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Effect of phosphorus and sulphur levels on growth and yield of yellow mustard (*Brassica campestris* L.)

Ratikanta Sahoo, Vikram Singh and Dhananjay Tiwari

Abstract
A field research trial was conducted to study "Effect of phosphorus and sulphur levels on growth and yield of Yellow Mustard (*Brassica campestris* L.)" at Crop Research Farm, Naini Agriculture Institute, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during the period of Rabi season of 2020-21. The experiment was carried out in a randomized block design comprising of nine treatments of three levels of phosphorus (40,50 and 60 kg P_2 O_5 /ha) and sulphur (30,40 and 50 kg S/ha) which were replicated three times. The nutrients phosphorus and sulphur were applied through DAP and gypsum. The result revealed that growth and yield attributes of yellow mustard ware increased through successive increases in phosphorus and sulphur levels. The application of 60 kg phosphorus/ha + 50 kg sulphur/ha reported significantly maximum plant height (120.79 cm), number of branches per plant (8.67), dry matter accumulations (19.39 g), crop growth rate (13.92 g/m²/day), relative growth rate (0.052 g/g/day), siliqua per plant (94.67), seed per siliqua (43.33), test weight (3.87 g), seed yield (1893.33 kg/ha) and stover yield (4323.33 kg/ha) and also found highest gross return (₹126853.11/ha), net return (₹66396.11/ha) and benefit: cost ratio (1.09) respectively.

Keywords: Yellow mustard, phosphorus, sulphur, growth and yield

1. Introduction
Yellow Mustard (*Brassica compestris* L.) or *Brassica hirta or Sinapsis alba* is a very important good oilseed crop among the rapeseed and mustard group in terms of high oil and protein content. It is also called as white mustard or sufed rai in hindi which belongs to the family *Cruciferae* and genus Brassica and it has an eminent place among all oilseed crops next to groundnut (Verma *et al.*, 2018) [19]. Yellow Mustard (*Brassica campestris* L.) is the 2nd prominent oil-yielding crop among the Brassica family after Indian mustard (*Brassica juncea* L.) followed by toria (*Brassica campestris var. toria*) which contain a chemical named as "Sinalbin". Yellow mustard (*Brassica campestris* L.) is originated from the European temperate region. 23% of the world total rapeseed and mustard production is done in India. India ranks third in respect of area coverage and production of rapeseed and mustard after China and Canada. In India rapeseed and mustard are grown in an area of 6.36 million hectare which has a production of 8.03 million tonnes of seeds (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2012-2013) [5]. Among all rapeseed and mustard growing states, Rajasthan, Utter Pradesh produce about 80% of total rapeseed and mustard production of entire country. In utter Pradesh, mustard are grown in an area of about 0.66 million hectares and the production and productivity of about 0.74 million tones and 1112kh/ha. (Anonymous, 2015) [1]. The oil content of the yellow sarson seeds ranges from 35-48% whereas Indian mustard seed ranges from 38 to 40% (NIIR Board).
Phosphorus is referred as "KING PIN" in Indian agriculture (Solanki *et al.*, 2015) [16]. Indian soil are low, medium and high in availability of phosphorus and the total concentration of phosphorus in soil surface varies from 0.02 to 0.10%. It acts as an energy currency for living cell as it contains high adenosine tri-phosphate (ATP). Phosphorus promotes vigorous root and shoot growth. Phosphorus helps in seed formation and proper seed filling in seed/siliqua, increasing the size of seed, promoting the development of nitrogen fixing bacteria and also helps in increasing maturity of seed and oil content of seeds.Phosphorus deficiency in soil supresses the root and shoot growth of rapeseed and mustard plants so that the dry matter usually decreases. And in serious cases, it prevents the flowering on plant.
After phosphorus, the next most important element that hugely required by the oilseed crops is Sulphur. Sulphur is 13th most important available element present in earth crust which varies from 0.06 to 0.10 percent and also 4th most important major and secondary nutrient which has major role in oil seed production.

Oil seed crops required sulphur largely because oil seed crops need sulphur containing amino acid that are cystine (27%), cysteine (26%) and methionine(21%) which are responsible for vegetative growth of plant and also for protein and oil synthesis in plant. Sulphur is mainly responsible for formation of glucosinolates (in rapeseed and mustard oil), glucosides and green colour (chlorophyll).and also responsible for activation of sulphydryl linkage which has the main role of adding pungency to oil crops mainly rapeseed and mustard. Sulphur increase the oil content in oil seed (Kumar and Trivedi 2012) [8] Brassica family crops are more prone to sulphur deficiency by showing symptom like leaves cupping or curling inward with reddish color on lower surface of leaves and in severe cases it extends both side of leaves

Considering and noticing the above these point in mind a field experiment entitled, "Effect of Phosphorus and Sulphur Levels On Growth and Yield of Yellow Mustard (*Brassica campestris* L.)." was carried out with the following main objectives: To study the influence of phosphorus and sulphur levels on growth and yield of yellow mustard and To work out the economics of different treatments combinations

2. Materials and Methods

The above mentioning agronomic field experiment was executed at the crop research farm of Naini Agriculture institute, Department of Agronomy, SHUATS, Prayagraj, Utter Pradesh during the rabi season of 2020-21. The research farm is situated geographically at 25º 24' 42" N latitude, 81º 50' 56" E longitude and 98 m altitude above the mean sea level. The area is located near the bank of river Yamuna and from 7 to 8 km away from Prayagraj City. Just before the layout preparation and sowing, 5 samples of soil from the various spot of the allotted research plot was collected randomly from a depth of 0 to 15 cm for analysing the soil sample. The soil texture of the experimental site was sandy loam having available N (110.8 kg/ha) P (6.9 kg/ha), potassium (119.2kg/ha) and organic carbon of soil was of 0.34% with 6.8 available pH of soil. the experimental plot was a randomized block design with having nine treatments which replicated three times with a suitable plot size was of 3m×3m.There were nine treatments combination used for this experiment which are T_1 : 40 kg Phosphorus + 30 kg Sulphur, T_2: 40 kg Phosphorus + 40 kg Sulphur, T_3: 40 kg Phosphorus + 50 kg Sulphur, T_4: 50 kg Phosphorus + 30 kg Sulphur, T_5: 50 kg Phosphorus + 40 kg Sulphur, T_6: 50 kg Phosphorus + 50 kg Sulphur, T_7: 60 kg Phosphorus + 30 kg Sulphur, T_8: 60 kg Phosphorus + 40 kg Sulphur, T_9: 60 kg Phosphorus + 50 kg Sulphur. Urea, DAP, MOP and Gypsum were taken as major sources of the nutrients N, P, K & S for the application of fertilizer. Half doses of nitrogen through urea and full doses of phosphorus, potassium and sulphur through DAP, MOP and Gypsum were applied at the time of sowing as basal doses and the rest of nitrogen were applied as top-dressed at 30 days after sowing with maintaining spacing 45cm × 10cm. Variety NRCYS-05-02 was used for sowing in line. The observation recorded for plant growth and yield parameters were subjected to statistical analysis by using the analysis of variance suggested by Fisher (1950).

3. Results and Discussion

3.1 Growth attributes

Data represented in table 1 revealed the effect of phosphorus and sulphur levels on growth attributes of yellow mustard (*Brassica campestris* L.). the growth attributes that were considered in this experiment for observations were plant height (cm), number of branches per plant, dry matter accumulations (g/plant), crop growth rate (CGR) (g/m²/day) and relative growth rate (RGR) (g/g/day).

The growth parameters of yellow mustard were significantly influenced with increasing the levels of phosphorus and Sulphur. The highest (120.79 cm) plant height was achieved in T_9 (60 kg Phosphorus + 50 kg Sulphur) which was significantly superior over all the treatment combination but T_8 (60 kg Phosphorus + 40 kg Sulphur) was found to be statistically at par with T_9 . Number of branches per plant and dry matter accumulations per plant were significantly influenced by the incensement of phosphorus and sulphur levels. Maximum (8.47) branches per plant and highest (19.39 g/plant) dry matter accumulations were observed in T_9 (60 kg Phosphorus + 50 kg Sulphur) which were found to superior over all treatments. No any treatment found to statistically at par among themselves. In case of CGR, significantly highest (13.93 g/m²/day) CGR was recorded in T_9 (60 kg Phosphorus + 50 kg Sulphur) without showing at par values and incase of RGR, significantly maximum (0.052 g/g/day) RGR was reported in T_9 (60 kg Phosphorus + 50 kg Sulphur) but the T_8 (60 kg Phosphorus + 40 kg Sulphur) was found to statistically at par with T_9.

Increase in height of plant and number of branches per plant were due to the positive effect of phosphorus at higher levels which provide better environment of nutrition for active growth of plants at vegetative stages and also help in multiplication, elongation and expansion of cell in plant body due to which increase in height and branches of plant. Not only phosphorus, sulphur was also responsible for promoting and increasing the amino acid metabolic constituents in plant body which might be the another reason of increase in plant height and branches. maximum dry matter accumulations of plant (g/plant) were achieved due to increase the supply of phosphorus and sulphur levels which helps in promoting and hastening the metabolic process, physiological activities and increasing the photosynthesis process related to growth as a result of increasing in height in plant, number of branches of plant and leaves and others above ground and below ground structures of plant which were the probable reason of hastening the dry matter accumulations in plant. All these results finding were found to be similar with Mallick *et al.* (2015) [9], Famda *et al.* (2017) [6], Upadhyay *et al.* (2018) [18], Begum *et al.* (2012) [2], Sahoo *et al.* (2017) [13], Rajput *et al.* (2018) [12], Singh *et al.* (2016) [14], Yadav *et al.* (2014) [20] and Verma *et al.* (2018) [19].

3.2 Yield attributes

Data represented in table 2 indicated the effect of phosphorus and sulphur levels on growth attributes of yellow mustard (*Brassica campestris* L.). the yield characters that were considered in this experiment for observations were like siliqua/plant (No.), seeds/siliqua (No.), test weight (g), seed yield (kg/ha) and stover yield (kg/ha).

The yield attributes of yellow mustard were significantly influenced with increasing the levels of phosphorus and sulphur. Significantly Maximum (94.67) number of siliqua/plant was obtained with the application of T_9 (60 kg Phosphorus + 50 kg Sulphur). The highest (43.33) number of seed /siliqua was recorded in T_9 (60 kg Phosphorus + 50 kg Sulphur) which was significantly superior over all treatment. Significantly maximum (3.87 g) test weight of seed was found with application of highest treatment combination i.e. of T_9

(60 kg Phosphorus + 50 kg Sulphur) but T_6 (50 kg Phosphorus + 50 kg Sulphur), T_7 (60 kg Phosphorus + 30 kg Sulphur) and T_8 (60 kg Phosphorus + 40 kg Sulphur) was found statistically at par with T_9 (60 kg Phosphorus + 50 kg Sulphur). Highest (1893.33 kg/ha) seed yield was recorded in T_9 (60 kg Phosphorus + 50 kg Sulphur) which was significantly superior over all but in case of stover yield, highest (4323.33kg/ha) significant stover yield was shown in T_9 (60 kg Phosphorus + 50 kg Sulphur) and T_7 (60 kg Phosphorus + 30 kg Sulphur) and T_8 (60 kg Phosphorus + 40 kg Sulphur) was found statistically at par with T_9 (60 kg Phosphorus + 50 kg Sulphur).

Increase in siliqua/plant (No.) seeds/siliqua (No.) and test weight (g) were due to the positive effect of phosphorus and sulphur at higher levels which is responsible for stimulating of flower, formation of siliqua and formation of seed in siliqua and also the maximum amount of phosphorus nutrient found in the seed and siliqua of yellow mustard plant which is responsible for formation seed and thickness of seed and the favorable effect of sulphur enhanced the translocation of photosynthates product toward seed and sink strength and production of assimilates was increased which may be the reason of increase siliqua/plant (No.) seeds/siliqua (No.) and test weight (g). increase in seed and stover yield were due to higher amount of phosphorus in plant and also found higher siliqua/plant, seed/siliqua, test weight which were effectively correlated with yield of the plant. These results were closely agreed to Nath *et al.* (2018) [10], Kabdal *et al.* (2018) [7], Chetry *et al.* (2018) [4], Tomar *et al.* (2007) [17], Sonalki *et al.* (2015) [16], Chauhan *et al.* (2020) [3] and Sipai *et al.* (2015) [15].

3.3 Economics attributes

Data represented in table 3 shown the economics performance of different treatment combination which evaluation was based on cost of cultivation (₹/ha), gross return (₹/ha), net return (₹/ha) and benefit cost ratio (B:C). Highest cost of cultivation (₹ 60457/ha), gross return (₹ 126853.11/ha), net return (₹ 66396.11/ha) and benefit cost ratio (1.09) ware found with the application of T_9 (60 kg Phosphorus + 50 kg Sulphur). Increased in economic performance of yellow mustard ware due to the positive effect of phosphorus and sulphur combination on plants at higher levels which were responsible for higher marketable seed and stover yield.

Table 1: Effect of Phosphorus and Sulphur Levels on Growth Parameters of Yellow Mustard (*Brassica campestris* L.)

Treatments	Plant height (cm) 100 DAS	Branches/plant (No.) 100 DAS	Plant dry matter accumulations (g/plant) 100 DAS	Crop growth rate (CGR) (g/m^2 /day) 80-100 DAS	Relative growth rate (RGR) (g/g/day) 80-100 DAS
T_1= 40 kg P/ha + 30 kg S/ha	90.46	4.27	10.63	8.57	0.032
T_2= 40 kg P/ha + 40 kg S/ha	93.47	4.87	11.28	8.83	0.032
T_3= 40 kg P/ha + 50 kg S/ha	96.97	5.20	11.75	8.97	0.030
T_4= 50 kg P/ha + 30 kg S/ha	103.46	6.20	12.46	9.02	0.026
T_5= 50 kg P/ha + 40 kg S/ha	103.87	6.67	13.09	9.37	0.027
T_6= 50 kg P/ha + 50 kg S/ha	110.95	7.20	13.48	9.50	0.030
T_7= 60 kg P/ha + 30 kg S/ha	112.95	7.60	14.72	10.66	0.035
T_8= 60 kg P/ha + 40 kg S/ha	116.95	8.00	16.12	11.40	0.049
T_9= 60 kg P/ha + 50 kg S/ha	120.79	8.67	19.39	13.92	0.052
Sem (+)	1.62	0.18	0.45	0.45	0.002
CD (5%)	4.86	0.55	1.36	1.36	0.007

Table 2: Effect of Phosphorus and Sulphur Levels on Yield Attributes of Yellow Mustard (*Brassica campestris* L.)

Treatments	siliqua/ plant (No.)	Seeds/siliqua (No.)	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)
T_1= 40 kg P/ha + 30 kg S/ha	33.40	21.53	2.75	896.67	2293.33
T_2= 40 kg P/ha + 40 kg S/ha	36.53	24.40	2.82	1026.67	2520.00
T_3= 40 kg P/ha + 50 kg S/ha	44.13	27.07	3.12	1160.00	2793.33
T_4= 50 kg P/ha + 30 kg S/ha	50.07	30.60	3.28	1200.00	3140.00
T_5= 50 kg P/ha + 40 kg S/ha	60.73	32.80	3.33	1340.00	3333.33
T_6= 50 kg P/ha + 50 kg S/ha	67.73	36.00	3.49	1493.33	3660.00
T_7= 60 kg P/ha + 30 kg S/ha	74.27	38.40	3.61	1526.67	3963.33
T_8= 60 kg P/ha + 40 kg S/ha	84.07	40.53	3.77	1710.00	4176.67
T_9= 60 kg P/ha + 50 kg S/ha	94.67	43.33	3.87	1893.33	4323.33
Sem (+)	2.46	0.67	0.15	54.36	191.08
CD (5%)	7.38	2.02	0.46	162.98	572.87

Table 3: Effect of Phosphorus and Sulphur Levels on Economics of Yellow Mustard (*Brassica campestris* L.)

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit cost ratio
T_1= 40 kg P/ha + 30 kg S/ha	48682	60076.89	11394.89	0.23
T_2= 40 kg P/ha + 40 kg S/ha	54082	68786.89	14704.89	0.24
T_3= 40 kg P/ha + 50 kg S/ha	59382	77720	18338	0.30
T_4= 50 kg P/ha + 30 kg S/ha	49207	80400	31193	0.63
T_5= 50 kg P/ha + 40 kg S/ha	54607	89780	35173	0.64
T_6= 50 kg P/ha + 50 kg S/ha	59907	100053.11	40146.11	0.67
T_7= 60 kg P/ha + 30 kg S/ha	49757	102286.89	52529.89	1.05
T_8= 60 kg P/ha + 40 kg S/ha	55157	114570	59413	1.07
T_9= 60 kg P/ha + 50 kg S/ha	60457	126853.11	66396.11	1.09

4. Conclusion

From the result of above field research it can be concluded that among all the treatment combination, the treatment T_9 (60 kg Phosphorus + 50 kg Sulphur) was considered to be the best treatment combination for achieving maximum seed yield (1893.33 kg/ha), stover yield (4323.33kg/ha), gross return (₹ 126853.11/ha), net return (₹ 66396.11/ha) and benefit cost ratio (1.09) in yellow mustard plant with variety (NRCYS-05-02).

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