	Gross income (Rs. ha ⁻¹)	Net income (Rs. ha ⁻¹)	B.C. Ratio
N ₀ P ₀ (T1)	19435.58	26422	6986.42	0.35
N ₀ P ₁ (T2)	19615.58	28920	9304.42	0.47
N ₀ P ₂ (T3)	19795.58	31880	12084.42	0.61
N ₀ P ₃ (T4)	19975.58	35418	15442.42	0.77
N ₁ P ₀ (T5)	19528.58	41150	21621.42	1.10
N ₁ P ₁ (T6)	19708.58	42372	22663.42	1.14
N ₁ P ₂ (T7)	19888.58	44100	24211.42	1.21
N ₁ P ₃ (T8)	20068.58	45260	25191.42	1.25
N ₂ P ₀ (T9)	19621.58	46408	26786.42	1.36
N ₂ P ₁ (T10)	19801.58	47560	27758.42	1.40
N ₂ P ₂ (T11)	19981.58	48700	28718.42	1.43
N ₂ P ₃ (T12)	20161.58	50376	30214.42	1.49
N ₃ P ₀ (T13)	19714.58	52718	33003.42	1.67
N ₃ P ₁ (T14)	19894.58	53890	33995.42	1.70
N ₃ P ₂ (T15)	20074.58	55098	35023.42	1.74
N ₃ P ₃ (T16)	20254.58	56256	36001.42	1.77

CONCLUSION

It can be concluded from the above results that lentil crop should be fertilized with 45 kg N/ha alongwith 60 kg P₂O₅ ha⁻¹ to obtain higher yield and more net income under central plain zone of U.P.

COMPETING INTERESTS

Authors have declared that no competing interests exists.

Author's contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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