International Journal of Plant & Soil Science

34(21): 249-255, 2022; Article no.IJPSS.88810
ISSN: 2320-7035

Effect of the Phosphorus and Sulphur Levels on Growth and Yield of Mustard (*Brassica juncea L.*) Crop under Rainfed Condition

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Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2022/v34i2131259

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/88810

Original Research Article

Received 30 April 2022
Accepted 06 July 2022
Published 12 July 2022

ABSTRACT

Background: Phosphorus has been pointed out as one of most important in oilseed crop wich is responsible for vegetative growth,reproduction and consequently yield of mustard. Sulphur element is important for crop growth and development especially in oilseed. At present, 42% of Indian soil have been found to the sulphur deficient, sulphur is essential for synthesis of oil percentage, protein, vitamins, in oilseed crops.
Methods: The field investigation was carried out at the Rajaula Research Farm, Faculty of Agricultural Science ,Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalay, Chitrakoot- Satna (M.P.) during Ravi season 2019-20. The treatment comprised three levels of phosphorus and three levels of sulphur along with absolute control.
Result: The result revealed that application of 30kg phosphorus/ha significantly increase the plant height , plant leaves, primary branches, secondary branches and yield indices vis number of siliqua/plant, number of seed/siliqua, 1000 seed weigh and seed yield than 20kg phosphrus/ha and 0kg phosphorus/ha . Sulphur levels also hed significantly influereced on these growth and yield indices and reconded higher values 20kg sulphur/ha found at per 10kg sulphur/ha and significantly higher over 0kh sulphur/ha. The finding that application of 30kg phosphorus with 20kg sulphur/ha proved the most optimum and beneficial fertility management for the Pusa Mahak veriety mustard for the Bundelkhand/ chitrakoot region of M.P.

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Keywords: Mustard; sulphur; phosphorus; growth and yield.

1. INTRODUCTION

The oilseed from essential part of human diet Besides it produces basic raw materials for agro-based industries and has large acreage covering 20.7 million ha under various oilseeds in different agro-climatic zones of this country, the average Indian consumer uses relatively low quantities of edible oil, no doubt influenced by his modest level of income. The annual per capita "disappearance" of oils and fats in 1999 was as high as 82.3 kg in malaysia, 47 kg in USA, 45.8 in EU-15,17.3 kg in average for the world as a whole and 11.9 kg in the China as against 9.9 kg in India. This has been primarily due to phenomenal increase in human population and lower rate of productivity of these crops. Rapeseed and mustard are the major Rabi oilseed crops of Indian and stand next to groundnut in the oilseed economy [1-3].

"Rapeseed and mustard are one of the most important edible oils of northern and eastern parts of Indian" Varma et al. [4].

"Sulphur plays an important role in the chemical composition of mustard tissue. Sulphur is the fourth major nutrient in crop production. The nitrogen and sulphur requirements of crops are closely related because both nutrients are required for protein synthesis" [5]. "Sulphur is a component of the amino acid, cysteine , and methionine needed for protein synthesis. Sulphur is involved in the synthesis of chlorophyll.Sulfur is one of the 17 elements essential to crop production. Sulfur (S) is the fourth major plant nutrient after nitrogen (N), phosphorus (P) and potassium (K). It is essential for synthesis of the amino acids like cystine cysteine and methionine, a component of vitamin A and activates certain enzyme systems in plants" [5]. "Under S deficient conditions, the efficiency of applied NPK fertilizers may be seriously affected and crop yield levels may not be sustainable" [6]."Continnuous removal of S from soils though plant uptake has led to widespread S deficiency and affected soil S budget" [7] all over the world. Zoha et al. [8] reported "S is one of the most limiting nutrients for agricultural production in many European countries. Similarly, widespread S deficiency in Chinese soils, due to continuous cropping" and "regular use of S free fertilizers was reported and in several agro-ecological zones of Indian by" Hedge and Murthy [9]. Literature is available in respect of phosphorus and sulphur requirement of mustard is limited such studies may act as an important determinant of the productivity in mustard crop in Chitrakoot area as well as Bundelkhand region.

2. METHODS AND MATERIALS

Find experiment was conducted to study the effect of different levels of phosphorus and sulphur on growth and yield of mustard (*Brassica juncea* L.) at the experimental farm of rajola the faculty of agriculture science and technology at mahatma Gandhi chitrakoot gramodaya Vishwavidyalaya chitrakoot satna mp located from 24° 31' N latitude and 81° 15' E latitude. The climate of the district is semi arid with hot summer and cold winter. The rainfall very scantly less than 300 mm/year and mean annual temperature varies from 32.6 to 45.02 °C the humidity is about 60%.

The physio-chemical properties of experimental field were determined in composite soil sample taken before sowing. The value are given below in the Table 1.

Table 1. Physio-chemical properties of experimental field

SN	Soil properties	Value
1	pH	7.4
2	EC (ds/ma at 25 oC)	0.29
3	CEC (c mol/kg (p+)	20.80
4	Organic matter %	0.21
5	Total Nitrogen %	0.090
6	Available Nitrogen %	0.003
7	Total phosphorus %	0.085
8	Available phosphorus %	0.028
9	Available potassium %	0.005
10	Available sulphur %	0.016
11	Sand %	51.0
12	Silt%	21.6
13	Clay %	27.0
14	Taxture class	Sandy loam

The mustard variety PUSA MAHAK was sown in recommended manner, thinning, weeding carried out in two phases. To check the damage by mustard aphid indosulphan 35 EC spraying has be done at the rate of 1.25 lit/ha.

The crop was harvested after 130 days of sowing, when it becomes mature as judged by visual observation. The production of net plot is weighted individually and recorded after threshing [10,11]. Threshing is done by wooden stick and seed weight. Plant samples were taken randomly from each treatment at maturity stage. These plant samples were taken for the analysis of growth parameters and biochemical analysis, Plant height, number of primary and secondary branches, no. of siliqua/plant, no. of seed/siliqua, seed yield, straw yield recorded at pre fix time and interval.

Table 2. Experimental details

SN	Particulars	Details
1	Variety	PUSA MAHAK
2	Germination %	85
3	Physical purity %	80
4	Genetical purity %	85
5	Seed rate kg/ha	6
6	Test weight (g)	4.2
7	Planting distance (cm)	30*10
8	Depth of seed sowing (cm)	3.5
9	Season of seed sowing	Winter
10	Crop length (in days)	130
11	No. of treatment	9
12	No. of replication	3
13	Total no. of plots	27
14	Design	RBD

3. RESULTS

3.1 Growth Attribute

3.1.1 Plant height

The plant height is an important indication of growth. Data on the height of plants were recorded on 30, 60 and 90 days after sowing. These were subjected to statistical analysis and the mean data are presented in Table 3. It is evident from the results in to Table 3 that the plant height increased steadily with the increase of plant growth up to 90 days of observation. The plant height at 30 days stage ranged from 17.11 to 21.22 cm in different treatments, where at 90 days stage, it increased from 178.03 to 183.46cm. At 30 and 90 days stages, applied phosphorus up to 30kg/ha raised the plant height significantly over zero level. Thus the maximum height was up to 21.22 and 183.46cm, respectively rather increase in P level up to 30kg/ha increased the plant height significantly. Thus, 20kg P_2O_5/ha were found statistically at par in their influence. The increasing levels of sulphur only up to 20kg/ha increased the plant height significantly at every stage of observation. Thus the maximum height at 30, 60 and 90 days was 21.11, 151.17 and 182.97 cm, respectively. Rather increase in S level up to 20kg/ha tended to decrease the plant height almost significantly.

3.1.2 Number of the leaves

The number of leaves in mustard at 30, 60 and 90 das growth intervals. The mean values are presented in Table 3 Application of phosphorus only up to 30kg/ha resulted in significant increase in the leaves (153.84/plant) as well as no phosphorus (142.93) at the 90 days.The increasing sulphur levels only up to 20kg/ha increased these significantly (144.46 to 151.66/plant) at the 90days. Farther increased in S levels up to 20 kg/ha resulted increased in this parameter significantly. This was noted at every stage of observation.

3.1.3 Number of branches/plant

The number of primary and secondary branches/plant was recorded in each treatment and the data so obtained were subjected to. The mean values are presented in Table 3. The different phosphorus and sulphur levels brought about significant changes in the number of branches per plant. Application of phosphorus only up to30 kg/ha resulted in significant increase in the secondary branches (19.83/plant) as well as primary branches (7.31/plant) at 90 days over on phosphorus. The corresponding values at zero level were 17.02 secondary and 5.44 primary branches/plant. The increasing sulphur levels only up to 20 kg/ha increased these parameters significantly (19.64 secondary and 7.33 primary branches) on 90 days. The correspond values at zero level were 16.67 secondary and 5.44 primary branches/plant. Application of sulphur up to 20 kg/ha best beneficial.

3.2 Yield-attributing

3.2.1 Number of Siliqua/plant

The number of Siliqua/plant were counted from the randomly sample plants in each plot and the mean data so obtained were statistically analyzed as depicted in Table 4. Accordingly, the numbers of Siliqua/plant were enhanced significantly up to 473.80 Siliqua due to 30 kg P/ha over no phosphorus (466.93Siliqua). Further increase in P level up to 30 kg/ha bring about any significant change (473.80 Siliqua/plant).As regards with the sulphur levels the Siliqua were increased significantly with each increased in the S levels only up to 20 kg/ha 472.48 Siliqua/plant. Thus the maximum 472.48 Siliqua/plant was counted in case of 30kg P/ha as against 468.66 Siliqua /plant in case of no sulphur.

3.2.2 Number of seeds/Siliqua

The number of seeds/Siliqua was counted form the randomly selected five plants in each treatment and the mean valued so obtained were subjected to statistically analyzed as depicted in Table 4. The increasing levels of phosphorus only up to 30kg/ha enhanced the seed number significantly (15.68 seeds/Siliqua). However further increase in P level this parameter. Higher dose of phosphorus proved advantageous (15.68 seeds/Siliqua). The significantly lowest seeds (13.84/.Siliqua) were obtained in case of no phosphorus. Accordingly, 20kg S/ha produced maximum 15.35 seeds/Siliqua and seeds/Siliqua proved significantly superior to no sulphur (14.42seed/Siliqua).

3.2.3 Test weight

The test weight of 1000 grains was recorded treatment wise and the data so obtained were subjected to statistical analysis as depicted in Table 4. The phosphorus levels were found to have identical influence upon this parameter. The test weight ranged from 14.05 g in case of 30kg P/ha to 9.84g in case of no phosphorus. The increasing levels of sulphur up to 20kg/ha increased the test weight significantly (13.40 g). Thus the maximum test weight 13.40 g was recorded in case of no sulphur applications (3.22 g).

3.2.4 Grain yield

The grain yield was recorded in kilogram and then converted into quintals per hectare. The data so obtained were subjected to statistical analysis as shown in Table 4. Application of phosphorus up to 30kg/ha the grain yield significantly up to 14.01q/ha as compared to no phosphorus (8.80q/ha). The increasing sulphur level only up to 30kg/ha the grain yield significantly up to 13.41q/ha as compared to no sulphur (9.84q/ha).

4. DISCUSSION

4.1 Growth Characters

“Among the growth characters, plant height and were studied at 30, 60 and 90 days growth intervals. Leaves per plant were also counted. The plant height and number of branches were increased steadily with the advancement of plant growth up to 90 days of observation. This may be due to the fact that with the increase in the stage of the activity growing plants, the branches development. As regards with the influence of sulphur only up to 20kg/ha increased the plant height, leaves and branches significantly. This phenomenon was quite natural because of the greater availability of this element in the soil and its stimulating effect on the growth of the plants” Gangwal (2011) and Yadav (2010). “The height of shoot was stimulated due to sulphur which may be attributed to its essentiality in cell division. Mover this nutrient plays an important role in the activity of shoots and meristematic tissues and development of shoots and leaf.The beneficial effect of sulphur was found to be limited only up to 20kg S/ha. It is as well as known fact that plants absorb all the essential plant nutrients from soil solution in a balanced requirement quantity, and even if certain nutrients are added in excess of the plants requirement, the plant growth is likely to sulphur supported by” Gangwal (2011) and Yadav (2010)

“The increasing levels phosphorus levels, all the above mentioned growth parameters including Trifoliate leaf per plant were increased significantly, only up to 30kg P_2O_5/ha the crop response of applied phosphorus only up to 30kg/ha indicate the fact that the existing available- P in the experimental field soil not much deficient and only 30kg applied P proved sufficient to meet out the complete requirement of the crop plants” Gagwal (2011). “The beneficial effect of applied P on the growth parameter under study may be attributed to the important role of phosphorus played in the branches development as well as in the translocation of photosynthesis, and being the constituent of nucleic acid, phytin and phospholipids its application increased the height and branches per plant. The differential response of phosphorus can be attributed to its efficiency and its fertilization which in turn may be influenced by the environmental factors supported by” Gagwal (2011).

4.2 Yield- attributes

“The yield attributing parameters viz. Sulphur only up to 20kg/ha the number of Siliqua/plant, number of seeds/Siliqua and 1000-seed weight significantly. Further increase in sulphur application up to 20kg/ha brought about incurious

Table 3. Efeect of different levels on growth attributing characters

Levels (kg/ha)	Plant height			Leves			Branches			
							Primery Branches		Secondary Branches	
P-level	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90DAS	60 DAS	90 DAS	60 DAS	90 DAS
0	17.11	148.87	178.03	5.24	52.11	142.93	3.23	5.44	9.31	17.02
20	18.77	151.15	180.52	6.04	53.75	147.4	3.74	6.44	11.2	17.72
30	21.22	151.74	183.46	6.37	57.22	153.84	4.6	7.31	13.36	19.83
CD(P=0.05)	0.68	0.25	0.78	0.1	0.84	1.02	0.17	0.35	0.41	0.48
S- Levels										
0	17.33	149.93	178.34	5.55	52.13	144.46	3.18	5.44	9.44	16.67
10	18.66	150.66	180.7	6	54.51	148.04	3.94	6.42	11.43	18.25
20	21.11	151.17	182.97	6.11	56.44	151.66	4.44	7.33	13	19.64
CD (P=0.05)	0.68	0.25	0.78	0.1	0.84	1.02	0.17	0.35	0.41	0.48

Table 4. Efeect of different levels on yield attributing characters

Levels (kg/ha)	Siliqua/plant	Seeds/Siliqua	1000seed weight (g)	Seed yield(q/ha)
P-level				
0	466.93	13.84	9.84	8.8
20	471.71	15.22	11.28	11.51
30	473.8	15.68	14.05	14.01
CD(P=0.05)	0.48	0.1	0.3	0.26
S- level				
0	468.66	14.42	10.21	9.84
10	471.28	14.97	11.57	11.07
20	472.48	15.35	13.4	13.41
CD(P=0.05)	0.48	0.1	0.3	0.26

influence. These parameters tended to increase which indicate the fact that this application rate of sulphur was in excess of the crop requirement" Raman et al. (2012). The increase in the number of Siliqua /plant may be due to the fact that number of trifoliate leaf were increased due to higher sulphur application only up to 20 kg/ha. Since the chlorophyll synthesis in greatly affected by sulphur content of the growing medium, therefore plants as well as supplied with sulphur would have naturally photosynthesis and accumulated move photosynthesis which Tran located to the sink supported by Raman et al. (2012).

The increasing levels of phosphorus up to Number of Siliqua/plant, number of seeds/Siliqua and 1000 seed weight were found to enhance significantly only up to 30 kg P_2O_5/ha Father increase in phosphorus level of this parameter.

"The crop responded to its lower level (20 kg/ha) may be attributed to the fact that mustard crop taken it's require quantity for its proper growth and development. Application of phosphorus up to 30kg/ha proved to be the excess among under the existing dauphin conditions. The higher number of Siliqua/plant, seeds/Siliqua and 1000 seed weight may be due to the fact that applied P enhanced the metabolic activities promoting chlorophyll formation and photosynthesis at one hand and branches development completed with accelerated microbial activities on the other supported by" Gagwal (2011).

4.3 Productivity Parameters

"The increasing levels of sulphur only up to 20kg/ha increased the grain yield (13.41q/ha) significantly. Thus, 20kg/ha appeared to be the optimum dose for achieving the maximum productivity of mustard Verity. "PUSA MAHAK" under the existing agro-climatic conditions of Chitrakoot region. The increased grain and straw yields may be attributed to the accumulative effect of increased growth and yield attributing characters due to sulphur application" Gangwal (2011). "The plants supplemented with adequate sulphur, according to the requirement, might have synthesized greater photosynthesis and Tran located towards the reproductive organs (sink) resulting in higher seed yield. The increase in straw yields may be attributed to the increased growth characters viz. Plant height and trifoliate leaf plant due to application of sulphur up to 20kg/ha The beneficial influence of sulphur application on mustard seed yield supported by" Gangwal (2011).

"The physiological basis of variations in grain yield was mainly due to the increase in trifoliate leaf per plant, number of Siliqua per plant and 1000 seed weight. In the present study of grain and straw yields were significantly increased due to increase in phosphorus level only up to the maximum yields were 14.01q/ha respectively 30kg/ha. The increased grain yield may be attributed to the accumulative due to phosphorus application" Gangwal (2011). "The nutritional environment for plant growth and development might have improved which favorably influenced the energy transformation activities of enzymes and chlorophyll synthesis as well as carbohydrate metabolism. Moreover, phosphorus is a component of many bio-molecules involved in photosynthesis, respiration and branches growth. The beneficial effect of phosphorus on the productivity of mustard supported by" Gangwal (2011).

5. CONCLUSION

The growth and yield of mustard responded significantly upto 30 kg P_2O_5 and 20 kg S/ha. However the combination of 30 kg P_2O_5 + 20 kg S/ha gave highest value of crop growth and yield.

The findings elude that application of 30kg P with 20kg S/ha proved the most optimum and the beneficial fertility management for the "PUSA MAHAK" Variety Mustard for the Bundelkhand /Chitrakoot region of Madhya Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/88810