Original research article

Influence of Phosphorus and Iron on growth and yield of Lentil(*Lens culinaris* L.)

ABSTRACT

A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) on the topic "Effect of phosphorus and iron on growth and yield of lentil (*Lens culinaris* L.)", to study treatments consisting of three levels of Phosphorus *viz.* 20 kg, 30 kg and 50 kg/ha and three levels of Iron *viz.* 5, 10 and 20 kg/ha. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.28 %), available N (225 kg/ha), available P (19.50 kg/ha) and available K (92 kg/ha). There were 10 treatments each being replicated thrice and laid out in Randomized Block Design. The results revealed that treatment 9 (Phosphorus at 50 kg/ha + FeSO4 at 20 kg/ha) recorded significantly higher plant height (26.03 cm), plant dry weight (11.61 g), number of pods/plant (113.07), number of seeds/pod (1.93), Test weight (31.20 g), seed yield (1.25 kg/ha), Stover yield (2.07 kg/ha), harvest index (37.67 %), compared to other treatments.

Keywords: *Phosphorus, Iron, Growth, Yield.*

Introduction

India is the world's largest vegetarian population and is the biggest producer of pulses. For the people of India, pulses supply a cheap and nutritious source of protein. One of the a few pulse species is lentil (*Lens culinaris* L.). foods that are high in nutrients of the cold seasons, legumes. Lentils have been consumed by humans since the dawn of civilization. As a winter crop, it is commonly grown in temperate, subtropical, and tropical climates. It may be grown on a wide range of soil types from light loams to black cotton soils light loams to black cotton soils, it may be grown on a wide range of soil types. In the Indo-Gangetic plain (IGP), it is one of the main sources of plant protein. Important nutrients for human nutrition can be found in lentils, include 25% protein, 1.1% fat, and 59% carbohydrates. **(www.dpd.gov.in)**.

Leguminous plant seeds, such as pulses, belong to the Fabaceae family. There are significant part of a vegetarian diet because they serve as a good source of protein and satisfy the majority of physiological requirements. In India, plants make up 88% of all protein consumption. Pulses are also an important source of vitamin B. Pulse seeds that have already germinated include vitamin C. Since they contain 2 to 6% fat, they can deliver the fatty acids that are necessary for survival. They are able to considerably satisfy their own nitrogen needs by employing nitrogen-fixing bacteria found in their nodules to fix atmospheric nitrogen. They are resistant to drought because of their deep roots and the fact that many of them are short-lived crops. These work well for many cropping systems as well. They may greatly satisfy their own nitrogen needs through using nitrogen-fixing bacteria found in their nodules to fix surrounding nitrogen. They are immune to drought because of their deep roots and the fact that many of them are short-lived crops. These are also excellent for intercropping and a wide range of cropping systems. **Malika *et al*., (2015).**

Due to its role in root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation, crop quality, and resistance to plant diseases, phosphorus is a crucial component for the successful production of pulses. It is vital to the stimulation of biological processes such Legume yield is increased via nodulation, nitrogen fixation, and nutrient uptake in the rhizosphere environment. Application of phosphorus reduces the negative effects of drought on physiological parameters and can increase yield in water situations of stress **(Singh *et al*., 2005)**. The majority of soils used for producing lentils have low to medium levels of phosphorus that are readily available, therefore they respond well to the suggested quantity of phosphorus fertilizers. Pulses' increased yield is a result of phosphorus application, which also improves the soil's nitrogen content for subsequent non-legume crops that require less nitrogen. However, high rates of phosphorus application cause P fixation because they chelate with iron and aluminium in acidic soils and calcium in alkaline soils, making them unavailable to plants. So, to get the ideal lentil yield, phosphorus needs to be applied in the proper amount. Therefore, phosphorus must be applied in the proper amount to produce the highest possible yield of lentils.

In several crops, including lentil, iron (Fe) insufficiency is a prevalent nutritional problem **(Erskine *et al*., 1993).** The yield losses of the vulnerable genotypes ranged from 18 to 25%. According to **Sakal *et al*. (1984)**, the Fe^{2+} concentration of the leaf tissue, as compared to the total iron content, was closely correlated with the symptoms of Fe lack and was determined to be a good index to identify soil where response to Fe attitudes can be expected. Leghemoglobin, ferredoxin, and nitrogenase are all made up of iron. During the process of fixing nitrogen, bacteria have used this element. Some legumes have low nitrogen concentrations in their shoots as a result of iron deficiency, which typically reduces nodule formation, leghaemoglobin production, and Nitrogenase activity. The nitrogen fixation processes have been shown to benefit from iron and molybdenum fertilisation, increasing lentil yield and nitrogen status. The ability to actively fix nitrogen depends on the crop's health and an appropriate supply of nutrients, as is well established **(Brar and Sidhu, 1992)**. According to **Lindsay and Norwell (1969)**, the essential level of iron is 4.5 ppm.

Keeping in view the above facts, the present experiment was undertaken to find out "Influence **of phosphorus and iron on growth and yield of lentil (*Lens culinaris* L.)"**

MATERIALS AND METHODS:

The experiment was conducted during *rabi* season of 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.28 %), available N (225 kg/ha), available P (19.50 kg/ha) and available K (92 kg/ha). The treatment consists of Phosphorus @ 20 kg, 30 kg and 50 kg/ha and Iron consists 5 kg, 10 kg and 20 kg/ha. The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T1- Phosphorus at 20 kg/ha + Iron at 5 kg/ha, T2- Phosphorus at 20 kg/ha + Iron at 10 kg/ha, T3 - Phosphorus at 20 kg/ha + Iron at 20 kg/ha, T4 - Phosphorus at 30 kg/ha + Iron at 5 kg/ha, T5 - Phosphorus at 30 kg/ha + Iron at 10 kg/ha, T6 - Phosphorus at 30 kg/ha + Iron at 20 kg/ha, T7 - Phosphorus at 50 kg/ha + Iron at 5 kg/ha, T8 - Phosphorus at 50 kg/ha + Iron at 10 kg/ha, T9- Phosphorus at 50 kg/ha + Iron at 20 kg/ha, T10- Control N:P:K (20:40:20Kg/ha). The growth parameters and yield, production was recorded at harvest from randomly selected plants in each plot. The data was computed and analysed by following statistical method of **Gomez and Gomez (1984)**.

RESULT AND DISSCUSSION

Growth parameters

Plant height (cm)

The data revealed that significant and higher plant height (26.03 cm) was observedin treatment 9 (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha). However, treatment 8 (Phosphorus at 50 kg/ha + $FeSO_4$ at 10 kg/ha) was statistically at par with the treatment 9 (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha).

The higher P fertilization improves the plant height of lentil which might be due to stimulation of biological activities in the presence of balanced supply of phosphorus **(Datta *et al.*, 2013)**. Several studies reported that plant height increases with increment in phosphorus dose, the maximum plant height was obtained at 60 kg/ha compared to 30 kg/ha **(Togay *et al,* 2008).** The increase in the availability of iron to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the plant reported by **(Trivedi *et al.*,2011).**

Plant dry weight (g)

Results revealed that treatment 9 (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha) recorded significantly higher plant dry weight (5.00 g). However, treatment with (Phosphorus at 50 kg/ha + $FeSO_4$ at 10 kg/ha) and (Phosphorus at 30 kg/ha + $FeSO_4$ at 20 kg/ha) were statistically at par with the (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha).

Increase in growth parameters owing to phosphorus application in the soil might be due to increase availability and uptake of soil nutrients by the crop contributed by phosphorus fertilization. The greater uptake of nutrients might have increased the photosynthetic ability and translocation of the metabolites to different parts which ultimately increased the root and shoot development of the crop. These findings corroborate the results of **Zafar *et al.*, (2003), Pandey *et al.*, (2016) and Singh *et al.*, (2016)** in lentil.
The increase in the availability of iron to plant might have stimulated the metabolic and enzymatic activities thereby increasing the growth of the crop. Similar findings were also reported by **Kuldeep *et al.*, (2018).**

Crop Growth Rate (g/m^2/day)

The data recorded that during 60-80 DAS no significant difference among all the treatments. However highest Crop Growth Rate (12.00g/m^2 /day) However, treatments with (Phosphorus at 50 kg/ha + $FeSO_4$ at 10 kg/ha), (Phosphorus at 50 kg/ha + $FeSO_4$ at 5 kg/ha), (Phosphorus at 30 kg/ha + $FeSO_4$ at 10 kg/ha) and (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha) were statistically at par with the treatment control.

Rasheed *et al.*, (2010) reported that each increasing level of P (20, 40, 60 and 80 kg/ha) significantly accelerate the CGR. The stimulation in CGR may be due to superior nodulation and its weight per plant, these result in better acquisition of P and other nutrients there by increasing the crop growth.

Relative Growth Rate (g/g/day)

At 60-80 DAS, treatment with control recorded highest Relative Growth Rate (0.052g/g/day) and there was significant difference among the treatments.

YIELD PARAMETERS

Number of pods/plant

Treatment 9 with (Phosphorus at 50 kg/ha + $FeSO_4$ at 20kg/ha) recorded significantly highest Number of pods per plant (113.07). However, treatments with (Phosphorus at 50 kg/ha + $FeSO_4$ at 10kg/ha) and (Phosphorus at 50 kg/ha + $FeSO_4$ at 20kg/ha) were statistically at par with the (Phosphorus at 50 kg/ha + $FeSO_4$ at 20kg/ha).

It might be the reason of moderate plant nutrients availability due to which the plant produce more pods plant^{-1} as compare to other treatments and also phosphorus strongly increases the reproduction of the plants i.e. flowering and fruiting **(Ali *et al.*, 2017)**. These results were similar with that of **Saleh, 1976 and Jayapaul *et al.*, 1990.**

Number of seeds/pod

Treatment 9 with (Phosphorus at 50 kg/ha + $FeSO_4$ at 20kg/ha) recorded significantly highest Number of seeds per pods (1.93). However, treatments with (Phosphorus at 50 kg/ha + $FeSO_4$ at 10kg/ha), (Phosphorus at 50 kg/ha + $FeSO_4$ at 5 kg/ha), (Phosphorus at 30 kg/ha + $FeSO_4$ at 20 kg/ha), (Phosphorus at 30 kg/ha + $FeSO_4$ at 5 kg/ha), (Phosphorus at 30 kg/ha + FeSO4 at 10 kg/ha). (Phosphorus at 30 kg/ha + $FeSO_4$ at 20 kg/ha), and (Phosphorus at 20 kg/ha + $FeSO_4$ at 20 kg/ha) were statistically at par with the (Phosphorus at 50 kg/ha + $FeSO_4$ at 20kg/ha).

The increase in number of seeds/pod by the application of molybdenum along with iron may be due to the fact that molybdenum and iron may fixed that much amount of nitrogen which was required by the plant to show better performance as molybdenum is related directly to nitrogen fixation by legumes. Result also showed that the molybdenum and iron nutrition had similar effect on lentil. Similar observations were found by **Landge *et al.* (2002) and Tahir *et al.* (2011)** in case of chick pea.

Test weight (g):

Highest test weight (31.20) was recorded in Treatment 9 with application of (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha), though there was significant difference among the treatments.

The possible reason for thousand grain weight could be the effect of cell division, phosphorus contents present inside the seed as well as the formation of albumin and fats **(Ali *et al.*, 2017).**

Seed Yield (kg/ha):

Treatment 9 with (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha) recorded the highest seed yield (1253.33 kg/ha). However, treatment with Phosphorus at 50 kg/ha + $FeSO_4$ at 10kg/ha was statistically at par with the (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha).

The reason for increasing grain yield is the balance nutrient supply and timely application of the nutrients which enhances the plant growth and the grain yield will be increased. Similar results support that increasing phosphorus level, the grain yield increased too **(Chaubey *et al.*, 1999 and Singh *et al.*, 1999).** The increase in seed yield by application of 60 kg P_2O_5 /fed might be associated with high number of pods /plant, 1000 seed weight and seed yield /plant **(Zeidan, 2007).** Similar results were reported by **Chaubey *et al.*, 1999 and Singh *et al.*, 1999** and they found that phosphorus fertilization at 50kg/P_2O_5/ha increased seed yield as compared with control. It is widely known that Fe helps improve the chlorophyll content necessary for photosynthetic activities. Moreover, Fe and Mo are integral components of nitrogenase enzyme which are essential for symbiotic N2 fixation **(Nasar *et al.*, 2017).** These findings are supported by **Sharief and Said (1998)** found that foliar application of micronutrients either separately or in combination significantly improved the grain yield of lentil.

Stover yield (kg/ha)

Treatment 9 with (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha) recorded the highest stover yield (2073.33 kg/ha). However, treatments with Phosphorus at 50 kg/ha + $FeSO_4$ at 10kg/ha and Phosphorus at 50 kg/ha + $FeSO_4$ at 5kg/ha were statistically at par with the (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha).

The higher stover yield with suitable dose of phosphorus might be contributed by better growth of the plant as expressed in terms of plant height, number of branches per plant, fresh and dry weight of the plant as a result of improved nutrient uptake. These findings were supported by **Choubey *et al.*, (2013), Zeidan (2007) and Rasool and Singh (2016)** in lentil. This might be due to increased availability of physiologically active iron (Fe^{2+}) in the plant system which in turns affects various physiological functions of plants favourably. Translocation of the same to reproductive structures. Since uptake is the function of seed and straw yield and their nutrient concentration, there was significant improvement in concentration of these nutrients coupled with seed and straw yield **(Meena *et al.*, 2013).**

Harvest Index (%)

Treatment 9 with (Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha) recorded the highest harvest index (37.67 %).

Each increment of P from (25 to 75 kg ha^{-1}) gave superior HI value of lentil **(Fatima *et al.*, 2013),** however, the low HI at low level of P might be due to poor development of plant.

Table 1: Influence of Phosphorus and Iron on Growth attributes on Lentil.

Sl No.	Treatments	Plant height (cm)	Plant dry weight (g/plant)	CGR (g/m^2 /day)	RGR (g/g/day)
1	Phosphorus at 20 kg/ha + $FeSO_4$ at 5 kg/ha	22.83	4.40	11.28	0.047
2	Phosphorus at 20 kg/ha + $FeSO_4$ at 10 kg/ha	23.03	4.47	11.28	0.046
3	Phosphorus at 20 kg/ha + $FeSO_4$ at 20 kg/ha	23.23	4.53	11.17	0.045
4	Phosphorus at 30 kg/ha + $FeSO_4$ at 5 kg/ha	24.20	4.67	11.00	0.044
5	Phosphorus at 30 kg/ha + $FeSO_4$ at 10 kg/ha	24.53	4.83	10.78	0.042
6	Phosphorus at 30 kg/ha + $FeSO_4$ at 20 kg/ha	24.77	4.93	10.67	0.042
7	Phosphorus at 50 kg/ha + $FeSO_4$ at 5 kg/ha	24.97	4.80	10.78	0.043
8	Phosphorus at 50 kg/ha + $FeSO_4$ at 10 kg/ha	25.30	4.97	10.72	0.042
9	Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha	26.03	5.00	10.72	0.041
10	Control (RDF 20-40-20 NPK/ha)	22.07	3.90	12.00	0.052
	F-Test	S	S	S	S
	SEm(±)	0.25	0.06	0.11	0.001
	CD (p=0.05)	0.76	0.17	0.33	0.002

Table 2: Influences of Phosphorus and Iron on Yield attributes and Yield of Lentil.

Sl No.	Treatments	No. of pods/plant	No. of Seeds/Pod	Test weight(g)	Seed yield (kg/ha)	Stover Yield (kg/ha)	Harvest Index (%)
1	Phosphorus at 20 kg/ha + $FeSO_4$ at 5 kg/ha	94.80	1.13	27.67	900.00	1533.33	37.02
2	Phosphorus at 20 kg/ha + $FeSO_4$ at 10 kg/ha	97.47	1.33	27.73	910.00	1596.67	36.34
3	Phosphorus at 20 kg/ha + $FeSO_4$ at 20 kg/ha	97.80	1.47	27.73	936.67	1706.67	35.46
4	Phosphorus at 30 kg/ha + $FeSO_4$ at 5 kg/ha	98.67	1.53	27.80	996.67	1793.33	35.73
5	Phosphorus at 30 kg/ha + $FeSO_4$ at 10 kg/ha	99.67	1.53	29.40	1033.33	1853.33	35.79
6	Phosphorus at 30 kg/ha + $FeSO_4$ at 20 kg/ha	104.47	1.53	29.73	1036.67	1856.67	35.81
7	Phosphorus at 50 kg/ha + $FeSO_4$ at 5 kg/ha	109.33	1.53	30.40	1110.00	1930.00	36.50
8	Phosphorus at 50 kg/ha + $FeSO_4$ at 10 kg/ha	110.00	1.80	30.47	1153.33	1973.33	36.87
9	Phosphorus at 50 kg/ha + $FeSO_4$ at 20 kg/ha	113.07	1.93	31.20	1253.33	2073.33	37.67
10	Control (RDF 20-40-20 NPK/ha)	91.47	1.07	27.60	880.00	1470.00	37.47
	F-Test	S	S	NS	S	S	NS
	SEm(±)	1.74	0.16	1.10	42.26	62.86	1.42
	CD (p=0.05)	5.17	0.46	-	125.55	186.76	-

CONCLUSION

It was concluded that application of 50 kg/ha Phosphorus with 20 kg/ha Iron (treatment 9) recorded higher seed yield and maximum net returns and benefitcost ratio in lentil crop.

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