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Evaluation of interaction effect of phosphorus and sulphur on growth, yield and yield components of sesame (*Sesamum indicum* L.) under rainfed condition of Chitrakoot area

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Abstract

A field experiment was carried out to study the phosphorus-sulphur interaction at Mahatma Gandhi Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) on a sandy loam soil having medium status of available phosphorous and available sulphur. The treatment consisted of three levels of P (0, 50 and 60 kg P_2O_5 ha-1) and four levels of S (0, 20, 30 and 40 kg ha-1) applied from diammonium phosphate (DAP) and sulphur, respectively. On the basis of the results emanated from present investigation, it could be concluded that growth parameter i.e. plant height, no. of leaves and no. of branches and yield attributes i.e. 1000 seed weight, no. of seed per capsule and no. of capsule per plant and productivity parameter i.e. seed yield (q ha-1) were increased with increase in level of P and S individually as well as in various combinations. Sesame variety *GJT-5*was grown with the recommended agronomic practices. The synergistic effect of phosphorus and sulphur was reported on no. of seed per capsule and no. of capsule per plant.

Keywords: Interaction, phosphorous, sesame and sulphur

Introduction

Sesame (*Sesamum indicum* L.) belonging to the order Tubiflorae, family Pedaliace an important oil seed crop being cultivated in the tropics as well as in the temperate zone of the world and cultivated for its high quality oil and contains high amount of oil (up to 60%), hence sesame is known as the “king of oil seeds” [13]. Beside food, sesame has also many potential applications in other areas such as pharmaceutics, industrial and as biofuel. Sesame is used as active ingredients in antiseptics, bactericides, viricides, disinfectants, moth repellents, anti-tubercular agents and considerable source of Phosphorus, Iron, calcium, tryptophan, methionine, valine, niacin and thiamine. Among the edible oils, sesame oil has the highest antioxidant content and possesses plentiful fatty acids [10].

Sesame (*Sesamum indicum* L.) is believed to be one of the most ancient crops cultivated by humans. Sesame seed has higher oil (around 50%) and protein (25%) content Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as the queen of oilseeds [12]. Sesame seed contains high amounts of (83% - 90%) unsaturated fatty acids, mainly linoleic acid (37% - 47%), oleic acid (35% - 43%), palmitic (9% - 11%) and stearic acid (5%-10%) with trace amount of linolenic acid [4].

The major sesame producing states are Uttar Pradesh, Madhya Pradesh and Rajasthan Gujrat, which occupy 30%, 23%, 20%, and 8% area of total sesame cultivation in the country, respectively. The highest yield of 565 kg ha-1 was estimated for Gujarat, followed by 289 kg ha-1 for Rajasthan, 262 kg ha-1 for Madhya Pradesh and 239 kg ha-1 for Uttar Pradesh. In 13 districts of Madhya Pradesh, the highest yield (569 kg ha-1) was estimated in Bhind and the lowest (128 kg ha-1) for Panna. (Directorate of Economics and Statistics, Govt. of India) fungicides are more costly and pollutant to environment. Many plant extract are known to have antifungal activity. Therefore, keeping in view the importance of the crop, seriousness of the disease, non-availability of suitable management practices and gaps in our knowledge abo.

Phosphorous is the second i.e. next to nitrogen. Due to deficiency of single element Phosphorous, plant cannot complete their life cycle. Hence, P is called ‘Key to life’. It governs the root growth. P is essential constituent of nucleic acid, phytin and phospholipid.

Phosphorus is essential for the general health and vigor of all plants. Some specific growth factors that have been associated with adding phosphorus to the crop are: stimulated root development, increased stalk and stem strength, improved flower formation and seed production, more uniform and earlier crop maturity, increased nitrogen-fixing capacity of legumes, improvements in crop quality, and increased resistance to plant diseases [17].

Sulphur plays a key role in the plant metabolism, indispensable for the synthesis of essential oils, chlorophyll formation, required for development of cells and it also increases cold resistance and drought hardiness of crops especially for oilseed crops [8].

Use of high analysis sulphur free fertilizers, heavy sulphur removal by the crops under intensive cultivation and neglect of sulphur replenishment contributed to widespread sulphur deficiencies in arable soils. Sulphur has become one of the major limiting nutrients for oilseeds in recent years due to its widespread deficiency [11]. Sulphur use was also reported to be very remunerative in many crop sequences involving oilseeds [15].

Materials and Methods

Study Place and Weather Condition

The experiment was conducted at the Research farm of at Agriculture farm of Mahatma Gandhi Gramodaya Vishwavidyalaya Chitrakoot, Satna (M.P.) during July to November 2020 to examine effect of Phosphorus and Sulphur on Sesame (*Sesamum indicum* L.) Under rainfed condition of Chitrakoot area.It is located on 24031' N latitude, 81015' E longitude and at an altitude of 306meters above mean sea level. Experimental site area is situated in Bundelkhand Zone of northern Madhya Pradesh and have typically sub-tropical and semi-arid with monsoon commencing by the third week of June and with drawing by end of September. Total rainfall received during the crop growing period was 482 mm.

Experimental Soil

The experimental field is sandy loam in texture, neutral in reaction (pH 7.46), low in organic carbon (0.33%), available N (205.4 kg ha-1), medium in available P (15.38 kg ha-1), high in available K (308.99 kg ha-1) and medium in available S (26.41 kg ha-1).

Study Design

The experiment was laid out in a randomized block design (RBD) assigning treatment combinations *viz.* T0 [Absolute Control], T1 [0 kg P ha-1+ 20 kg S ha-1], T2 [0 kg P ha-1+ 30 kg S ha-1], T3 [0 kg P ha-1+ 40 kg S ha-1], T4 [50 kg P ha-1+ 0 kg S ha-1], T5 [50 kg P ha-1+ 20 kg S ha-1], T6 [50 kg P ha-1+ 30 kg S ha-1], T7 [50 kg P ha-1+ 40 kg S ha-1], T8 [60 kg P ha-1+ 0 kg S ha-1], T9 [60 kg P ha-1+ 20 kg S ha-1], T10 [60 kg P ha-1+ 30 kg S ha-1] and T11 [60 kg P ha-1+ 40 kg S ha-1], with three replications. Each treatment was randomly allocated with in them. The row-to-row and seed to seed distance were 30 and 10 cm, respectively.

Use of Fertilizer

Fertilizers were applied as side placement, for which 4-5 cm deep furrows were made along the seed rows with a hand hoe. The nutrient sources were urea, diammonium phosphate (DAP), muriate of potash (MOP) to fulfill the requirement. The recommended dose was applied according to the treatment details as through Urea, DAP, MOP and sulphur. Whole of nitrogen, phosphorus, potash and sulphur was applied as basal at the time of sowing.

Statistical Analysis

The data recorded during the course of investigation was subjected to statistical analysis by “Analysis of variance technique”. The significant and non-significant treatment effects were judged with the help of ‘F’ (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level [1].

Result and Discussion

Plant Height (cm/plant)

Data presented in Table 1 showed that the application of 60 kg P2 O5 ha-1 increased the plant height from [15.93-18.26 cm], [103.46 - 124.86 cm] and [106.20 - 128.66 cm] at 25 DAS, 50 DAS and 75 DAS respectively over 50 kg P2 O5 ha-1 and control. Application of S @ 40 kg ha-1 also increased plant height from [11.66 - 18.26 cm], [77.53 – 124.86 cm] and [80.93 – 128.86 cm]at 25 DAS, 50 DAS and 75 DAS respectively over 30 kg S ha-1 and control. Similar results were also reported [7], [17] and [14] in sesame. The maximum plant height was reported at the highest level of phosphorus (60 kg P2 O5 ha-1) along with sulphur (40 kg S ha-1).The increase in plant height might be due to better root development with increasing levels of these nutrients. Phosphorus, being the constituent of nucleic acid and different forms of proteins, might have stimulated cell division resulting in increased growth of plants.

Table 1: Interaction of Phosphorous and Sulphur levels on Plant height (cm/plant) at different growth intervals

Added P2 O5 (kg ha-1)	Added S (kg ha-1)				Mean
	0	20	30	40	
			25DAS		
0	6.73	12.26	12.73	11.66	10.85
50	11.86	9.73	12.60	12.26	11.61
60	15.93	14.46	16.80	18.26	16.36
Mean	11.51	12.15	14.04	14.06	
CD(p=0.05)	P=1.82	S=2.11	P×S=NS		
			50DAS		
0	72.33	77.00	74.13	77.53	75.25
50	85.20	92.66	84.80	87.86	87.63
60	103.46	102.73	119.46	124.86	112.63
Mean	87.00	90.80	92.80	96.75	
CD(p=0.05)	P=6.69	S=NS	P×S=NS		
			75DAS		

0	77.33	80.66	76.73	80.93	78.91
50	87.60	94.66	87.00	89.53	89.70
60	106.20	105.26	121.88	128.86	115.55
Mean	90.37	93.53	95.20	99.77	
CD(p=0.05)	P=6.23	S=2.11	P×S=12.47		

Number of Eaf/plant

Data presented in Table 2 showed that the application of 60 kg P2 O5 ha-1 increased the number of leaf plant-1 from [9.13-15.73], [78.26 – 88.26] and [73.60 – 91.13] at 25 DAS, 50 DAS and 75 DAS respectively over 50 kg P2 O5 ha-1 and control. Application of S @ 40 kg ha-1 also increased the number of leaf plant-1 from [5.60 –15.73 cm], [57.53 – 88.26] and [61.00-91.13] at 25 DAS, 50 DAS and 75 DAS respectively over 30 kg S ha-1 and control. Similar findings were reported by [7] and [14]. The result clearly revealed that the positive interaction between P and S for number of leaf plant-1at the level of phosphorus (60 kg P2 O5 ha-1) along with sulphur (40 kg S ha-1).

Table 2: Interaction of Phosphorous and Sulphur levels on Number of Leaves per Plant (cm/plant) at different growth intervals

Added P2 O5 (kg ha-1)	Added S (kg ha-1)				Mean
	0	20	30	40	
	25DAS				
0	4.86	7.00	5.33	5.60	5.70
50	7.66	6.60	8.33	9.00	7.90
60	9.13	10.86	11.86	15.73	11.90
Mean	7.22	8.15	8.51	10.11	
CD(p=0.05)	P=0.72	S=0.83	P×S=1.44		
50DAS					
0	42.53	43.53	54.20	57.53	49.45
50	65.53	63.86	68.20	68.53	66.53
60	78.26	74.26	87.86	88.26	82.16
Mean	62.11	60.55	70.08	71.44	
CD(p=0.05)	P=4.48	S=5.18	P×S=NS		
75DAS					
0	44.20	45.33	58.33	61.00	52.21
50	69.06	66.86	70.40	70.66	69.25
60	73.60	77.60	90.53	91.13	83.21
Mean	62.28	63.26	73.08	74.26	
CD(p=0.05)	P=4.92	S=5.68	P×S=NS		

Number of branches/plant

Data presented in Table 3 showed that the application of 60 kg P2 O5 ha-1 increased the number of branches plant-1 from [6.56-7.76], [6.86-8.26] and [7.20-9.06] at 25 DAS, 50 DAS and 75 DAS respectively over 50 kg P2 O5 ha-1 and control. Application of S @ 40 kg ha-1 also increased the number of branches plant-1 from [4.43- 7.76], [5.06-8.26] and [5.53-9.06] at 25 DAS, 50 DAS and 75 DAS respectively over 30 kg S ha-1 and control.

Similar findings were reported by [14], [7] and [6]. The result clearly revealed that the synergestic effect P and S for number of branches plant-1 at the level of phosphorus (60 kg P2 O5 ha-1) along with sulphur (40 kg S ha-1).

Table 3: Interaction of Phosphorous and Sulphur levels on Number of branches/plant at different growth intervals

Level of P(kg ha-1)	Levels of S (kg ha-1)				Mean
	0	20	30	40	
	25DAS				
0	4.76	4.86	4.83	4.43	4.72
50	5.06	5.96	6.33	7.00	6.09
60	6.56	5.13	7.26	7.76	6.68
Mean	5.46	5.32	6.14	6.40	
CD(p=0.05)	P=0.47	S=0.54	P×S=0.94		
	50DAS				
0	5.33	6.00	5.23	5.06	5.40
50	5.73	6.33	6.60	7.30	6.49
60	6.86	5.43	7.80	8.26	7.09
Mean	5.97	5.92	6.54	6.87	
CD(p=0.05)	P=0.48	S=0.56	P×S=0.96		
	75DAS				
0	6.13	6.20	5.60	5.53	5.86
50	5.93	6.70	6.93	7.53	6.77
60	7.20	5.93	8.00	9.06	7.55
Mean	6.42	6.27	6.84	7.37	
CD(p=0.05)	P=0.52	S=0.60	P×S=1.04		

Yield Attributing Parameters

Data presented in Table 3 showed that the application of 60 kg P2 O5 ha-1 increased 1000 seed weight from 3.66-4.63 gm, no. of seed per capsule from 67.00-78.00 and no. of capsule per plant from 17.00-20.66at par with over 50 kg P2 O5 ha-1 and control. Application of S @ 40 kg ha-1 also increased 1000 seed weight from 2.56-4.63 gm, no. of seed per capsule from 47.00-78.00 and no. of capsule per plant from 14.00-20.66 at par with 30 kg S ha-1 and control. Similar findings were reported by [4] and [16]. The result clearly revealed that the synergestic effect P and S for number of 1000 seed weight, no. of seed per capsule and sno. of capsule per plant at the level of phosphorus (60 kg P2 O5 ha-1) along with sulphur (40 kg S ha-1).

Table 4: Interaction of Phosphorous and Sulphur levels on Yield Attributing Parameters

Level of P(kg ha-1)	Levels of S (kg ha-1)				Mean
	0	20	30	40	
	1000 seed weight				
0	2.07	2.60	3.13	2.56	2.59
50	3.16	3.16	3.76	3.83	3.48
60	3.66	3.76	3.90	4.63	3.99
Mean	2.96	3.17	3.60	3.67	
CD(p=0.05)	P=0.24	S=0.28	P×S=0.49		
	No. of seed per Capsule				
0	40.00	48.00	48.33	47.00	45.83
50	52.33	54.33	60.33	63.66	57.66
60	67.00	68.00	76.66	78.00	72.41
Mean	53.11	56.77	61.77	62.88	
CD(p=0.05)	P=2.11	S=2.43	P×S=4.22		
	No. of Capsule per plant				
0	12.00	12.33	13.00	14.00	12.83
50	14.66	16.00	15.66	16.66	15.75
60	17.00	17.66	18.00	20.66	18.33
Mean	14.55	15.33	15.55	17.11	
CD(p=0.05)	P=0.87	S=1.00	P×S=NS		

Seed Yield (q ha-1)

Data presented in Table 5 showed that the application of 60 kg P2 O5 ha-1increased the seed yield (q ha-1) from3.75-4.11 q ha-1at part with 50 kg P2 O5 ha-1 and control. Application of S @ 40 kg ha-1 also increased the seed yield (q ha-1) from3.18-4.11 q ha-1 at par with 30 kg S ha-1 and control. The probable reason may be that the increasing P and S levels resulted in greater accumulation of carbohydrate, protein and their translocation to the productive organs, which in turn, improved all growth and yield attributing characters, resulting more seed yield. Besides this, the addition of Sulphur providing adequate balanced quantity of the plant. The findings confirm the results of [2] and [5].

Table 5: Interaction of Phosphorous and Sulphur levels on Seed Yield (q ha-1)

Level of P(kg ha-1)	Levels of S (kg ha-1)				Mean
	0	20	30	40	
0	2.71	3.03	3.09	3.18	3.00
50	3.27	3.47	3.51	3.63	3.47
60	3.75	3.71	3.94	4.11	3.88
Mean	3.24	3.40	3.51	3.64	
CD(p=0.05)	P=0.03	S=0.03	P×S=0.06		

Conclusion

The present findings concluded that application of 60kg P along with 40 kg S ha-1 proved the most optimum and the beneficial fertility management for the "GJT-5" Variety of Sesame for the Bundelkhand /Chitrakoot region of Madhya Pradesh. This fertility management (P 60 S 40) resulted in maximum seed productivity up to 4.11 q ha-1.

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