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Response of different levels of sulphur and phosphorus on growth, yield and quality of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during *rabi* season in 2021-2022 at the student instructional field, Department of Agronomy, AKS University, Satna (M.P.), to evaluate the response of different levels of phosphorus and sulphur on growth, yield and quality of Indian mustard (*Brassica juncea* L.). The experiment was laid out in factorial randomized block design comprising two factors namely Sulphur with four levels *viz*., S_0 @ 0 kg/ha, S_1 @ 15 kg/ha, S_2 @ 25 kg/ha, S_3 @ 35 kg/ha along with three levels of Phosphorus *viz*., P_1 @ 20 kg/ha, P_2 @ 30 kg/ha, P_3 @ 40 kg/ha. Results of the current experiment implies application of Sulphur @ 35 kg/ha as compared to other levels found to be significant for plant height (168.53 cm), Number of branches per plant at 90 DAS (8.38), Number of leaves per plant at 90 DAS (42.67), Fresh weight (15.56), Dry weight (5.36), Number of siliquae per plant (255.56), Length of siliqua (5.71), Number of seeds per siliqua (10.98), Test weight (5.67), Seed yield per plant (7.47), Seed yield per plot (1.79), Seed yield per hectare (14.88), Stover yield per hectare (50.56), Harvest Index (22.71), Oil Content (42.47), Gross monetary return (86894.00), Net monetary return (64195.00), B: C ratio (2.83). whereas for phosphorus treatment @ 40 kg/ha found to be significant for plant height at 90 DAS (158.31), Number of branches per plant at 90 DAS (7.48), Number of leaves per plant at 90 DAS (39.60), Fresh weight (14.42), Dry weight (4.31), Number of siliquae per plant (234.30), Length of siliqua (5.21), Number of seeds per siliqua (9.90), Test weight (5.34), Seed yield per plant (6.97), Seed yield per plot (1.62), Seed yield per hectare (13.51), Stover yield per hectare (47.20), Harvest Index (22.09), Oil Content (41.11), Gross monetary return (79008.00), Net monetary return (56821.00), B: C ratio (2.54) exhibits higher significant values.

Keywords: sulphur, phosphorus, Indian mustard, quality, growth, yield

Introduction
Mustard in our country is among the top oil seed crops grown in different regions and under different agro-climatic conditions for the reason of its wide adaptability and higher production potential. At global scale the area and production of rapeseed-mustard is 36.81 million ha and 72.61 million ton, respectively (USDA, 2020) [7]. While in India, it is grown on 14.4% of total gross cropped area (25.50 million ha), which contributes to the production of 32.26 million tones with the productivity of 1265 kg /ha (DACFW, 2020) [1]. Rapeseed and mustard is India's most important rabi oilseed crop, accounting for 27.8% of the country's oilseed economy. When looked at the production, acreage and economic values, mustard oilseed is second only to food grains. India having 6.23 million ha area under rapeseed-mustard and 9.34 million tonnes production with average productivity of 1499 kg /ha, which is about three forth of the world's average productivity of 1960 kg /ha (DAC, 2020) [1]. With the seven edible oilseeds grown in India, rapeseed-mustard contributes to around 28.6% of total production of oilseeds.
Phosphorus is a key element of molecules such as nucleic acids, phospholipids and ATP. It is needed for maintaining and transfer of energy, transfer of genetic characteristics and advantageous in root growth and development as well as vital growth for yield, quality and nodule formation in legume crops. The next most important element that immensely required by the oilseed crops is Sulphur. Sulphur is a secondary plant nutrient which plays a significant role in increasing oil content and production specially in oil seed.

Material and Method
The field experiment was laid out in Randomized block design having factorial concept (FRBD) with three replications at the Student instructional field, Department of Agronomy, AKS University, Satna (M.P.) during Rabi season of the year 2021-22.

Treatment combinations consisting of four levels of Sulphur and three levels of phosphorus thus making 12 treatment combinations was employed in this study. Geographically, Satna district lies in the Kymore Plateau and Satpura Hill Zone, MP-4 (Agro-climatic Zone-VIII). It is situated in the north-eastern part of Madhya Pradesh the latitude of $23^0$58' to $25^0$12' N and longitude of $80^0$21' to $81^0$23' east in Rewa division of M.P. State of India at an elevation of 315 m above mean sea level. With the maximum temperature of 45.00^0C with twelve treatment combinations of Sulphur and Phosphorus at different levels *viz*., S @ 0 kg/ha, S @ 15 kg/ha, S @ 25 kg/ha, S @ 35 kg/ha and P_2O_5 @ 20 kg/ha, P_2O_5 @ 30 kg/ha, P_2O_5 @ 40 kg/ha. The seed of mustard variety Pusa Mahak were used and sown on the furrow on during November, 2021. Seeds were treated with Bavistin for the control of seed borne disease. Sowing was completed by hand with the help of *Kudali* in furrows which are 45.0 cm x 10.0 cm apart continuously as per treatment at about 2-3 cm depth and covered with soil.

Result and Discussion

The findings of the experiment results with the effect of treatments are explained as under: The significant effect of different levels of sulphur on growth characters of Indian mustard was studied and results imply that higher values for characters like plant height at 90 DAS (168.53), Number of branches per plant AT 90 DAS (8.38), Number of leaves per plant at 90 DAS (42.67), Fresh weight (15.56), dry weight (5.36) were noticed under the treatment S_3 (35 kg S ha^{-1}) and have been presented in (Table 1), followed by the values of treatment S_2 (25 kg S ha^{-1}), while the lowest values were recorded from absolute control treatment S_0 (00 kg S $ha^{-1)}$.

The different levels of sulphur on yield and yield attributing characters of Indian mustard was studied and results imply that higher values for characters like Number of siliquae per plant (255.56), Length of siliqua (5.71), Number of seeds per siliqua (10.98), Test weight (5.67), Seed yield per plant (7.47), Seed yield per plot (1.79), Seed yield per hectare (14.88), Stover yield per hectare (50.56), Harvest Index (22.71) were noticed under the treatment S_3 (35 kg S ha^{-1}) and have been presented in (Table 2), followed by the values of treatment S_2 (25 kg S ha^{-1}), while the lowest values were recorded from absolute control treatment S_0 (00 kg S $ha^{-1)}$.

The effect of different levels of sulphur on Quality characters of Indian mustard was studied and results imply that higher values for characters like Oil Content (42.47) were noticed under the treatment S_3 (35 kg S ha^{-1}) and have been presented in (Table 3), followed by the values of treatment S_2 (25 kg S ha^{-1}), while the lowest values were recorded from absolute control treatment S_0 (00 kg S $ha^{-1)}$.

The conclusive effect of different levels of sulphur on Economic analysis of the treatments of Indian mustard was studied and results imply that higher values for characters like Gross monetary return (86894.00), Net monetary return (64195.00), B: C ratio (2.83) were noticed under the treatment S_3 (35 kg S ha^{-1}) and have been presented in (Table 3), followed by the values of treatment S_2 (25 kg S ha^{-1}), while the lowest values were recorded from absolute control treatment S_0 (00 kg S $ha^{-1)}$.

The significant effect of different levels of Phosphorus on growth characters of Indian mustard was studied and results imply that higher values for characters like plant height at 90 DAS (158.31), Number of branches per plant AT 90 DAS (7.48), Number of leaves per plant at 90 DAS (39.60), Fresh weight (14.42), Dry weight (4.31) were noticed under the treatment P_3 (40 kg P ha^{-1}), followed by the values of treatment P_2 (30 kg P ha^{-1}), while the lowest values were recorded from absolute control treatment P_1 (20 kg P $ha^{-1)}$ presented in (Table 1).

The different levels of Phosphorus on yield and yield attributing characters of Indian mustard was studied and results imply that higher values for characters like Number of siliquae per plant (234.30), Length of siliqua (5.21), Number of seeds per siliqua (9.90), Test weight (5.34), Seed yield per plant (6.97), Seed yield per plot (1.62), Seed yield per hectare (13.51), Stover yield per hectare (47.20), Harvest Index (22.09) were noticed under the treatment P_3 (40 kg P ha^{-1}), followed by the values of treatment P_2 (30 kg P ha^{-1}), while the lowest values were recorded from absolute control treatment P_1 (20 kg P $ha^{-1)}$ presented in (Table 2).

The effect of different levels of Phosphorus on Quality characters of Indian mustard was studied and results imply that higher values for characters like Oil Content (41.11) were noticed under the treatment P_3 (40 kg P ha^{-1}), followed by the values of treatment P_2 (30 kg P ha^{-1}), while the lowest values were recorded from absolute control treatment P_1 (20 kg P ha^{-1}) presented in (Table 3).

The conclusive effect of different levels of Phosphorus on Economic analysis of the treatments of Indian mustard was studied and results imply that higher values for characters like Gross monetary return (79008.00), Net monetary return (56821.00), B: C ratio (2.54) were noticed under the treatment P_3 (40 kg P ha^{-1}), followed by the values of treatment P_2 (30 kg P ha^{-1}), while the lowest values were recorded from absolute control treatment P_1 (20 kg P $ha^{-1)}$ presented in (Table 3). Present of higher values could be attributable to the fact that of increase in level of sulphur and phosphorus apart from the regular NPK doses and present of good characteristically variety of crop with goof nutrient uptake results are in great conformality with the findings of Kumar *et al.* (2021) [3], Meena *et al.* (2011) [4], Sonam *et al.* (2020) [5] and Singh *et al.* (2017) [6].

Table 1: Growth characters as influenced by different levels of Sulphur and phosphorus.

Treatment	Plant height at 90 DAS	Number of branches per plant at 90 DAS	Number of leaves per plant at 90 DAS	Fresh weight	Dry weight
Sulphur Level					
S0 (0 kg/ha)	132.35	3.96	33.64	8.77	2.16
S1 (15 kg/ha)	154.38	5.11	37.53	12.75	3.44
S2 (25 kg/ha)	160.86	5.91	39.56	14.34	4.47
S3 (35 kg/ha)	168.53	6.51	40.67	15.56	5.36
S.Em±	0.50	0.16	0.28	0.28	0.14
C.D. (P= 0.05)	1.46	0.48	0.81	0.82	0.41

Phosphorus Level					
P1 (20 kg/ha)	150.98	4.67	36.22	11.41	3.50
P2 (30 kg/ha)	152.81	5.37	37.73	12.73	3.77
P3 (40 kg/ha)	158.31	6.08	39.60	14.42	4.31
S.Em±	0.43	0.14	0.24	0.24	0.12
C.D. (P= 0.05)	1.26	0.41	0.70	0.71	0.36

Table 2: Yield and yield attributing characters as influenced by different levels of Sulphur.

Treatment	Number of siliquae per plant	Length of siliqua	Number of seeds per siliqua	Test weight	Seed yield per plant	Seed yield per plot	Seed yield per hectare	Stover yield per hectare	Harvest Index
Sulphur Level									
S0 (0 kg/ha)	168.76	3.69	5.96	3.28	4.60	1.10	9.19	36.97	19.87
S1 (15 kg/ha)	203.84	4.41	8.07	4.40	6.25	1.34	11.15	42.77	20.64
S2 (25 kg/ha)	235.56	5.25	9.84	5.32	6.97	1.57	13.07	47.17	21.63
S3 (35 kg/ha)	255.56	5.71	10.98	5.67	7.47	1.79	14.88	50.56	22.71
S.Em±	0.89	0.10	0.15	0.12	0.14	0.03	0.23	0.56	0.32
C.D. (P= 0.05)	2.62	0.28	0.43	0.35	0.40	0.09	0.69	1.65	0.96
Phosphorus Level									
P1 (20 kg/ha)	199.07	4.41	7.60	4.07	5.72	1.29	10.72	41.79	20.23
P2 (30 kg/ha)	214.42	4.67	8.63	4.58	6.28	1.44	12.00	44.12	21.31
P3 (40 kg/ha)	234.30	5.21	9.90	5.34	6.97	1.62	13.51	47.20	22.09
S.Em±	0.77	0.08	0.13	0.10	0.12	0.02	0.20	0.49	0.28
C.D. (P= 0.05)	2.27	0.25	0.37	0.30	0.35	0.06	0.60	1.43	0.81

Table 3: Quality and Economic analysis characters as influenced by different levels of Sulphur.

Treatment	Oil Content	Gross monetary return	Net monetary return	B: C ratio
Sulphur Level				
S0 (0 kg/ha)	36.38	54267.00	33493.00	1.61
S1 (15 kg/ha)	39.36	65592.00	43993.00	2.03
S2 (25 kg/ha)	41.28	76625.00	54476.00	2.45
S3 (35 kg/ha)	42.47	86894.00	64195.00	2.83
S.Em±	0.34	3882.17	3882.17	0.18
C.D. (P= 0.05)	1.02	11646.51	11646.51	0.54
Phosphorus Level				
P1 (20 kg/ha)	38.64	63113.00	41689.00	1.93
P2 (30 kg/ha)	39.88	70412.00	48607.00	2.22
P3 (40 kg/ha)	41.11	79008.00	56821.00	2.54
S.Em±	0.30	4482.75	4482.75	0.21
C.D. (P= 0.05)	0.90	2241.37	13448.25	0.63

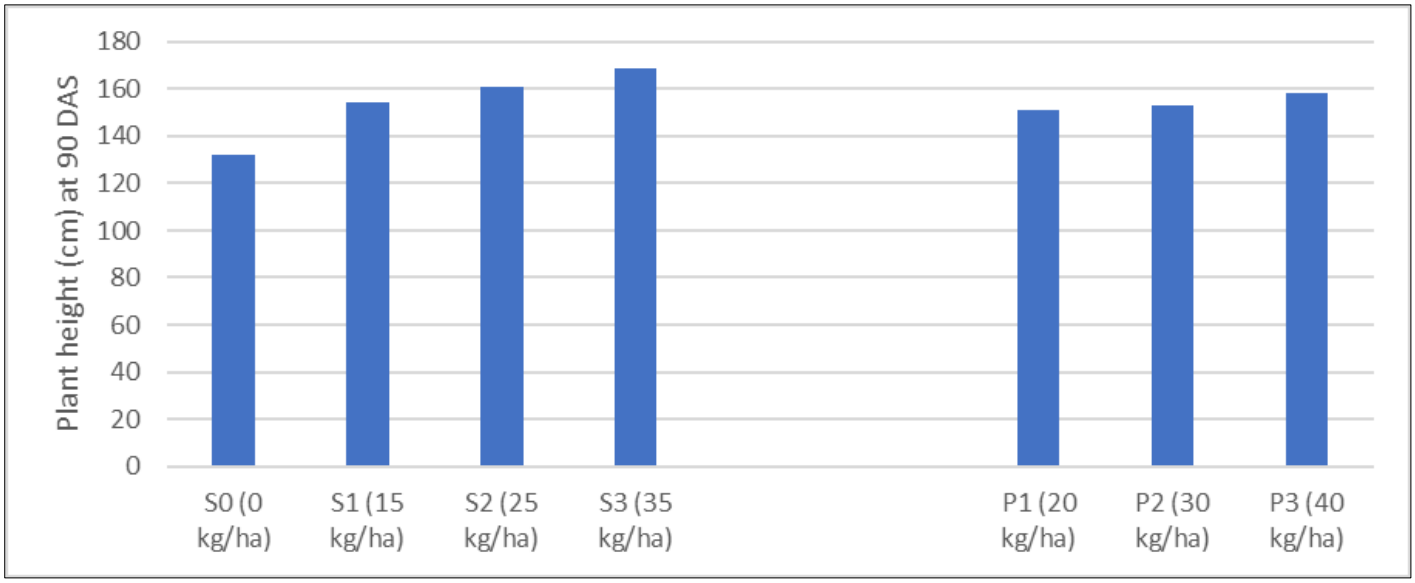

Fig 1: Plant height of mustard at 90 DAS as influenced by different levels of Sulphur and phosphorus.

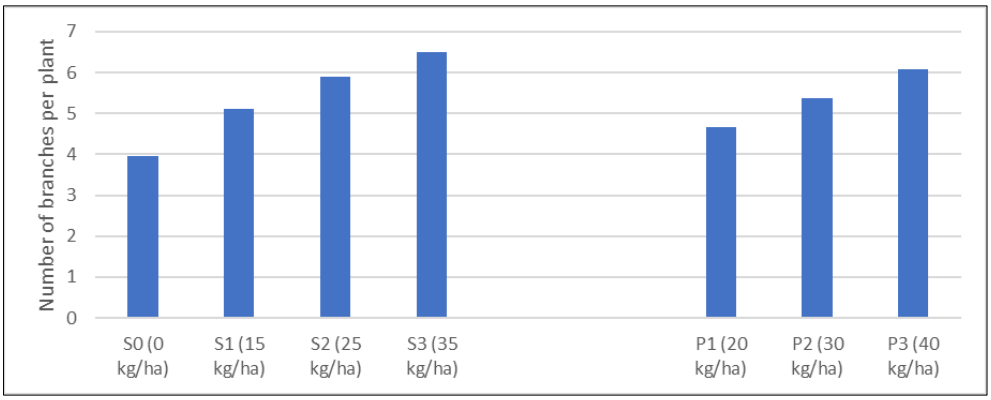

Fig 2: Number of branches per plant of mustard at 90 DAS as influenced by different levels of Sulphur and phosphorus.

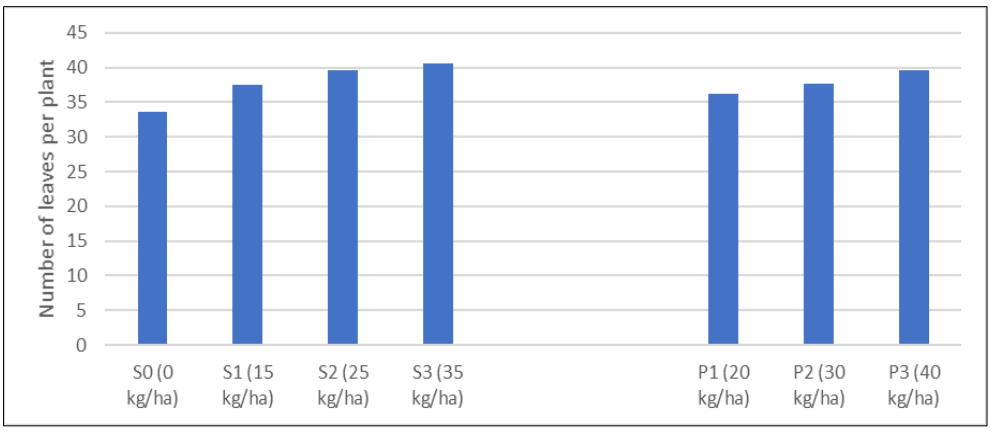

Fig 3: Number of leaves per plant of mustard at 90 DAS as influenced by different levels of Sulphur and phosphorus.

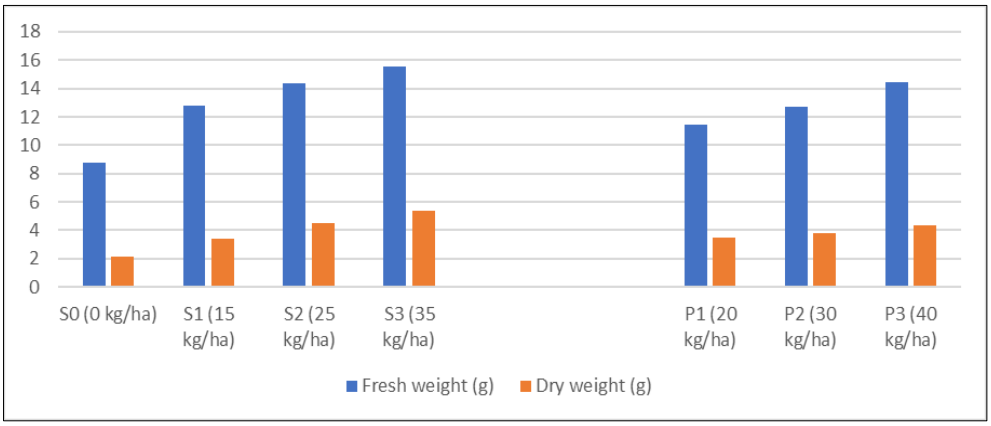

Fig 4: Fresh and dry weight (g) of mustard as influenced by different levels of Sulphur and phosphorus.

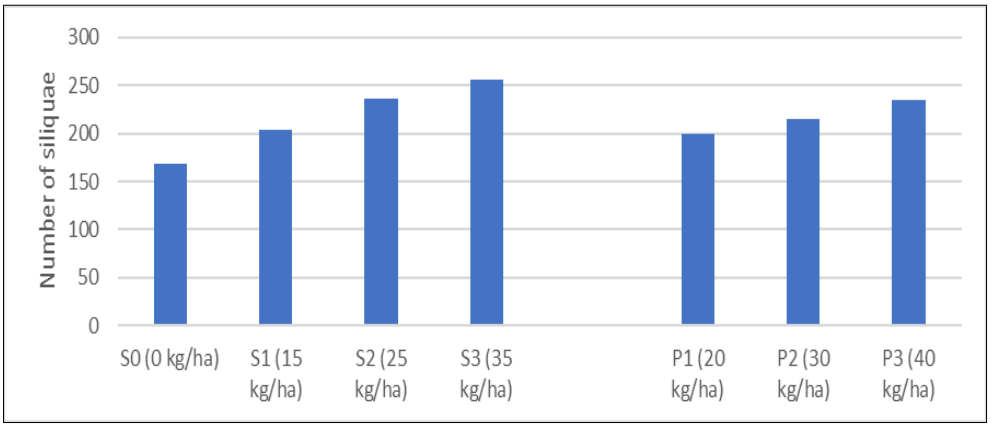

Fig 5: Number of siliquae per plant of mustard as influenced by different levels of Sulphur and phosphorus.

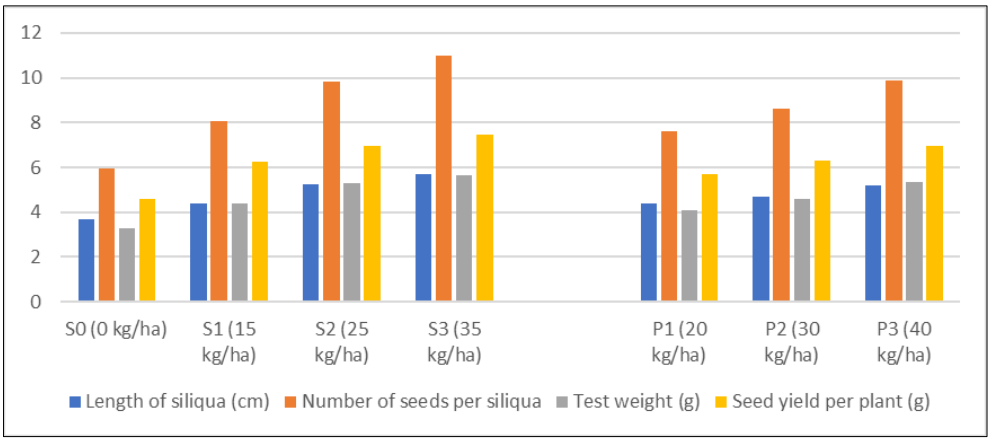

Fig 6: Length siliqua, number of seeds per siliqua, test weight and seed yield per plant of mustard as influenced by different levels of Sulphur and phosphorus.

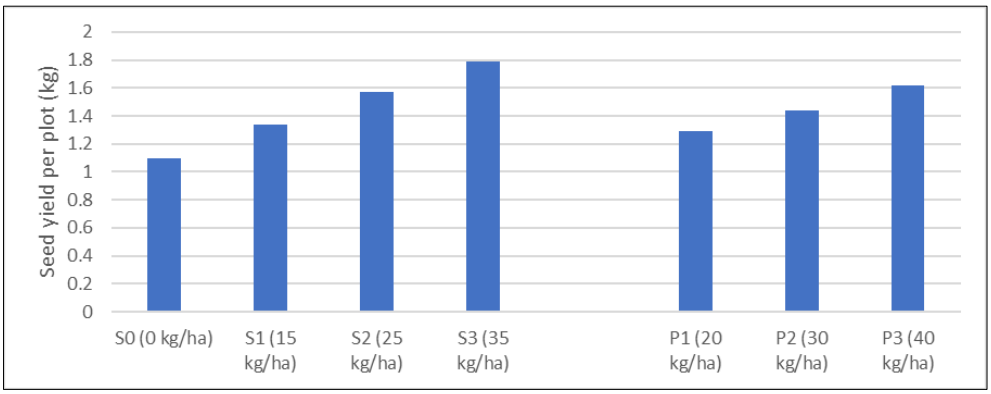

Fig 7: Seed yield per plot (kg) of mustard as influenced by different levels of Sulphur and phosphorus.

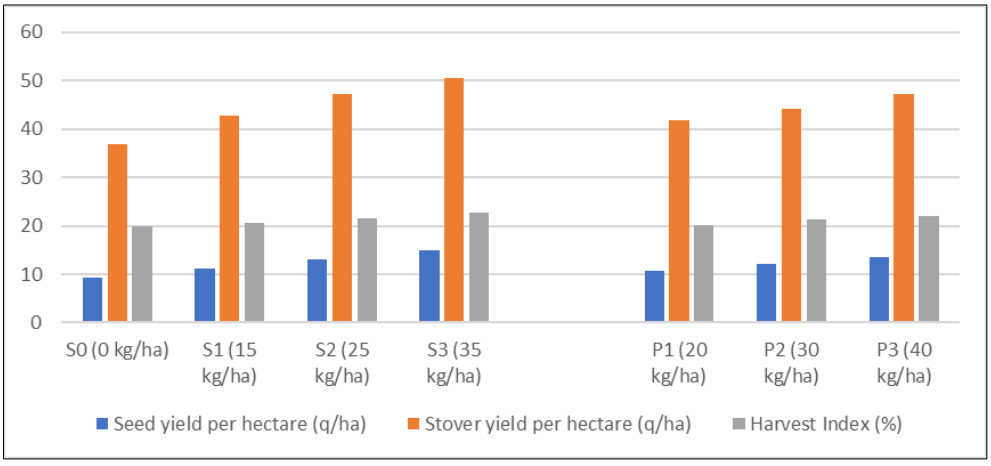

Fig 8: Seed yield (q/ha), stiver yield (q/ha) and harvest index (%) of mustard as influenced by different levels of Sulphur and phosphorus

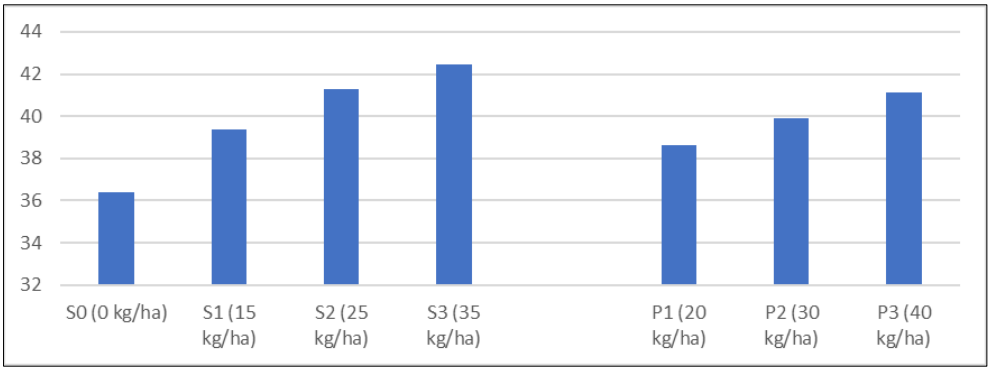

Fig 9: Oil content (%) of mustard as influenced by different levels of Sulphur and phosphorus.

Conclusion

This experiment concluded that the application of Sulphur @ 35 kg/ha in combination with phosphorus @ 40 kg/ha noted the maximum and significantly higher values.

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