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Effect of land configuration methods and Sulphur levels on growth, yield and economics of Indian mustard (*Brassica juncea* L.)

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Abstract

A field experimental trial on mustard was conducted during *rabi* season, 2021 at Lovely Professional University, Department of Agronomy, Phagwara, (Punjab). To evaluate the effect of land configuration methods and Sulphur levels on growth, yield, and quality of Indian mustard. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.2), low in organic carbon (0.28%), available N (215.87 kg/ha), available P (16.78 kg/ha), available K (180 kg/ha). The experiment was laid out in Factorial Randomized Block Design with 12 treatments replicated thrice. The treatment comprised of four land configuration methods (M1 – Flatbed broadcasting - M2 – Flatbed line sowing M3 - Raised sowing and M4 - Ridge sowing) as the main plot factor and 3 sulphur levels (0 kg S ha^{-1}, 25 kg S ha^{-1}, 50 kg S ha^{-1}) as sub plot factor. In the view of this experiment, Ridge sowing and Raised bed planting were significantly superior to other land configuration methods like flatbed Line sowing and flatbed Broadcasting in terms of growth parameters, yield attributes, and yield as well as the economics of crop cultivation. The different levels of sulphur showed a positive response in influencing the growth attributes, yield attributes and yield of mustard. The application of 50 kg S ha^{-1} was significant over other sulphur levels in terms of growth parameters, yield attributes and yield and profitability of mustard crop cultivation.

Keywords: Growth, land configuration, sulphur, yield

Introduction

India is one of the world's most important producers of oilseeds. After cereals, oil seeds are the second most important agricultural product. After groundnut, mustard is India's second most significant edible oilseed crop. It has a significant impact on the country's oilseed economy.

Rapeseed-mustard ranks second among the seven edible oilseeds produced in India, accounting for 28.6% of total oilseed output, following groundnut, which accounts for 27.8% of the Indian oilseed economy. Brassicas are used as oil seeds, vegetables, forage & fodder, green manure, and condiments in agriculture. With 26.5 percent and 16.6 percent of total hectarage and output of Rapeseed-Mustard, respectively, India ranks second and third in the world in terms of area and production. The world's estimated rapeseed-mustard acreage, production, and productivity were 34.19 mha, 63.09 mt, and 1,850 kg ha^{-1}, respectively (Anonymous, 2016). According to FAO statistics from 2015, India accounts for 19.29 percent of total acreage and 10.07 percent of rapeseed and mustard production worldwide. In India, the mustard crop produced roughly 6.31 mt from a total area of 6.51 mha in 2014-15, with average productivity of 1089 kg ha^{-1}.

Land configuration methods include the alteration of the shape of seedbed and land surface among the various methods like flatbed method, raised bed method and ridge sowing method, furrow sowing, tied ridge sowing, ridge with mulches, on the ridge, alternate furrow sowing, ridge sowing are adopted by the crop grower for rapeseed and mustard and other crops for obtaining the better yield over the flatbed or conventional method of sowing. Better conditions for plant growth are provided in-ridge sowing due to higher soil moisture, higher salt leaching and reduction in evaporation from the soil surface (Zhang *et al.*, 2007; Li *et al.*, 2010) [25, 9]. Oilseed development needs a variety of nutrients and micronutrients, but one nutrient, in particular, sulphur, plays multiple functions in giving nutrition to oilseed crops, particularly those belonging to the Cruciferae (Brassicaceae) family (Yadav *et al.*, 2010) [25]. In comparison to other crops, mustard responds to sulphur. Sulphur is required for all crop growth and development. The purpose of this study was to assess the effect of land configuration methods and sulphur levels on the growth, yield and quality of Indian mustard [*Brassica juncea* (L.)].

Sulphur deficiency is pervasive in India. Due to the expansion of agriculture with high-yielding varieties, sulphur deficiency is becoming more prevalent in Indian soils.

After nitrogen, phosphorus, and potassium, sulphur is increasingly becoming considered the fourth main nutrient (Tandon *et al.*, 2002) [21]. Because each unit of Sulphur fertilizer produces 3-5 units of edible oil, it is the master nutrient for oilseed production. In oilseeds, sulphur is essential for seed growth and quality improvement (Anjum *et al.*, 2012) [4]. Sulphur is involved in the production of cystine, methionine, chlorophyll, vitamins (B, biotin, and thiamine), carbohydrate metabolism, oil content, protein content, and growth and metabolism, particularly through its action on proteolytic enzymes (Najar *et al.*, 2011) [11]. Flowering, fruiting, cupping of leaves, reddening of stems, petiole, and stunted growth are all symptoms of a sulphur deficiency. Over the last few years, there has been a lot of discussion about soil S deficiency in agriculture soils (Schere, 2001; Ahmad *et al.*, 2005a; Ahmad *et al.*, 2005b) [18, 1, 2]. During the last two decades, sulphur availability has decreased in many parts of Europe (Schnug, 1991; McGrath *et al.*, 1996; Zhao, *et al.*, 1996) [19, 10, 26]. However, Asia has the highest S fertilizer demand of all the regions. In Asia, India, and China together account for roughly 60% of the total estimated deficit. Soil mining has resulted in widespread S deficiency and a negative soil budget (Aulakh, 2000) [5]. One of the six macronutrients required for proper plant development is sulphur (S). The amount of S required by plants varies depending on their stage of development, and its concentration in plants ranges from 0.1 to 1.5 percent of dry weight. In catalytic centers and disulfide bridges of proteins, the reduced S incorporated in cysteine and methionine amino acids plays an important role. S is also required for the synthesis of amino acids, protein, and a variety of other cellular components, including thiol compounds and so-called secondary Sulphur compounds, which play an important role in plant stress and pest resistance.

Materials and Method

The experiment entitled ‘‘Effect of land configuration methods and Sulphur levels on growth, yield, and quality of Indian mustard [*Brassica juncea* (L.)]’’ was carried out at the research farm of lovely professional university, Punjab during the rabi season 2021-22. The site of the experiment was situated at 31°15′ N, 75°42′ E and 235 m from mean sea level in Punjab and used Factorial Randomized Block Design with 12 treatments replicated thrice. The treatment comprised of four land configuration methods (M1 – Flatbed broadcasting - M2 – Flatbed line sowing M3 - Raised sowing and M4 - Ridge sowing) as the main plot factor and 3 sulphur levels (0 kg S ha^{-1}, 25 kg S ha^{-1}, 50 kg S ha^{-1}) as sub plot factor. Total thirty six treatments viz: (T1) Flatbed Broadcasting + 0 sulphur per hectare, (T2) Flatbed Broadcasting + 25 kg sulphur per hectare, (T3) Flatbed Broadcasting + 50 kg sulphur per hectare, (T4) Flatbed Line sowing + 0 sulphur per hectare, (T5) Flatbed Line sowing + 25 kg sulphur per hectare, (T6) Flatbed Line sowing + 50 kg sulphur per hectare, (T7) Raised bed + 0 sulphur per hectare, (T8) Raised bed + 25 kg sulphur per hectare, (T9) Raised bed + 50 kg sulphur per hectare, (T10) Ridge Planting + 0% sulphur per hectare, (T11) Ridge Planting + 25 kg sulphur per hectare, (T12) Ridge Planting + 50 kg sulphur per hectare. The mustard variety 'Gobi sarson' was sown on November 27th, 2021, with a seed rate of 3.75 kg ha^{-1} at 3 to 4 cm depth with sowing done according to treatment, and harvested on April 07th, 2022. Different sulphur levels (0,25,50 kg sulphur per acre) were used depending on the treatment. The other nutrient fertiliser was administered according to the crop's needs in a specific location under irrigated conditions. After 30 DAS and the first irrigation, a half dosage of nitrogen, a full dose of phosphorus, and a full dose of potash were applied as a basal dressing, and the remaining dose of nitrogen was treated as a top dressing. Weeding, intercultural, plant protection measures, and other cultural practices were used as needed.

Results and Discussion

Growth attributes

From the data given below in (Table 1 and Table 2), it shows at all phases of plant growth, variations in plant height, functional leaves plant-1, fresh weight and leaf area index was identified as related to land configuration methods. Except for 30 DAS, when the ridge sowing recorded the maximum plant height at all stages, considerable variation was noted at most of the stages. Plant height improved significantly when sulphur levels were increased from 0 to 50 kg S ha^{-1} at all development phases. At all growth stages, 50 kg S ha^{-1} produced the highest plant height compared to the other treatments. Between 60 and 90 DAS, the number of green leaves plant^{-1} increased dramatically. At all growth stages up to 90 DAS, the ridge planting method of land configuration recorded the most leaf area index, followed by raised bed sowing, and 50 kg S ha^{-1} recorded the highest LAI at different growth stages, which is statistically significant. There was a significant difference in the number of branches plant^{-1} with the ridge planting method of land configuration. Though the number of primary and secondary branches plant^{-1} was comparable, the application of 50 kg S ha^{-1} resulted in a considerably larger number of primary and secondary branches plant^{-1} at 60 and 90 DAS. Different methods of land configuration produced different quantities of dry matter accumulation, and it was discovered that the ridge method of sowing produced significantly higher dry matter plant^{-1} than the other methods of land configuration and that at 30, 60, 90 DAS and at harvest application of 50 kg S ha^{-1} produced significantly higher dry matter plant^{-1} than the lower level. Ridge and raised planting were considerably better than flatbed line sowing and flatbed broadcasting in all conditions. Kuotsu *et al.*, (2014) [8], Parihar *et al.*, (2009) [15], Khanpara *et al.*, (1993) [7], and Ali *et al.*, (1996) [3] have all found similar findings.

Yield attributes

Among the land configuration approaches, the ridge sowing methods had the highest number of siliquae plant^{-1}, length of siliqua, seeds siliqua^{-1}, and 1000- seed weight (g), followed by the raised bed sowing methods. The generation of siliquae in mustard was similarly affected by differing sulphur levels. The number of siliqua plant-1 increased as the sulphur level increased from 0 to 50 kg S ha^{-1}, and the sulphur applied at 25 and 50 kg sulphur ha^{-1} generated considerably more siliquae plant^{-1} than the control. The advantage of 50 kg S ha^{-1} over 25 and 0 kg S ha^{-1} was also demonstrated. The ridge method of sowing was shown to be better than other ways and statistically significant when compared to the raised bed method. Sulphur application at various amounts altered mustard siliqua length 25 and 50 kg S ha^{-1} over control and 50 kg S ha^{-1} was found significantly superior over 25 and 0 kg S ha^{-1}. In all situations, ridge and raised planting outperformed flatbed line sowing and flatbed broadcasting. The maximum number of seeds per siliqua was recorded by ridge sowing of mustard, followed by raised bed over other land configuration techniques and the flatbed broadcasting method of sowing shows the lowest. The influence of sulphur treatment on the production of seeds siliqua^{-1} was also seen. Sulphur application levels increased from 0 to 50 kg S ha^{-1}, resulting in an increase in the number of seeds per siliqua 25 and 50 kg S ha^{-1} over control, with 50 kg S ha^{-1} being considerably superior to 25 and 0 kg S ha^{-1}. Table 2 shows that different techniques of land configuration vary significantly in terms of 1000 seed test weight. The highest test weight (4.41 g) was obtained by the ridge sowing method of mustard sowing, followed by raised bed sowing (4.30 g), flatbed line sowing (4.22 g), and flatbed broadcasting (4.22 g) among the land configuration methods (4.00 g). The change, however, did not reach statistical significance. The present study supports the findings of Parihar *et al.,* (2010) [14], Rathore *et al.,* (2010) [16], Om *et al.,* (2013) [13], Chiroma *et al.,* (2006) [6], Verma *et al.,* (2012) [23], and Ray *et al.,* (2015) [17], who found that increasing amounts of sulphur treatment from 0 to 50 kg S ha^{-1} enhanced mustard test weight significantly.

Seed and stover yields

Table 3 shows that different techniques of land layout resulted in considerable differences in seed yield. The ridge method of sowing yielded the most mustard seed (3.50 t ha^{-1}), followed by raised bed sowing (3.19 t ha^{-1}), flatbed line sowing (2.67 t ha^{-1}), and flatbed broadcasting sowing (2.45 t ha^{-1}). It is also obvious from the data that with increasing levels of sulphur treatment, mustard seed production (t ha^{-1}) improved significantly with sulphur levels up to 50 kg S ha^{-1} compared to the control.50 kg S ha^{-1} was shown to be superior to other treatments (25 and 0 kg S ha^{-1}) in terms of mustard seed yield t ha^{-1}. However, 25 kg S ha^{-1}at par with 50 kg S ha^{-1}. Stover yield (t ha^{-1}) was impacted by land arrangement methods, as evidenced by the data. There was a substantial difference between the treatments when different techniques of the land layout were used, and the ridge method of sowing produced the maximum seed yield, followed by the raised bed approach. The results showed that increasing sulphur levels up to 50 kg S ha^{-1} increased stover yield, with 50 kg S ha^{-1} found significantly higher than other treatments, followed by raised bed method and flatbed broadcasting method of sowing showing the lowest, and that the stover yield is significantly higher with 50 and 25 kg of sulphur per hectare than 0 kg of sulphur per hectare. The findings show that varied land layout methods and sulphur levels significantly boosted the harvest index, although the changes did not achieve statistical significance, these findings are consistent with Parihar *et al.*, (2010) [14], Kuotsu *et al.*, (2014) [8], and Om *et al.*, (2013) [13], Chiroma *et al.*, (2006) [6], Singh and Kumar (2014) [20] Tiwari *et al.*, (2003) [22].

Table 1: Represents the effect of land configuration methods and Sulphur levels on growth attributes of Indian mustard (*Brassica juncea* L.)

Treatments	Plant height (cm)				No of Leaves			Fresh weight			Dry weight		
	30 Days	60 Days	90 Days	At harvest	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
Sources													
Flat bed broadcasting	9.18	77.48	128.48	175.35	5.77	35.17	86.19	11.61	160.50	444.86	0.22	23.15	31.64
Flat bed line sowing	9.53	78.03	133.06	178.33	5.88	35.29	88.78	11.84	161.52	451.52	0.22	23.30	32.20
Raised bed	10.22	82.62	139.48	211.80	6.44	40.81	91.44	12.56	162.89	484.94	0.23	25.06	34.85
Ridge planting	12.79	89.29	150.4	222.64	6.91	42.37	93.14	12.68	164.45	491.54	0.27	27.48	35.56
CD at 5%	NS	0.45	0.09	7.06	0.12	0.20	0.35	NS	1.67	0.25	NS	0.58	0.98
SEM±	0.01	0.15	0.03	2.41	0.04	0.06	0.12	0.04	0.57	0.08	0.006	0.20	0.33
CV	0.39	0.56	0.07	3.67	2.09	0.53	0.40	1.09	1.05	0.05	7.58	2.42	2.99
Levels (S kg ha^{-1})													
0	8.55	65.19	127.69	194.45	5.66	31.01	83.12	10.72	156.11	414.08	0.15	22.64	30.07
25	11.05	92.09	140.54	195.70	6.25	40.19	91.80	12.45	162.66	489.05	0.27	24.17	34.87
50	11.00	92.28	145.34	209.50	6.85	44.02	94.75	13.35	168.24	501.51	0.28	27.43	35.74
CD at 5%	NS	0.39	0.08	NS	0.11	0.17	0.30	NS	1.45	0.21	NS	0.50	0.85
SEM±	0.01	0.13	0.02	2.08	0.03	0.05	0.10	0.03	0.99	0.07	0.005	0.17	0.29
CV	0.39	0.56	0.07	3.67	2.09	0.53	0.40	1.09	1.05	0.05	7.58	2.42	2.99

Table 2: Represents the effect of land configuration methods and Sulphur levels on growth attributes of Indian mustard (*Brassica juncea* L.)

Treatments	Leaf Area			Leaf Area Index			Primary branches		Secondary branches	
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days	60 Days	90 Days	60 Days	90 Days
Sources										
Flat bed broadcasting	6.80	67.18	148.93	0.034	2.99	7.44	0.35	6.75	0	10.33
Flat bed line sowing	7.37	68.35	151.11	0.036	3.01	7.55	1.07	5.24	0	13.10
Raised bed	7.80	69.51	171.56	0.039	3.57	8.74	4.62	9.88	6.68	18.37
Ridge planting	8.15	71.5	186.00	0.040	3.65	9.30	5.12	10.48	7.41	20.46
CD at 5%	0.13	1.20	2.82	0.060	0.11	0.22	0.06	0.12	0.20	0.1
SEM±	0.04	0.41	0.96	0.002	0.03	0.07	0.02	0.04	0.06	0.07
CV	1.85	1.78	1.75	0.018	0.034	0.27	2.46	1.42	5.84	1.38
Levels (S kg ha^{-1})										
0	5.40	65.73	149.72	0.027	3.30	7.61	1.95	8.04	3.33	13.28

25	8.20	67.89	165.74	0.041	3.65	8.20	2.83	8.32	3.36	15.96
50	8.97	73.77	177.74	0.044	3.39	8.97	3.59	10.1	3.87	17.45
CD at 5%	0.11	1.04	2.44	0.059	10	0.19	0.05	0.10	0.17	0.18
SEM±	0.04	0.35	0.83	0.002	0.03	0.06	0.03	0.99	0.05	0.06
CV	1.85	1.78	1.75	0.018	0.034	0.27	1.09	1.05	5.84	1.38

Table 3: Represents the effect of land configuration methods and Sulphur levels on yield and yield attributes of Indian Mustard [*Brassica juncea* (L.)]

Treatments	Siliqua length (cm)	Siliqua/plant	Seeds/siliqua	Test weight	Biological yield (t/ha)	Stover yield(t/ha)	Yield(t/ha)	Harvest Index (%)
Sources								
Flat bed broadcasting	6.03	567.00	19.33	4.00	8.01	5.50	2.45	32.50
Flat bed line sowing	6.28	630.88	20.23	4.22	8.27	5.61	2.67	32.59
Raised bed	7.39	711.24	24.07	4.30	8.89	5.70	3.19	32.71
Ridge planting	7.60	732.11	25.62	4.41	9.04	5.53	3.50	32.93
CD at 5%	0.03	9.18	0.12	0.24	0.10	0.06	0.06	0.72
SEM±	0.01	3.13	0.04	0.08	0.03	0.02	0.02	0.24
CV	0.57	1.42	0.55	5.79	1.25	1.14	2.17	2.15
Levels (S kg ha^{-1})								
0	6.71	652.66	21.95	4.00	8.09	5.41	2.67	31.53
25	7.03	661.44	22.07	4.08	8.64	5.69	3.01	31.83
50	6.93	676.83	22.91	4.66	8.93	5.75	3.17	31.96
CD at 5%	0.03	7.95	NS	0.20	0.09	0.05	0.05	0.62
SEM±	0.01	2.71	0.03	0.07	0.03	0.01	0.01	0.21
CV	0.57	1.42	0.55	5.79	1.25	1.14	2.17	2.15

Table 4: Represents the effect of land configuration methods and Sulphur levels on the Economics of Indian Mustard [*Brassica juncea* (L.)]

Treatments	Gross cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net returns (Rs ha^{-1})	B: C ratio
Sources				
Flat bed broadcasting	37454	75575	38121	2.02
Flat bed line sowing	38466	86906	48440	2.26
Raised bed	38778	96988	58210	2.50
Ridge planting	38990	98044	59054	2.51
CD at 5%	-	8066.99	-	-
SEM±	-	2618.07	-	-
CV	-	5	-	-
Levels (S kg ha^{-1})				
0	38566	86990	48424	2.26
25	38778	96771	57993	2.50
50	38990	98019	59029	2.51
CD at 5%	-	8060.99	-	-
SEM±	-	2618.07	-	-
CV	-	5	-	-

Conclusion
Based on my experiment trail, the treatment combination of T12 (Ridge planting + 50 kg S ha^{-1}) followed by T9 (Raised bed planting + 50 kg S ha^{-1}) was found to be more productive and the lowest found in T1 (Flatbed broadcasting + 0 kg S ha^{-1}). Although the findings are based on one season further research is needed to confirm the findings and their recommendation.

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