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A Meta Analysis of the Effects of Different Levels of Phosphorus Supply on the Growth of Linseed Crop (*Linum usitatissimum* L.)

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Authors' contributions

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

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ABSTRACT

During Rabi season of 2022-23, a field experiment was carried out at SAGE Agricultural farm under the aegis of School of Agriculture, SAGE University, Bhopal (M.P). The study aimed to investigate the "A Meta Analysis of the Effects of Different Levels of Phosphorus Supply on the Growth of Linseed crop (*Linum usitatissimum* L.)." under irrigated conditions." The experimental design employed for the study was Randomized Block Design (RBD) with Factorial arrangement and three replications covering an area of 215 square meters. In this experiment, fifteen distinct treatments combinations including five varying levels of phosphorus application as P1- 0 kg/ha, P2- 30 kg/ha,

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P3- 40 kg/ha, P4- 50 kg/ha and P5- 100 kg/ha were used in the study. It was found that highest plant height (75.8 cm), highest number of branches per plant (4.41), highest maximum dry weight (10.84 g), highest number of capsules (42.9), test weight (8.02 g), highest seed yield (1.01q/ha), and stover yield (2.84 q/ha) at maximum crop growth stage was observed and jotted down in plots treated with application of phosphorus @ 100 kg/ha in combination. It can be analyzed and concluded from the results obtained that in linseed, application of P@ 100 kg/ha observed maximum values in all the three attributes namely growth, yield and economics.

Keywords: Linseed; phosphorus; quality; stover yield; yield.

1. INTRODUCTION

"India is one of the major oilseeds growing country and importer of edible oils in the world. India holds 4th position in vegetable oil economy. Oilseeds account for 13% of the Gross Cropped Area, 3% Gross National Product and 10 % of the value of all agricultural commodities" (https://nmoop.gov.in/Guidelines/NMOOP20114.pdf). "Around 72% of the total oilseeds area comes under rainfed condition and mostly cultivated by small and marginal farmers of India. India has been cultivating almost all the oilseed crops. Soybean, Groundnut, Rapeseed-Mustard, Sesame, Sunflower, Castor, Safflower, Linseed and Niger are the major ones. Out of all the nine oilseed crops in India, the highest average contribution to total production of oilseeds is of soybean (38%) followed by Rapeseed-Mustard (27%) and groundnut (27%) (Average of 2016-17 to 2020-21). Likewise the highest average area contribution to total oilseeds area is of Soybean (44%) followed by Rapeseed-Mustard (24%) and Groundnut (20%). It has been estimated that total Kharif oilseed crops contribution to total production is about 67% and the remaining 33% is of contributed by Rabi oilseed crops. Lack of appropriate and need based technologies, low resource base, biotic and abiotic stresses are some of the reasons for poor productivity of Oilseeds. The launch of Technology Mission on Oilseeds (TMO) was a major breakthrough in increasing Oilseeds production in the country. In this mission, an integrated approach was used for introducing recent advanced production technologies, timely supply of inputs and advisory services, market support, post-harvest interventions and systematic cooperation between all the stakeholders [1-3]. The main purpose of Oilseed crops are grown for extraction of oil, which is found in their seeds. Oil content in different oilseeds vary from 20% in Soybean to 40% as in Sunflowers. Oils have enormous uses both in industrial and food sector. Analyzing and studying production potential and sustainability of oilseeds and looking forward to its future application and commercialization for the production of biodiesel and bio-energy is the major concern of the researchers and need of the hour too". (Solo *et al.,* 2021).

Linseed enjoys an important place among all the oilseeds due to its multifarious uses in domestic, medicinal, edible and industrial purposes (Meena *et al.*, 2011). Linseed (*Linum usitassimum L.*) is commonly known as flax and belong to family Linaceae. It is a self-pollinated crop considerably shaped to temperate climate. In India, linseed cultivation can be traced from pre-historic times. Each and every part of linseed is utilized for commercial and medicinal values [4-6].

"India ranked fifth in the world after Canada in terms of area and third with respect to Linseed production. The average yield of 544 kg/ha in India was found to be very low compared to the world average yield of 927 kg/ha and the highest average yield recorded is 1497 kg/ha in Canada" (FAOSTAT, 2018). "The major factors found responsible for low yield of oilseed crops are poor fertility of the soil, practice of traditional crop management practices and inadequate and untimely supply of fertilizers. Among these, the imbalance of nutrients in the soil appears to be the most crucial one foe its growth and production. Research studies have stated that the crop yield can be increased by choosing appropriate high yielding varieties of linseed along with considerable and timely supply of nutrients through fertilizers" [7].

"Phosphorus (P) is responsible for increasing root density proliferation that helps in extensive exploration, supply of nutrients and water to growing plant parts, ultimately to increase growth and yield" [8]. "Phosphorus is necessary for maintenance and transmission of energy, transfer of inheritable characteristics and salutary for vigorous growth, root development, better yield, quality and bump conformation in oil painting seed crops. Phosphorus is an important factory nutrient which helps in growth and development and eventually for better crop yield. It involves in numerous biochemical functions in physiological system of a factory. It is essential part of skeleton of plasma membrane, nucleic acid, many co – enzymes and phospo related compound. Additionally it stimulates fruit setting and seed formation" [9].

"Since last few decades, growth, development and productivity of oilseed crops have been hampered due to various factors including the unbalanced plant mineral nutrients in soil. In fact, extra exerted pressure on limited land resources and use of high yielding varieties to feed rapidly increasing production have led to the present scenario of shortage of important plant mineral nutrients in major soils around the globe. The deficiency of soil P & S in agricultural soils has been reported frequently over the past years" [10]. Taking this whole situation into account a study entitled "A Meta Analysis of the Effects of Different Levels of Phosphorus Supply on the Growth of Linseed crop (*Linum usitatissimum* L.)" was conducted.

2. MATERIALS AND METHODS

A field experiment was conducted on the SAGE Agricultural Farm, SAGE University, Bhopal in Rabi season 2022-23. The experiment was laid out in Factorial Randomized Block Design (FRBD) replicated four times with net plot size 3.60 x 2.40 m^{2}..The soil of the experimental plot was well drained and sandy loam in texture with pH 6.3, available N 293.08 kg ha-1, P_2O_5 22.4 kg ha-1, K_2O 210.3 kg ha-1 and S 8.50 mg kg-1. Different rates of phosphorus were applied to the plots as per treatments. The treatment comprised of 5 levels of P (0, 30, 40, 50 and 100 kg ha-1). The sowing was done on November 22, 2023 with healthy viable seed @35 kg ha-1 was used for sowing in furrows with spacing of 30cm x 10cm. The data were recorded at 30, 60, and 90 and at harvest. Crop was raised with recommended package of practices and was harvested at maturity on April 20, 2023. The seed and stover yield were recorded treatment wise and were separated, air dried; all parameters were analyzed by following standard statistical procedures. Half dose of phosphorus was applied as basal dose and remaining half dose of phosphorus was applied in two equal splits during first and second irrigation. All other agronomic practices were applied uniformly to all the treatments.

3. RESULTS AND DISCUSSION

3.1 Effect of Phosphorus on Growth attributes

Data presented in Table 1 revealed the effect of different phosphorus levels on growth stages of Linseed (*Linum usitatissimum* L.). Three growth attributes were considered for observations in the experiment i.e. plant height (in cms) number of branches per plant and dry weight. The growth parameters of Linseed were significantly influenced with increasing the levels of Phosphorus. The highest (75.8 cm) plant height was recorded in T4 (100 kg/ha Phosphorus in the form of P_2O_5) which was significantly superior over all the treatment combinations. Number of branches per plant and dry weight per plant were significantly influenced by the increased levels of phosphorus. Maximum (4.41) branches per plant and highest (10.84 g/plant) dry weight were observed in T5 (100 kg/ha Phosphorus). On the other hand, the lowest plant height was observed in the P0 treatment under without phosphorus was applied @ 0kg/ha. This might be due to higher availability of P and their uptake, progressively enhanced the vegetative growth of the plant. The increased number of leaves that produce more nutrients for the plant's growth may account for the rapid increase in the height seen in the early stages of development. Infact, larger leaves were responsible for making more photosynthates, which made it easier for cells to divide and made the plants grow quickly. The increase in plant height and number of branches per plant was also reported by Bharat et al. [11]; Kumar et al. [12]; Vyas et al. [13].

3.2 Effects of Phosphorus on Yield Attributes

Data presented in Table 2 indicated the effect of phosphorus levels on yield of Linseed (*Linum usitatissimum* L.). "The yield characters that were considered in this experiment are seeds/capsule (No.), capsules/plant (No.), test weight (g), seed yield (t/ha) and stover yield (t/ha). The yield attributes of linseed were significantly influenced with increasing the levels of phosphorus. Significantly Maximum number of (9.33) seeds/capsule was obtained with the application of T5 (100 kg/ha Phosphorus). The highest (42.90) number of capsules/plant was recorded in T5 (100 kg/ha Phosphorus) which was significantly superior over all other treatments. Significantly maximum (8.02 g) test weight of seed was found with application of highest treatment combination i.e. of T5 (100 kg/ha Phosphorus) Highest (1.01 t/ha) seed yield was recorded in T5 (100 kg/ha Phosphorus). In the context of stover yield, the q highest (2.84 t/ha) significant value was found in T5 (100 kg/ha Phosphorus). Application of each increasing level of phosphorus significantly increased the number of seeds/ capsules, capsules/plant and test weight. Application of nitrogen & phosphorus might exert flower initiation and seeds/capsules by increasing the rate of photosynthesis and transport of source to sink sites. With Phosphorus application, tissue differentiation increases which results into greater flower production and it later develops into capsules" [14]. This finding has been found similar to the results of Kalita et al. [15]; Singh et al. [16]. The higher yield of linseed can be expected due to higher values of growth parameters like plant height, number of branches plant-1 which was also stated by Kashyap et al. [17] in his study. The seed yield is increased due to overall improvement in plant vigour and production of sufficient photosynthates owing to higher availability of P resulting in better yield attributes viz. capsules/plant, seeds/capsule, 1000- seed weight. Thereafter, increase in suitable fertilizer dose significantly improves stover yield, this might be due to higher supply of nutrients to the linseed crop upon use of fertilizer dose thereby resulting in better growth and development of the crop. The similar findings were also witnessed by Gupta et al. [18]; Tanwar et al. [19].

3.3 Effects of Phosphorus on Economical Attributes

Data presented in Table 3 indicates that the economics performance of different treatment combination evaluation based on cost of cultivation (INR/ha), gross return (INR/ha), net return (INR/ha) and benefit cost ratio (B: C). Cost of cultivation (51370 INR/ha), gross return (116601.45 INR/ha), net return (65231.45INR/ha) and benefit cost ratio (1.33) were found highest in the application of T5 (100 kg/ha Phosphorus). With Increased levels of phosphorus, the net returns and benefit cost ratio increased significantly too. The gross monetary return and net monetary returns were influenced variably due to different levels of fertilization. Similar findings were reported by Gaikwad et al. [20]; Patel et al., (2012); Kumar and Deka [21].

Table 1. Effect of phosphorus on growth parameters of linseed (90 DAS)

Treatments	Plant height (cm)	No. of branches /plant	Dry weight (g/plant)
T1 - 0 Kg P_2O_5	72	3.17	7.39
T2 - 30 Kg P_2O_5	74.2	3.48	7.90
T3 - 40 Kg P_2O_5	74.8	3.69	8.24
T 4- 50 Kg P_2O_5	75	4.22	10.51
T 5- 100 Kg P_2O_5	75.8	4.41	10.84
SEm±	0.228	0.137	0.03
CD (p=0.05)	0.643	5.945	0.09

Table 2. Effect of phosphorus on yield parameters of linseed

Treatments	Seeds/ Capsule	Capsules/ plant	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)
T1 - 0 Kg P_2O_5	7.20	35.48	7.0	0.82	1.89
T2 - 30 Kg P_2O_5	7.63	37.14	6.9	0.84	2.07
T3 - 40 Kg P_2O_5	7.86	38.62	7.10	0.91	2.25
T 4- 50 Kg P_2O_5	8.96	41.92	7.15	0.93	2.62
T 5- 100 Kg P_2O_5	9.33	42.90	8.02	1.01	2.84
SEm±	0.18	0.53	0.37	0.03	0.17
CD (p=0.05)	0.65	1.51	1.13	0.15	0.44

Table 3. Effect of phosphorus with respect to economical parameters of linseed (90 DAS)

Treatments	Cost of cultivation (INR /ha)	Gross returns (INR /ha)	Net returns (INR /ha)	B: C ratio
T1 - 0 Kg P_2O_5	48185	72625.00	42440	0.84
T2 - 30 Kg P_2O_5	49822	77175.56	37353	0.92
T3 - 40 Kg P_2O_5	50070	115244.15	61455.90	1.27
T 4- 50 Kg P_2O_5	50473	100800.23	60327	1.20
T 5- 100 Kg P_2O_5	51370	116601.45	65231.45	1.33

4. CONCLUSION

On the basis of the seasonal experiment in Linseed it might be concluded that the application of 100 kg of Phosphorus/ha has showcased superiority in growth and yield attributing characters such as seed yield (1.20 t/ha) and stover yield (2.84 t/ha) and as well as it is economically more profitable, hence it is more desirable and preferable to farmers for uplifting their socio-economic condition and fetching remunerative fair price to the farming community.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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