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Effect of different levels of phosphorous and sulphur on growth and yield of mustard (*Brassica juncea* L.) under teak (*Tectona grandis*) based agroforestry system

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Abstract
Field experiment was conducted to find out the "Evaluate of Different levels of phosphorous and sulphur on growth and yield of mustard (*Brassica juncea L.*) under Teak based agroforestry system" at Forest Nursery, the research farm of College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U.P.), experiment laid out in randomized block design with three levels of Phosphorus (0 kg ha^{-1}), (30 kg ha^{-1}) and (60 kg ha^{-1}) and three levels of Sulphur (20kg ha^{-1}), (40kg ha^{-1}) and (60kg ha^{-1}). The result shows that application of different levels combination of phosphorus and sulphur fertilizers increased growth and yield of mustard. It was recorded from the application of phosphorus and sulphur fertilizers in treatment T_8 (P_{60} kg/ha^{-1} + S_{60} kg/ha^{-}) increased Pre-harvest observation viz. plant height, number of leaves and number of branches per plant increased. It was also concluded from trail that the application of fertilizers in treatment T_8[P_{60} kg/ha^{-1} + S_{60} kg/ha^{-}] was found in increasing post- harvest observations *viz.*, Number of siliqua $plant^{-1}$, Length of siliqua $plant^{-1}$ (cm), Test weight (g) and Seed yield (q/ha).

Keywords: Phosphorus, sulphur, teak, agroforestry

1. Introduction
The forest analyse of India evaluate the country's forest cover to be 67.55 million hectares (Anonymous, 2001) [1]. Agroforestry, in true sense, has been realized as the need of the hour. It does not confine to regional, geographical or agro climatic boundaries. Agroforestry is the combination of agriculture and Silviculture in one system where the species changes between perennials, annuals and utilization of, for example green manure, coppicing, diverging crop rotation, mulching, contour hedgerows or alley cropping (Mercer, 2004) [4]. When two or more plants species grow together on the same land management until, one component may influence the performance of the others components as well as the system as a whole (Nair, 1993) [6].

India is the third largest rapeseed-mustard producer in the world after China and Canada with 12 per cent of world's total production (2006-07). This crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop. Due to the gap between domestic availability and actual consumption of edible oils, India has to resort to import of edible oils. Rapeseed-mustard is the major source of income especially even to the marginal and small farmers in rain fed areas Since these crops are cultivated mainly in the rain-fed and resource scarce regions of the country, their contribution to livelihood security of the small and marginal farmers in these regions is also very important. By increasing the domestic production substantial import substitution can be achieved.

India stands fourth largest edible oil economy in world after the U.S., China and Brazil, and is the second largest importer after China. India accounts for seven per cent of global oilseeds output; seven per cent of global oil meal production; six per cent of global oil meal exports; six per cent of global vegetable oil production; 14 per cent of global vegetable oil imports; and 10 per cent of global edible oils. Rapeseed-mustard cultivation is carried out widely in 13 states of India. Rajasthan ranks first in total mustard production (48.6%) followed by Uttar Pradesh (13.4%) and Haryana (11.4%) (Anonymous, 2010) [1].

Brassica juncea is a herbaceous annual plant. The plant shorter in height (45-150cm) then mustard (Rai.). The roots are more are less confined to surface layers with an extensive lateral spread. The stem is usually covered with a waxy deposit. In rape, leaves are borne sessile and are glabrous and hairy.

Fruits are thicker than those of mustard and are laterally compressed, with a beak one-third to half their length. Seeds are either yellow or brown with a smooth seed coat. Rape is self-pollinated, but cross pollination also takes place to some extent.

Tectona grandis is a deciduous trees having straight cylindrical bole, spares canopy and deep tap root system which makes it very suitable for agroforestry system. It thrives best in fairly moist, warm, tropical climate in dry localities, subject to great heat and drought in the hot season. Teak can tolerate extreme case of rainfall and as low as less than 750 mm per annum with long dry season and water vapour pressure below 30% and 2500 mm received during monsoons. *i.e.,* from mid- June to mid- September but is sensitive to frost.

Phosphorus has a great role in energy storage and transfer and closely related to cell division and development of mustard. Phosphorus is a constituent of nucleic acid, phytin and phospho- lipid. Phosphorus compound act as "energy currency" within plants. Phosphorus is essential for transformation of energy, in carbohydrate metabolism, in fat metabolism, in respiration of plant and early maturity of mustard Potassium play important role in formation of protein and chlorophyll and it provide much of osmotic "pull" that draw water into plant roots. Potassium produces strong stiff straw in mustard and reduces lodging in mustard. Potassium imparts increase vigour and disease resistance to plant Singh *et al.,* (2010) [7].

Sulphur is a vital component of essential amino acids. In general, the amount of S taken up to produce one ton of economic yield (main produce) is considered to be 12 kg for oilseeds. When averaged across a number of field studies, the response to applied S (in terms of yield increase over no-S) was 30% or above in mustard. S fertilization significantly improved various quality parameters within plant system. The N/S ratio and the content of nitrate and non-protein N were reduced, and protein content increased.

Material and Methods

The field experiments were conducted at experimental field of forestry nursery college of Forestry, Department of Silviculture and Agroforestry, SHUATS, Allahabad-211007, India during the growing Rabi season of 2017- 2018. Before sowing the Indian mustard crop, soil samples were taken for physical and chemical analysis. Soil samples were collected from the experimental soil with the help of a soil auger to a depth of 0-30 cm prior to fertilizer application. Composite samples were air dried ground and passed through a 2 mm sieve and got analyzed for the physio-chemical properties. The soils are generally low to medium in organic matter content. The soil characteristic of the experiment is shown in Table 1. The experiment was conducted in fixed plot under Randomized Block Design (RBD) with 9 treatments and 3 replications.

Table 1: Soil characteristics of the site

Sand (%)	Silt (%)	Clay (%)	Textural Class	Organic Carbon (%)	Nitrogen (N) kg ha^{-1}	Phosphorus (P) kg ha^{-1}	Potassium (K) kg ha^{-1}	Soil pH	EC (dSm^{-1})
68.5	11.9	19.6	Sandy Loam	17	43	14.6	245	7.6	0.17

In the soil was given full optimum dose the three level of sulphur T_1(P_0+ S_{20} Kg/ha)+ T_2 (P_0+ S_{40} kg /ha) + T_3 (P_0+ S_{60}Kg/ha) + T_4(P_{30}+S_{20}Kg /ha) in 2x2 m plot in the same way Phosphorous T_5 (P_{30}+S_{40} Kg/ha) + T_6 (P_{30}+S_{60} Kg /ha)+ T_7 (P_{60}+S_{20} Kg/ ha) + T_8 (P_{60}+S_{40} Kg/ ha) + T_9 (P_{60}+S_{60}) respectively. The Basel dose of N P K, and S were given in the form of Urea, DAP, SSP, MOP, elements and sulphur. The cultivated variety is "Hybrid Mustard"(AEGIS-741) was selected having about 150 to 160 cm in height with average yield range from 18 q/ha. Seed were sown at the rate of 26 q/ha uniformly in all the treatment set. The seed were sown on 25, OCT 2017 to FEB15, 2018 were harvested the crop. Observations on different growth and yield parameters were recorded on 5 plants selected randomly and workout on hectare basis. The data obtained were analyzed statistically using ANOVA table. The means differences among the treatments were compared by least significant difference test (FRBD) at 0.05 levels.

Results and Discussion

Pre-harvest observation

Plant height at 90 DAS

Data presented in table no 2 indicated that highest the plant height (cm) at 90 DAS was observed in treatment T_8 168.61cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the plant height was observed in treatment T_0 156.99cm P_0 (control)+ S_{20} kg/ha^{-1} under teak based Agroforestry system respectively. The result obtained was found Significant throughout the study. The probable reasons for recording higher plant height in T_8-P_{60} kg/ha^{-1} + S_{60} kg/ha^{-}, might be due to higher dose of phosphorus and sulphur, in a readily available form to plant, which greatly help the plant to expose its potential to grow vigorously. (Mohiuddin *et al.,* 2011) [5]

Number of leaves per plant at 90 DAS

Data presented in table no 2 indicated that highest the Number of leaves at 90 DAS was observed in treatment T_8 16.83 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the Number of leaves was observed in treatment $T_0$9.98 cm P_0 (control)+ S_{20} kg/ha^{-1} under teak based Agroforestry system respectively. The result obtained was found Significant throughout the study. The probable reasons for recording higher Number of leaves in T_8-P_{60} kg/ha^{-1} + S_{60} kg/ha^{-}, might be due to higher dose of phosphorus and sulphur, in a readily available form to plant, which greatly help the plant to expose its potential to grow vigorously. (Mohiuddin *et al*., 2011) [5]

Number of branches per plant at 120 DAS

Data presented in table no 2 indicated that highest the Number of branches at 120 DAS was observed in treatment T_8 22.89 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the Number of branches was observed in treatment T_0 17.56 cm P_0 (control)+ S_{20} kg/ha^{-1} under teak based Agroforestry system respectively. The result obtained was found Significant throughout the study. The probable reasons for recording higher Number of branches in T_8-P_{60} kg/ha^{-1} + S_{60} kg/ha^{-}, might be due to higher dose of phosphorus and sulphur, in a readily available form to plant, which greatly help the plant to expose its potential to grow vigorously.

Table 2: Effect of Different levels of phosphorous and sulphur on Pre-harvest observation of mustard (*Brassica juncea*) under Teak based Agroforestry system.

Treatments No	Plant height(cm)	Number of leaves per plant	Number of branches per plant
T_0	156.99	9.98	17.56
T_1	159.72	13.17	18.11
T_2	160.26	13.61	18.45
T_3	160.51	13.88	19.45
T_4	164.80	13.91	19.67
T_5	166.32	15.45	20.67
T_6	167.44	15.61	21.56
T_7	168.44	15.91	21.78
T_8	168.61	16.83	22.89
F-test	S	S	S
S. Em. (±)	0.875	0.479	0.472
C.D. at	1.855	1.016	1.001

Post- harvest observation

Number of Siliqua plant^{-1}.

Data presented in table no 3 indicated that highest the Number of siliqua per plant observed in treatment T_8 365.16 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the Number of siliqua per plant plant was observed in treatment 163.78 cm P_0 (control)+ S_{20} kg/ha^{-1} under Teak based Agroforestry system respectively. The result obtained was found Significant throughout the study. (Karthikeyan and Shukla 2008 and Verma *et al.*, 2012) [3, 9]

Length of siliqua plant^{-1} (cm)

Data presented in table no 3 indicated that highest the Length of siliqua per plant observed in treatment T_8 4.50 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the Length of siliqua per plant plant was observed in treatment 2.90 cm P_0 (control)+ S_{20} kg/ha^{-1} under Teak based Agroforestry system respectively. The result obtained was found Significant throughout the study. Application of S +P had increased siliqua plant^{-1}due to might be higher soil organic matter improving soil structure and maximized microbial activities. (Verma *et al.*, 2012) [9]

Test weight (g)

Data presented in table no 3 indicated that highest the Test weight was observed in treatment T_8 6.03 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} The lowest value for the Test weight was observed in treatment 3.71 cm P_0 (control)+ S_{20} kg/ha^{-1} under Teak based Agroforestry system respectively. Increase in growth, yield characters and finally crop yield could be ascribed to the overall improvement in plant growth, vigour and production of sufficient photosynthesis through increased leaf area. (Dubey *et al.*, 1993) [2]

Seed yield (q/ha)

Data presented in table no 3 indicated that the highest Seed yield (q/ha) was observed in treatment T_8 23.38 cm P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1} the lowest value for the Seed yield (q/ha) was observed in treatment 9.53 cm P_0 (control) + S_{20} kg/ha^{-1} under Teak based Agroforestry system respectively. Increase in growth, yield characters and finally crop yield could be ascribed to the overall improvement in plant growth, vigour and production of sufficient photosynthesis through increased leaf area. the increase in grain yields might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favorable increase in yield attributing characters which ultimately led towards an increase in economical yield. (Singh 2007) [8]

Table 3: Effect of Different levels of phosphorous and sulphur on Post- harvest observations of mustard (*Brassica juncea*) under Teak based Agroforestry system.

Treatments No	Number of Siliqua plant^{-1}	Length of Siliqua plant^{-1} (cm)	Test weight (g)	Seed yield (q/ha)
T_0	163.78	2.90	3.71	9.53
T_1	199.78	3.31	4.32	12.70
T_2	242.12	3.50	4.46	14.95
T_3	283.12	3.78	4.76	17.28
T_4	284.45	3.98	5.06	18.00
T_5	346.12	4.00	5.46	20.38
T_6	360.78	4.15	5.54	20.55
T_7	362.97	4.25	5.66	21.18
T_8	365.16	4.50	6.03	23.38
F-test	S	S	S	S
S. Em. (±)	1.397	0.387	0.159	0.558
C.D. at	2.963	0.820	0.33	1.183

Conclusion

On the basis of trail it has been founded that the highest growth and yield have been seen in T_8 (P_{60} kg/ha^{-1} + S_{60} kg/ha^{-1}) found superior in all respect plant height, number of leaves, Number of branches, Number of siliqua, Number of seeds per siliqua, length of siliqua, grain yield, Stover yield, harvest index. However, since this is based on one year experiment, further trials may be needed to substantiate the results.

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