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Effect of different levels of phosphorus and potassium on yield, yield attributes and oil content of Sesame (*Sesamum Indicum* L.)

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Abstract

A field experiment was carried out during *Zaid* season of 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.). The soil of experimental site was sandy loam in texture, nearly neutral in soil reaction (pH 7.2), EC (0.34 dS/m), low in available N (203.7 kg/ha), medium in available P (17.2 kg/ha) and medium in available K (208.8 kg/ha). The experiment was laid out in Randomized block design and having nine treatment consisted of three levels of Phosphorus (P) *viz.,* (40, 30 and 20 kg/ha) and three levels of Potassium (K) *viz.,* (30, 20 and 10 kg/ha) which replicated thrice and effect was observed on Gujarat Til-4 sesame variety. The result showed significantly higher yield and yield attributes *viz.,* Number of Capsules per plant (49.80), Seeds per capsule (56.4), Test weight (3.90 g), Seed yield (361 kg/ha), Biological yield (2002.15 kg/ha) and quality analysis i.e. Oil content (50.53%) were recorded maximum in application of 40 kg P/ha plus 20 kg K/ha.

Key words: ***Oil content, Sesame, Phosphorus, Potassium, Yield***

Introduction

Sesame (*Sesamum indicum* L.) is the oldest oil seed crop and used by human beings. Sesame is variously referred to as Til, Sesamum, Beniseed, Rasi, Sim sim, Gergelim etc. Sesame is the member of family Pedaliaceae with chromosome number 2n=26. Sesame crop was known as "Queen of oil seed" due to the presence of stable unsaturated fatty acid (Palmitic acid (16%), linoleic acid (18.2%), oleic acid (18.1%) and Stearic acid (18%)) which causes resistance to rancidity (Uzun *et al*. 2008). Because of good quality characters, sesame is also used as substitute ghee for poor man's food (Pagal *et al*. 2017). Sesame seed is cultivated for seed purpose, which contains oil (38-54%) and protein (18-20%) consisting of both methionine and tryptophan, Vitamin- B_5 (niacin) and minerals (P & Ca) (Malik *et al.* 2003). Sesame seed also contains sesamine and sesamolin, sesamolin on hydrolysis yields sesmol, which has marked antioxidant activity, so it has a higher lifespan and is caused "Seed of immortality". White seeded sesame is extensively used in Bakery products, whereas black seeded sesame used for medicinal purposes (Jadav, 2004). Nearly 78% of sesame is used for oil extraction in India (Kalegore *et al.* 2018). Sesame nutrition remained very agonistic for a long time (Okpara *et al*. 2007). The dynamics of the nutrients in terms of their translocation, distribution and uptake in sesame plant is a crucial phase that will help in taking deciding ameliorating in its production management (Shehu *et al.* 2010). It will assist in the adjustment of proper package and practice for sesame crop and reduce the cost of fertilizer. Phosphorus is the major plant nutrients for enhance the crop yield. Phosphorus plays an important role in develpoment of energy-rich phosphate bond like nuclear protein, ADP and ATP and phospholipid and it is compulsory constitute of nucleic acids (DNA and RNA), nucleoprotein, amino acids, phytin, phosphatides and several co-enzymes *viz*., thiamine, pyrophosphate and pyridoxyl phosphate (Jahan *et al*. 2019). Phosphorus is associated with enhanced root density proliferation, which aids in the supply of nutrients, extensive exploration and water to growing plant parts, thus rise growth and yield, as well as enhance the yield of succeeding crop and come up with resistance against diseases (Shehu *et al.* 2010). Phosphorus also associates with energy transfer metabolic processes and basic reaction of transformation of sugars, photosynthesis, starch and

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nutrient movements in the plant. It also promotes extensive root system thereby enabling plant to take out moisture and mineral nutrition optimally (Adisu *et al.* 2020). Potassium enhances the yield and quality of agricultural produce and products and enhances the capability of plants to resists diseases, insect attacks, cold and drought stresses (Ahmad *et al*. 2018). Potassium shows a very important character in the activation of enzymes (Younis *et al*. 2020). Potassium helps in the development of a strong and healthy root system. Potassium shows an essential role in many metabolic actions in plants. Potash is involved in the transport of the products of photosynthesis to the pods and transformation into oil (Jat *et al.* 2017). A good supply of potassium leads to an increase in photosynthesis, which is actively concerned with the process of sugar formation and translocation of starch as well as photosynthesis. In view of these investigations, the experiment was under taken to find out suitable phosphorus and potassium levels on the application for maximizing the yield, quantity and quality of sesame under eastern Uttar Pradesh conditions.

Materials and Methods

The experiment entitled "Effect of different levels of Phosphorus and Potassium on Yield, Yield attributes and Oil content of Sesame (*Sesamum indicum* L.)", was held at Crop Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. The experiment was carried out during *Zaid* season of 2020 under irrigated condition at Crop Research farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (Allahabad) which is located at 25º 24’ 42” N latitude, 81º 50’ 56” E Longitude (Fig.1) and 98 m altitude above the mean sea level. It has a tropical climate with temperature ranges between 43ºC- 47ºC. The Experiment was carried out in Randomized Block Design having nine treatment consisted of Phosphors levels *viz.,* (40, 30 and 20 kg/ha) and Potassium levels *viz.,* (30, 20 and 10 kg/ha) which replicated thrice on Gujarat Til-4 sesame variety. On the basis of treatment details, treatment combination are T_1- Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 30 kg/ha, T_2- Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha, T_3- Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 10 kg/ha, T_4- Phosphorus (P) @ 30 kg/ha + Potassium (K) @ 30 kg/ha, T_5- Phosphorus (P) @ 30 kg/ha + Potassium (K) @ 20 kg/ha, T_6- Phosphorus (P) @ 30 kg/ha + Potassium (K) @ 10 kg/ha, T_7- Phosphorus (P) @ 20 kg/ha + Potassium (K) @ 30 kg/ha, T_8- Phosphorus (P) @ 20 kg/ha + Potassium (K) @ 20 kg/ha, T_9- Phosphorus (P) @ 20 kg/ha + Potassium (K) @ 10 kg/ha. Sowing was done by line sowing method with row spacing 30 cm and plant spacing 10 cm. The commended cultural practices were under taken as per recommendation. Hand weeding was done at 15 and 30 Days after sowing (DAS). Data on yield attributes *viz.,* Number of Capsules per plant, Number of Seeds per capsule, Test weight (g), Seed yield (kg/ha), Biological yield (kg/ha) and Quality analysis *viz.,* Oil content (%) were analyzed by analysis of variance (ANOVA) (Gomez and Gomez 1984). The data collected from the experiment at various growth stages and at the time of harvest was subjected to statistical analysis using Dry soft ICRISAT software. The level of significance used in F-test was P=0.05. Critical difference values were calculated wherever F-test was found significant.

Figure 1: Geotagged photos of the experimental field at Crop Research Farm, SHUATS, Prayagraj (Allahabad)

Results and Discussion

Plant height

Data on plant height by different treatment combinations are presented in Table 1. The plant height was increased with the improvement in crop stage, without consideration of the treatment and reached a maximum height at the time of harvest. The plant height of sesame was recorded at 15, 30, 45, 60 DAS and at the time of harvest differed significantly with different treatment combinations. Data on 30, 45, 60 DAS and at time of harvest shown significantly influenced among all treatments, increase with maximum plant height (29.61 cm, 78.53 cm, 116.09 cm and 116.91 cm) were recorded in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha as compared to other treatment combinations respectively. T_1 and T_3 were statistically at par with T_2 at 30 DAS, 60 DAS and at harvest, and only T_1 was statistically at par with T_2 at 45 DAS. The data on plant height at 15 DAS shown there is no significant dissimilarity among the treatments. The progressive increase in levels of phosphorus i.e. Phosphorus (P) @ 40 kg/ha significantly enhanced the growth attributing characters of sesame *viz.,* plant height was similar with the results by Jahan *et al.* (2019) in Sesame. Phosphorus work as catalysis in the conversion of many key biochemical reactions energy storage and transformation processes in plants. These results are in similarity with the findings of Rahman *et al*. (2008) and Chakraborty (2013). The increase in plant height could partly be attributed due to the beneficial effect of potassium fertilizer. This is in agreement with the findings of Jadav (2004) and Bhosale (2009) in sesame.

Number of branches per plant

The data on number of branches per plant at 45, 60 and 75 DAS influenced by different treatment in sesame are presented in Table 2. The number of branches of sesame was recorded at 45, 60 and at harvest differed significantly with different treatment combinations. Data on 45 DAS, 60 DAS and at the time of harvest shown significantly increase with higher number of branches per plant (2.73, 3.73 and 3.73) respectively were recorded in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha as compared to other treatment combinations. T_1 was statistically on par with T_2 at 45 DAS and at harvest and both T_1 and T_3 were statistically at par with T_2 at 60 DAS. The progressive increase in levels of phosphorus i.e. Phosphorus (P) @ 40 kg/ha significantly enhanced the growth attributing characters of sesame i.e. number of primary and secondary branches per plant was reported by Jahan *et al.* (2019) and Shelke *et al.* (2014) in Sesame. The effect of potassium on growth parameters may be due to augment of cell expansion and cell division. These results are found similar to the results of Thakur *et al.,* (2015) in sesame.

Leaf area (cm^2)

Phosphorus and Potassium levels had significantly influenced mean leaf area/plant at all stages of crop growth except at the time of harvest. The effect of different treatment on leaf area at 15, 30, 45, 60 and at harvest are presented in Table 3. Data on 30, 45, 60 DAS and at harvest, the maximum leaf area (227.80 cm^2, 2074.57 cm^2, 2270.49 cm^2 and 2568.70 cm^2) were recorded by application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha which was significantly superior overall treatment combinations respectively. T_1, T_3 and T_5 were statistically on par with T_2 at 45, 60 DAS and at harvest, and T_1 and T_3 were statistically on par with T_2 at 30 DAS. The data on leaf area at 15 DAS shown there is no significant difference among the treatments. Optimum moisture in root zone which favours uptake of phosphorus; resulting in better growth of the crop was parallelism with De *et al.* (2013) and Unde *et al.* (2017). The increase in levels of potassium also significantly increased the leaf area of sesame due to uptake and beneficial crop activity, similar results was also conformity by Sarkar and Pal (2005) in sesame.

Leaf area index

Effect of different treatment on leaf area index at 15, 30, 45, 60 DAS and at harvest time are presented in Table 4. and the data pertaining to the leaf area index were obtained lowest at 15 DAS and then it increases with development of crop growth stages. Data on 30, 45, 60 DAS and at harvest time, the maximum leaf area index (0.76, 6.58, 7.57 and 8.56) were recorded by application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha which was significantly superior overall treatment combinations respectively. The data on leaf area index at 15 DAS shown there is no significant dissimilarity among the treatments. The progressive increase in levels of phosphorus i.e.

Table 1: Influence of Phosphorus and Potassium levels on Plant height of Sesame

Treatments	Plant height (cm)				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
1. 40 kg P/ha + 30 kg K/ha	13.43	27.27	70.73	110.55	112.07
2. 40 kg P/ha + 20 kg K/ha	13.59	29.61	78.53	116.09	116.91
3. 40 kg P/ha + 10 kg K/ha	13.12	26.61	66.59	108.08	109.39
4. 30 kg P/ha + 30 kg K/ha	11.81	24.43	60.58	103.57	105.83
5. 30 kg P/ha + 20 kg K/ha	12.34	25.76	61.05	107.48	108.33
6. 30 kg P/ha + 10 kg K/ha	11.39	23.12	60.26	103.20	104.36
7. 20 kg P/ha + 30 kg K/ha	11.71	23.93	61.47	94.84	95.55
8. 20 kg P/ha + 20 kg K/ha	12.07	25.63	64.72	101.38	104.43
9. 20 kg P/ha + 10 kg K/ha	11.51	22.62	59.15	93.30	94.09
SEm±	0.69	1.22	3.39	2.73	2.68
CD (P=0.05)	-	3.65	10.17	8.18	8.02

Table 2: Influence of Phosphorus and Potassium levels on Number of Branches/plant of Sesame

Treatments	No. of Branches per Plant		
	45 DAS	60 DAS	75 DAS
1. 40 kg P/ha+ 30 kg K/ha	2.20	2.67	3.13
2. 40 kg P/ha + 20 kg K/ha	2.73	3.73	3.73
3. 40 kg P/ha + 10 kg K/ha	1.80	2.60	2.73
4. 30 kg P/ha + 30 kg K/ha	1.60	2.27	2.60
5. 30 kg P/ha + 20 kg K/ha	1.87	2.40	2.67
6. 30 kg P/ha + 10 kg K/ha	1.53	2.20	2.53
7. 20 kg P/ha + 30 kg K/ha	1.67	2.33	2.47
8. 20 kg P/ha + 20 kg K/ha	1.80	2.40	2.67
9. 20 kg P/ha + 10 kg K/ha	1.60	2.07	2.27
SEm±	0.22	0.23	0.27
CD (P=0.05)	0.66	0.69	0.80

Table 3: Influence of Phosphorus and Potassium levels on leaf area in Sesame

Treatments	Leaf area (cm^2)				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
1. 40 kg P/ha+ 30 kg K/ha	50.79	224.55	1972.91	2196.02	2200.12
2. 40 kg P/ha + 20 kg K/ha	54.78	227.80	2074.57	2270.49	2568.70
3. 40 kg P/ha + 10 kg K/ha	44.99	222.82	1798.18	1974.22	2192.17
4. 30 kg P/ha + 30 kg K/ha	47.21	148.10	1407.41	1741.69	1747.82
5. 30 kg P/ha + 20 kg K/ha	50.58	168.15	1636.20	1785.89	2121.41
6. 30 kg P/ha + 10 kg K/ha	37.31	107.14	1376.72	1695.73	1569.66
7. 20 kg P/ha + 30 kg K/ha	28.49	105.31	1018.28	1282.76	1435.49
8. 20 kg P/ha + 20 kg K/ha	46.22	167.95	1093.71	1434.21	1625.35
9. 20 kg P/ha + 10 kg K/ha	26.94	91.11	927.09	946.77	1199.31
SEm±	6.76	16.97	57.43	172.17	182.5
CD (P=0.05)	-	50.87	506.40	516.16	547.27

Phosphorus (P) @ 40 kg/ha significantly enhanced the growth attributing characters of sesame i.e. leaf area index was ultimately maximum in sesame (Chang *et al.* (2005)). The increase in levels of potassium also significantly increased the leaf area index of sesame plant. These results are similar to Sarkar and Pal (2005) in sesame.

Yield and Yield attributes

Observations regarding yield and yield attributes like Number of capsules per plant (No.), Number of seeds per capsules (No.) and Test weight (g), Seed yield (kg/ha) and Biological yield (kg/ha) of sesame depicted in Table 5.

Number of capsules per plant

The number of capsules per plant was significantly increased due to the different treatment combinations. Higher Number of capsules per plant (49.80) was recorded significantly higher in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. T_1 and T_5 were statistically at par with T_2. The more number of capsules per plant under higher Phosphorus doses might be due to proper availability of P at reproductive phase when plant needs more energy. These findings are similar with Thentu *et al*. (2014). Favorable enhance in levels of phosphorus significantly increased the yield attributing characters of sesame like number of capsules/plant Shelke *et al.* (2014). Higher uptake of nutrients *viz.,* potassium and higher dry matter accumulation and translocation might be attributed to reproductive plant parts was reported by Thakur *et al*., (2015) in sesame.

Table 4: Influence of Phosphorus and Potassium levels on leaf area index in Sesame

Treatments	Leaf area index				
	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS
1. 40 kg P/ha+ 30 kg K/ha	0.16	0.74	6.57	7.31	7.33
2. 40 kg P/ha + 20 kg K/ha	0.18	0.76	6.58	7.57	8.56
3. 40 kg P/ha + 10 kg K/ha	0.15	0.74	5.25	6.58	7.08
4. 30 kg P/ha + 30 kg K/ha	0.16	0.50	4.69	5.81	6.94
5. 30 kg P/ha + 20 kg K/ha	0.17	0.56	5.45	5.95	6.96
6. 30 kg P/ha + 10 kg K/ha	0.12	0.36	4.59	5.65	5.23
7. 20 kg P/ha + 30 kg K/ha	0.09	0.35	3.39	4.28	4.78
8. 20 kg P/ha + 20 kg K/ha	0.15	0.56	3.65	4.78	5.42
9. 20 kg P/ha + 10 kg K/ha	0.09	0.30	3.09	3.15	4.00
SEm±	0.03	0.06	0.45	0.57	0.76
CD (P=0.05)	-	0.17	1.36	1.72	2.27

Table 5: Influence of Phosphorus and Potassium levels on yield, yield attributes and Oil content in Sesame.

Treatments	At harvest					
	Capsules per plant (No.)	Seeds per capsule (No.)	Test weight (g)	Seed yield (kg/ha)	Biological yield (kg/ha)	Oil content (%)
1. 40 kg P/ha+ 30 kg K/ha	40.40	51.33	3.82	311.67	1771.60	47.62
2. 40 kg P/ha + 20 kg K/ha	49.80	56.40	3.90	361.00	2002.15	50.53
3. 40 kg P/ha + 10 kg K/ha	36.87	49.67	3.47	297.67	1729.03	41.75
4. 30 kg P/ha + 30 kg K/ha	31.67	49.27	3.35	292.00	1656.20	43.18
5. 30 kg P/ha + 20 kg K/ha	39.87	50.07	3.48	299.00	1753.93	41.58
6. 30 kg P/ha + 10 kg K/ha	29.73	48.93	3.10	281.33	1597.60	40.00
7. 20 kg P/ha + 30 kg K/ha	30.67	47.60	3.17	270.00	1557.73	41.97
8. 20 kg P/ha + 20 kg K/ha	34.40	49.87	3.19	271.67	1579.37	43.40
9. 20 kg P/ha + 10 kg K/ha	29.53	45.07	3.00	254.33	1425.73	37.72
SEm±	3.44	1.84	0.19	19.04	77.21	2.13
CD (P=0.05)	10.33	5.52	0.58	57.08	231.46	6.37

Number of seeds per capsules

An insight into the data declared distinct variation of number of seeds/capsules due to of treatment differences. Number of seeds/capsule (56.40) was recorded significantly higher in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. T_1 was statistically on par with T_2. Higher uptake of nutrients viz., phosphorus and potassium and higher dry matter accumulation and translocation might be attributed to reproductive plant parts. These results are found similar with the results of Patel (2017) in sesame.

Test weight (g)

Maximal 1000 seed weight was recorded (3.90 g) in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. T_1, T_3 and T_5 were statistically at par with T_2. Ample amount of water at capsule and development stages resulted in the more accumulation of P and other nutrients ultimately in the grains which help to increase seed weight per plant. These results are similar with Khadse *et al.* (2017) in sesame. The test weight and size of the seed of sesame was increased under application of potassium. These results are in conformity with Jadav (2004) in sesame.

Seed yield (kg/ha)

Data on seed yield of sesame specified that significant differences due to different treatments combination of higher dose of inorganic fertilizers brought significant ehancement in seed yield over all the treatment combinations. The highest number of seed yield was recorded significantly superior seed yield (361 kg/ha) in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. T_1 was statistically at par with T_2.The beneficial effect of phosphorus on seed yield of sesame due to the stimulating effect of phosphorus on different yield attributing character *viz.,* number of capsules/plant, number of seeds/capsule and test weight etc. These results are conformity with Choudhari and Patel (2007). Number of capsules per plant, number of seeds per capsule and test weight of seed has helped in enhancing the translocation of starch from source to sink and dry matter production, which promotes increasing the number of seeds per capsule. These results are in conformity with Bhosale (2009) in sesame.

Biological yield (kg/ha)

Data on Biological yield of sesame indicated significantly higher biological yield (2002.2 kg/ha) value in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. With an increase in Phosphorus level biological yield increasing significantly. These results are similar to the findings of Hafiz *et al.,* (2012). The Biological yield of sesame increased steadily with an increase in phosphorous levels. It might be attributed to higher dry matter accumulation and higher uptake of nutrients and translocation to reproductive plant parts. These results are in parallelism with Choudhari and Patel (2007) in sesame. The definite effect of potassium on Biological yield might be due to the effective role of potassium in photosynthesis and to its importance in cell elongation, carbohydrates synthesis more ever; higher nutrient uptake resulted in maximum plant height and number of branches per plant and eventually helped in increasing higher Stover yield. These results are in match up with those reported by Bhosale (2009) in sesame.

Quality parameters

Oil content

Data presented in Table 5. stated that the oil content in sesame indicated significant variation due to different treatments. The maximum oil content was recorded significantly highest in oil content (50.53%) in application of Phosphorus (P) @ 40 kg/ha + Potassium (K) @ 20 kg/ha. T_1 was statistically on par with T_2. The favorable impact of phosphorus on seed yield of sesame might be due to the stimulating effect of phosphorus on different yield attributing character viz., number of capsules per plant, number of seeds per capsule and test weight etc. These results are conformity with Choudhari (2007). Progressive increase in level of potassium significantly increased the quality i.e. oil content (46.75%). These results are equality with Jat *et al.* (2017) of sesame.

Conclusion

This study concluded that application of Phosphorus (P) @ 40 kg/ha plus Potassium (K) @ 20 kg/ha was found to be best that recorded the higher number of Capsules per plant, Seeds per capsule, Test weight, Seed yield, Biological yield. However, it produced significantly higher Oil content in sesame.

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