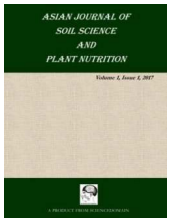

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Effect of Macro-nutrients and Farm Yard Manure on Productivity and Profitability of Mustard (*Brassica juncea* L.) in Western Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration between all authors. Author VK designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors VS and SS managed the analyses of the study. Author NKT managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *winter* season of 2015-16 at agricultural farm of IFTM University, Lodhipur Rajput, Moradabad (UP), India, to evaluate the effect of NPK, Sulphur and FYM on growth and yield of mustard (*Brassica juncea* L.) in western Uttar Pradesh. The experiment consisted ten treatment combination was laid out in randomized block design with three replications. The result revealed that the highest growth and yield attributing characters recorded with the application of 75% NPK in combination with 40 kg S and 10 MT FYM ha^{-1}. Highest plant height (174.63 cm), number of branches $plant^{-1}$ (24.47), dry weight (21.47 g), number of siliquae $plant^{-1}$ (381.40), 1000-seed weight (5.52 g), seed yield (1541.5 kg ha^{-1}) and stover yield (5161.0 kg ha^{-1}) was recorded the application of 75% NPK in combination with 40 kg S and 10 MT FYM ha^{-1}. Net return (Rs. 33119.4) and B: C ratio (1.04) was significantly differ from control. Oil and protein content was significantly influenced with the application of Sulphur and FYM. Significantly higher oil content was recorded at 75% NPK along with 40 kg S and 10 MT FYM ha^{-1}. Protein content was significantly higher in 75% NPK along with 40 kg S and 10 MT FYM ha^{-1}.

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Keywords: NPK; sulphur; FYM; mustard; yield; quality.

1. INTRODUCTION

Indian mustard (*Brassica juncea* L.) is a major *winter* oilseed crop belongs to the family of *Cruciferae*. Rapeseed and mustard are important oilseed crops which ranks third in vegetable oils after soybean and palm [1]. Rapeseed-mustard (*Brassica junce*a L.) in world production India ranks third after Canada and China. In India, soybean, groundnut and rapeseed-mustard are the major oilseed crops contributing nearly 88% of the total production. Its seed contains 37- 49% oil [2]. The oil and seeds are used as condiment in the preparation of pickles and for flavoring curies and vegetables. The mustard oil is utilized for human consumption throughout northern India in cooking and frying purposes. It is also used in the preparation of hair oils and medicines. The oil cake is used as cattle feed and manure, which contains about 4.9 percent nitrogen, 2.5 percent phosphorus and 1.5% potash [2].

Mustard is the third most important oilseed crops after soybean and groundnut in India occupying 6.65 million-hectare acreage, 7.88 million tonnes production and 1,185 kg ha^{-1} productivity [3]. Major states producing mustard are Rajasthan, Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal and Gujarat. Rajasthan ranks first in both area and total production of mustard. Gujrat has the highest productivity (1485 kg ha^{-1}) of rapeseed and mustard. Among the different states, Uttar Pradesh alone produces about 20 percent of total rapeseed and mustard production in India [2]. The area under mustard in Uttar Pradesh are 0.66 million hectares with production of 0.74 million tones and productivity 1112 kg ha^{-1} [3]. India's per capita edible oil consumption is currently estimated at 17.18 kg and vegetable oil consumption of the world average is 24.86 kg [4].

The continuous mining of nutrients from soils coupled with inadequate and imbalanced fertilizer use has resulted in emergence of multi nutrient deficiencies. Mainly at least six nutrients (N, P, K, S, Zn and B) were observed deficient in Indian soils. Sulphur is involved directly or indirectly in different metabolic pathways of plants and play important role in the metabolic activities. The involvement of sulphur is an important component of several enzymes and metabolic processes in plants [5]. Farm yard manure (FYM) improves the soil physio-chemical properties along with direct release of macro as well as micronutrient; ultimately the crop yields increase [6].

The objective of this study was to examine the effect of macro-nutrients and FYM on mustard productivity and profitability in western Uttar Pradesh, India.

2. MATERIALS AND METHODS

The present investigation was conducted at agricultural farm of IFTM University, Lodhipur Rajput Moradabad (UP), India during *winter* season of 2015-2016. The climate of Moradabad region comes under central plain zone climatic conditions. This area has been characterized by mild winters and moderate summers associated with high relative humidity during the rainy season. The soil of the experimental farm was sandy loam in texture, low in organic carbon (0.46%) and neutral (7.1 pH) in soil reaction, low in available nitrogen (146.4 kg ha^{-1}), low in available phosphorus (15.6 kg ha^{-1}) and medium in available potassium (261.3 kg ha^{-1}). The experiment was laid out in Randomized Block Design [7] with three replications. Ten treatment combinations *viz.* T_1(control), T_2(120% NPK), T_3(120% NPK+ 20 kg ha^{-1} Sulphur), T_4(120% NPK+ 40 kg ha^{-1} Sulphur), T_5(100% NPK), T_6(100% NPK + 20 kg ha^{-1} Sulphur), T_7(100% NPK + 40 kg ha^{-1} Sulphur), T_8(75 % NPK + 10 t ha^{-1} FYM), T_9(75% NPK + 20 kg ha^{-1} Sulphur + 10 t ha^{-1} FYM) and T_{10}(75 % NPK + 20 kg ha^{-1} Sulphur + 10 t ha^{-1} FYM). The recommended doses of NPK was applied at the rate of 120 kg N, 60 Kg P_2O_5 and 60 kg K_2O ha^{-1}.

The crop variety JKMS-8001 was sown in rows 40 cm apart on 7th October 2015 and harvested on 20th February 2016. Intercultural operations were done as and when required. Fertilizers applied are Urea (46% N), di-ammonium phosphate (18% N and 46% P_2O_5), muriate of potash (60% K_2O) and elemental sulphur (100% S). The 50 percent dose of nitrogen and full dose of phosphorus and potash was applied as basal. Sulphur also applied as basal as per the treatment. Remaining 50 percent dose of nitrogen was applied as top dressing. Well decomposed farm yard manure was applied 30 days before sowing as per treatments and mixed well with the soil. Thinning and manual weeding was completed within 20 days of sowing. Mustard was irrigated twice. During crop period,

a total rainfall of 114 mm was received. Imidacloprid, a systemic insecticide, was sprayed @ 0.5 ml liter^{-1} of water on the crop, as a prophylactic measure to avoid the aphid infestation. All the observation was recorded on individual plant basis and average. Observations were recorded on various growth parameters, yield components (*viz.* Plant height, number of branches plant^{-1}, dry weight, number of siliquae plant^{-1}, number of seeds siliquae^{-1} and 1000-seed weight) and yield. Protein content in seed was determined multiplying N content with a constant factor 6.25 [8] and oil content determined by Nuclear Magnetic Resonance technique [9].

All the data were statistically analyzed using analysis of variance (ANOVA) technique as applicable to randomized block design [10]. The significance of the treatment effect was determined using F-test, and to determine the significance of the difference between the means of the two treatments, least significant differences (LSD) were estimated at the 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The growth parameters indicating significant difference with respect of plant height, number of branches plant^{-1}, dry weight (Table-1). Plant height is a good index of crop vigor. In general, plant height increased with the advancement of plant age up to harvest. Replacement of NPK with FYM when combined with sulphur had marked effect on the plant height at various growth stages. The plant height was significantly higher with the application of T_{10} (75% NPK+40 kg S ha^{-1} + 10 t FYM ha^{-1}) which were at par with T_9 (75% NPK+20 kg S ha^{-1} + 10 t FYM ha^{-1}). Application of farm yard manures along with other chemical fertilizers and sulphur proves better result. That might be due to the role of FYM in enhancing soil health, quality and biological properties of soil. FYM has synergistic effect and helping in mineralization of applied nitrogen and phosphorus, which might help in enhancing of growth parameters [11]. Similar to plant height, number of branches plant^{-1} increased with the advancement of plant age up to harvest. Replacement of NPK with FYM when combined with sulphur had marked effect on the number of branches at various growth stages. This indicates that NPK requirement of the crop may be replaced by 25% with addition of other nutrient sources for branches of mustard [12].

3.2 Yield Attributes

All yield attributes were affected significantly with the application different nutrient levels. Number of siliqua plant^{-1} increased significantly with replacement of NPK with FYM alone and with addition of sulphur. Therefore, application of FYM and sulphur can be responsible for causing higher photosynthesis and assimilation rates lending to significant increase in siliqua number on plants as compared to other treatments. The seeds siliqua^{-1} varied with combination of different nutrients, due to sufficient dose of

Table 1. Effect of NPK, S and FYM on growth and yield attributes

Treatments	Plant height (cm)	No of branches plant^{-1}	Dry wt. (g)	No of Siliquae plant^{-1}	No of seeds siliquae^{-1}	1000-seed weight (g)
Control	135.71c	15.57d	11.8b	211.67d	11.63b	4.50c
120% NPK	164.43b	20.67c	14.2b	264.10cd	12.33b	4.62bc
120% NPK + 20 kg S ha^{-1}	170.81ab	25.67ab	17.87ab	279.60bc	13.60ab	4.57c
120% NPK + 40 kg S ha^{-1}	173.81a	27.47a	15.23b	265.67c	13.50ab	4.46
100 % NPK	163.58b	23.27bc	19.67a	240.80cd	15.27a	4.64bc
100% NPK + 20 kg S ha^{-1}	166.42b	23.80b	13.92b	249.93cd	13.43ab	5.61a
100% NPK + 40 kg S ha^{-1}	167.71b	23.53bc	18.47ab	318.47b	13.73ab	4.96b
75% NPK + 10 t FYM ha^{-1}	165.44b	25.47ab	19.27ab	375.10a	14.77a	5.41a
75% NPK +20 kg S ha^{-1} + 10 t FYM ha^{-1}	174.10a	24.53ab	20.60a	369.20a	15.70a	5.46a
75% NPK +40 kg S ha^{-1} + 10 t FYM ha^{-1}	174.63a	24.47ab	21.47a	381.40a	14.10ab	5.52a
SE(m)	1.56	1.04	1.37	14.35	0.78	0.12
LSD (p=0.05)	4.68	3.11	4.10	42.98	2.33	0.35

nutrients available during the entire period of crop growth for better vegetative growth and development of crop. The lowest test weight (4.50 g) in control plots is considerable to prove the effect of best treatment combinations. It might be due to direct involvement of number of branches, siliqua plant^{-1} and grains siliqua^{-1} in conjugation with consequent effect of fertilization [13,14,2,15].

3.3 Seed and Stover Yield

The data in Table 2 proved that the 75% NPK with Sulphur and FYM recorded significantly highest seed and stover yield per ha over the other treatment. This might be due to deprive of nutrients former and supply over critical level in later treatment, which increase siliquae plant^{-1}, number of seeds siliquae^{-1} and 1000-seed weight [16]. The Stover yield was found significantly variable according to the treatments. That might be possible because plants received nutrients from appropriate sources to give their full potential for influencing the harvest index of mustard. It seems that the better utilization efficiency of NPK, S and FYM in response on optimum these nutrients reflected in greater vegetative growth and increase growth enzymatic activity [17,15]. Integration of FYM increased the cost of treatment, therefore, reduced the system net returns as compared to chemical fertilizers, but if we replace the doses of chemical fertilizers with FYM it compensates total cost of inputs [18].

3.4 Oil and Protein Content

The oil content in seed at par with the increasing of NPK levels whereas, consecutive addition of sulphur and FYM increased oil content. Crop fertilized with 75% recommended dose of

Table 2. Effect of NPK, S and FYM on yield and economics

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B: C ratio
Control	812.6c	3183.47c	20.30	34841.41	10391.41	0.43
120% NPK	1273.8b	4386.40b	22.50	53710.2	24612.2	0.85
120% NPK + 20 kg S ha^{-1}	1430.9ab	4982.13ab	22.30	60416.5	30518.5	1.02
120% NPK + 40 kg S ha^{-1}	1421.0ab	5409.33a	20.84	60691	29993	0.98
100 % NPK	1207.1b	4413.60b	21.45	51283.1	23095.1	0.82
100% NPK + 20 kg S ha^{-1}	1356.3b	4515.20b	23.11	56955.9	27967.9	0.96
100% NPK + 40 kg S ha^{-1}	1469.6ab	4912.53a	23.11	61744	31956	1.07
75% NPK + 10 t FYM ha^{-1}	1280.8b	4933.07ab	20.63	54789.21	24546.21	0.81
75% NPK +20 kg S ha^{-1} + 10 t FYM ha^{-1}	1514.3ab	5381.33a	21.98	64101.1	33058.1	1.06
75% NPK +40 kg S ha^{-1} + 10 t FYM ha^{-1}	1546.5a	5161.60a	23.05	64962.9	33119.9	1.04
SE(m)	59.73	182.29	1.10			
LSD (p=0.05)	178.85	545.80	NS			

Table 3. Effect of NPK, S and FYM on oil and protein content

Treatments	Oil content (%)	Protein content (%)
Control	41.76d	21.20c
120% NPK	43.72c	23.36ab
120% NPK + 20 kg S ha^{-1}	44.04bc	23.75a
120% NPK + 40 kg S ha^{-1}	44.36b	23.95a
100 % NPK	44.37b	21.15c
100% NPK + 20 kg S ha^{-1}	43.99bc	22.53b
100% NPK + 40 kg S ha^{-1}	45.30a	23.81a
75% NPK + 10 t FYM ha^{-1}	45.59a	23.53ab
75% NPK +20 kg S ha^{-1} + 10 t FYM ha^{-1}	45.57a	24.08a
75% NPK +40 kg S ha^{-1} + 10 t FYM ha^{-1}	45.76a	24.28a
SE(m)	0.171	0.367
LSD (P=0.05)	0.511	1.098

fertilizer with sulphur and FYM recorded higher oil content than control. The lower oil content in control and other treatment may be due to more availability of nitrogen which, increase the protenious substances in the seeds. Higher availability of nitrogen may be resulted a higher portion of photo-synthates is delivered to protein formation leaving a potential deficiency of carbohydrates to be degraded to acetyl co-enzyme A for the synthesis of fatty acids [19]. The increase in oil content with Sulphur fertilization may be attributed to its role in oil synthesis and increase in glucosides [20-22]. Availability of Sulphur increased the conversion of fatty acid metabolites to the end product of fatty acid [23,24].

It was found that the application of Sulphur and FYM resulted significant increase in protein content. Sulphur being a constituent of S containing amino acids and increased in protein content. Significant increase in protein content may be due to the increase in availability of Sulphur and nitrogen resulted in protein synthesis [21].

4. CONCLUSIONS

Based on results obtained from the present investigation, it can be concluded that application of DAP 65 kg ha^{-1}, Urea 104 kg ha^{-1}, MOP 50 kg ha^{-1}, FYM 10 t ha^{-1} and Sulphur 20 kg ha^{-1} were proved to be most suitable dose for achieving higher growth and yield of mustard crop along with sustainable soil health for the farmers of western Uttar Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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