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Response of FYM nitrogen and sulphur on soil Pysico-chemical properties and yield of mustard (*Brassica juncea* L.) var. Varuna

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Abstract
A field experiment was conducted during *rabi* season of 2017-18 at the research farm of Soil Science, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad on "Response of FYM, Nitrogen and Sulphur on Soil Physico-chemical Properties and Yield of Mustard (*Brassica juncea* L.) var. Varuna. The experiment was laid out in randomized block design (RBD) with three replications and nine treatments. The fertilizer was applied at three different factors- N (@ 0, 40 80 kg ha^{-1}), S (@ 0, 10, 20 kg ha^{-1}) and FYM (@0, 5, 10 t ha^{-1}). The soil bulk density, porosity, pH and EC (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), phosphorous (kg ha^{-1}), potassium (kg ha^{-1}) and sulphur (ppm) of soil were found significant at different levels of FYM, N and S. It was concluded that the application of FYM, N and S @100% i.e., the treatment T_8 (@100%$N_{40}S_{20}$ + @10 t ha^{-1} FYM) was found more beneficial and significantly improved with growth parameters and yield of mustard as compared to other treatments. This treatment also showed maximum benefit: cost ratio (2.53) respectively.

Keywords: Mustard, FYM, Nitrogen, Sulphur, Soil properties and Yield, etc.

Introduction
Mustard plants are any of several plant species in the genera *Brassica* in the family *Brassicaceae*. Mustard *(Brassica spp*.) group of crops is the third most important oilseed crop after soya-bean and groundnut, contributing nearly 20-25% of the total oilseed production in the country. Mustard seed is grown with a different consumption pattern in the country (ICAR, 2009) [7]. Mustard is used as a spice, the seed is also used to make mustard oil and the edible leaves can be eaten as mustard greens.

In India, the various oilseed *Brassica* species are grown in the Northern plains with greatest average in state of Rajasthan followed by Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat, West Bengal, Assam, Bihar, Punjab, Himachal Pradesh and Jammu and Kashmir. Of these, Rajasthan. Uttar Pradesh and Madhya Pradesh together account for 77% of the total hactares of rapeseed-mustard. Rapeseed-mustard contributes 30% of India's edible oils and accounts for 21% of the total area under oilseeds (CMIE, 2002) [6].

Mustard is rich in minerals like calcium, manganese, copper, iron, selenium, zinc, vitamin A, B, C and proteins. 100g mustard seed contains 508 kcal energy, 28.09g carbohydrates, 26.08g proteins, 26.08g total fat and 12.2g dietary fiber (USDA, 2014) [19].

Mustard seeds are the small round seeds of various mustard plants. The seeds are usually about 1 to 2 millimeters in diameter and maybe colored from yellowish white to black. They are important spice in many regional foods and may come from one of three different plants: black mustard (*Brassica nigra),* brown Indian mustard (*B.juncea*), or white mustard (*B.hirta/ Sinapis alba).* Mustard oil contains a high level of sulphur compounds, and for the synthesis of oils adequate sulphur nutrition is crucial. The sulphur content in seeds of cruciferous crops like mustard is the highest (1-1.7%) among the crops. The amount of S absorbed by crops is generally 9-15% of the N uptake. However, in mustard; the S uptake is usually one-third of the N uptake. Application of farm yard manure (FYM) improve soil physical, chemical, biological properties. (Ould *et al.* 2010) [10].

FYM helps in maintaining soil sustainability in terms of nutrients supply capacity of soil. The increase in productivity of crops might be attributed due to its essential role of all nutrients present in FYM for plant growth through its effect as a good source of soil organic matter which improves the physiochemical and biological properties of soil.

Application of FYM also increases cation exchange capacity and helps in keeping soil micro nutrients in available form through its chelating action as well as microbial activity in soil besides supplying macro and micro plant nutrients. (Sipai *et al.* 2015) [15].

Nitrogen is the most important nutrient, which determines the growth of the mustard crop and increases the amount of protein and the yield. It promotes flowering, setting of siliqua and in increasing the size of siliqua and yield.

Nitrogen and Sulphur are among the secondary nutrients which plays an important role in the yields and quality of mustard. The ability of plants to produce more yield is dependent on the availability of adequate plant nutrients. Moreover use of balanced fertilizers is a key component of the crop production. Nitrogen being as essential constituent of plant is vitally important plant nutrient. An adequate supply of nitrogen is generally associated with vigorous vegetative growth of plants and deep green colour of leaves.

Oilseed crops respond to sulphur application remarkably depending on soil type and source of its use. The functions of sulphur within the plant are related to those of nitrogen and the two nutrients are synergestic. (Bharose *et al*., 2010) [4]. Sulphur plays the key role and is important in the production of oilseed crops. It plays significant role in the development of seed and improve quality. An oilseed crop requires sulphur comparatively higher than other nutrient.

Sulphur performs many physiological functions and most of the S in plants occur as amino acids like cystein, cystine and methionine which are important components of plant protein. Brassica has the highest sulphur requirement sowing to the presence of sulphur rich glucosinolates (Bharose *et al*. 2010) [4].

Materials and Methods

The investigation on "Response of FYM, Nitrogen and Sulphur on Soil Physico-chemical Properties and Yield of Mustard (*Brassica juncea* L.) var. Varuna" is carried out in Rabi season (Nov -feb) 2017-2018 at research farm of Soil Science and Agricultural Chemistry, Naini Institute of Sam Higginbottom University Of Agriculture, Technology And Sciences, Allahabad, located at $25^0.57^1$ N latitude $81^0.57^1$E longitude and 98 m above mean sea level. The experiment was laid out in 3x3 Randomized Block Design with three levels of FYM, Nitrogen and Sulphur consisting of nine treatments and three replications. The variety varuna was sown at a spacing of 40 x 10 cm, the treatment consisted of three levels of FYM (@ 0, 5, 10 t ha^{-1}), Nitrogen (@ 0, 40, 80 kg ha^{-1}) and Sulphur (@ 0, 10, 20). After harvest of the crop, the soils were collected to analyse soil physical and chemical properties as per standard laboratory methods. The soil samples were randomly collected from a depth of 0-15cm. The total number of plots was 27. The treatment consisted of nine combinations.

Table 1: Treatment combinations

Treatment	Combinations
T_0	Control
T_1	@0% (N_0S_0) + @5 t ha^{-1} FYM
T_2	@ 0% (N_0S_0) + @10 t ha^{-1} FYM
T_3	@ 50% ($N_{40}S_{10}$) + @0 t ha^{-1} FYM
T_4	@50% ($N_{40}S_{10}$) + @5 t ha^{-1} FYM
T_5	@50% ($N_{40}S_{10}$) + @10t ha^{-1} FYM
T_6	@100% ($N_{80}S_{20}$) + @0 t ha^{-1} FYM
T_7	@100% ($N_{80}S_{20}$) + @5 t ha^{-1} FYM
T_8	@100% ($N_{80}S_{20}$) + @10 t ha^{-1} FYM

Table 2: Physical and chemical analysis of soil (pre-sowing)

Particulars	Method	Results
Sand (%)	Bouyoucous Hydrometer (1927) [2]	64.2%
Silt (%)	Bouyoucous Hydrometer (1927) [2]	21.68%
Clay (%)	Bouyoucous Hydrometer (1927) [2]	14.12%
Textural class	Bouyoucous Hydrometer (1927) [2]	Sandy loam
Bulk density (Mg m^{-3})	Muthuval *et al.* (1992) [9]	2.85 Mg m^{-3}
Particle density (Mg m^{-3})	Muthuval *et al.* (1992) [9]	1.11 Mg m^{-3}
Pore space (%)	Muthuval *et al.* (1992) [9]	61.1 %
pH (1:2)	Digital pH meter (Jackson, 1958) [8]	7.17
EC (dSm^{-1})	EC meter (Wilcox, 1950) [20]	0.52 dSm^{-1}
Organic carbon (%)	Rapid titration method (Walkley and Black's marthod, 1947) [21]	0.9%
Available Nitrogen (Kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [13]	217.63 kg ha^{-1}
Available phosphorous (Kg ha^{-1})	Calorimetric method (Olsen et al, 1954) [11]	25.14 kg ha^{-1}
Available potassium (Kg ha^{-1})	Flame photometric method (Toth and Prince, 1949) [18]	202.50 kg ha^{-}
Available sulphur (ppm)	Turbidimetric (Chesnin & Yien, 1950) [5]	15.91 ppm

Table 3: Response of FYM, Nitrogen and Sulphur on soil Physio-chemical properties of Mustard

Treatment	pH	EC (dSm^{-1})	Bulk Density (Mg m^{-3})	Particle density (Mg m^{-3})	Pore space (%)	Organic carbon (%)	Nitrogen (kg ha^{-1})	Phosphorous (Kg ha^{-1})	Potassium (K ha^{-1})	Sulphur (ppm)
T_0	7.17	0.59	1.05	2.00	54.40	0.28	227.04	14.50	205.33	12.61
T_1	7.24	0.62	1.11	2.22	56.32	0.30	232.16	16.40	212.42	12.98
T_2	7.21	0.64	1.14	2.24	60.24	0.31	237.22	18.20	223.31	14.37
T_3	7.32	0.67	1.17	2.36	64.04	0.33	241.71	19.40	228.43	13.61
T_4	7.35	0.71	1.17	2.44	66.29	0.34	246.13	21.25	233.50	13.99
T_5	7.40	0.74	1.19	2.54	68.01	0.35	248.38	22.25	239.32	13.49
T_6	7.58	0.79	1.21	2.59	69.41	0.37	250.38	23.42	245.67	12.91

T_7	7.64	0.81	1.25	2.62	69.77	0.38	252.08	24.35	253.00	13.45
T_8	7.65	0.83	1.33	2.63	70.22	0.40	257.04	25.03	257.77	14.27
F-test	S	S	S	S	S	S	S	S	S	S
S.Ed (±) C.D.	0.11	0.03	0.02	0.02	0.30	0.02	1.66	0.388	0.272	0.514
(at 5%)	0.24	0.06	0.03	0.05	0.63	0.01	3.51	0.801	0.562	1.060

Table 4: Response of FYM, Nitrogen and Sulphur on growth and yield of mustard

Treatment	Plant height (cm)	No. of branches plant^{-1}	Fresh weight (g)	Dry weight (g)	Test weight (g)	Seed siliqua plant^{-1}	Seed yield (q ha^{-1})
T_0	124.20	6.77	17.20	6.74	3.19	120.66	14.33
T_1	125.23	7.22	25.77	9.50	3.40	128.53	17.53
T_2	126.65	7.99	32.27	13.21	3.60	134.46	19.95
T_3	126.88	8.10	48.20	15.15	3.73	142.35	21.12
T_4	127.41	9.88	67.03	16.46	3.79	150.38	22.20
T_5	129.07	10.22	71.27	17.82	3.80	158.79	25.40
T_6	130.03	10.89	78.0	19.61	3.85	165.71	26.01
T_7	131.97	11.23	83.40	22.30	3.93	172.18	27.32
T_8	136.33	12.37	89.27	24.52	4.13	180.78	29.98
F-test	S	S	S	S	S	S	S
S.Ed (±)	1.41	0.40	0.47	0.25	0.18	0.19	0.25
C.D.(at 5%)	3.00	0.86	0.22	0.53	0.37	0.41	0.52

Results and Discussion

Response of FYM, Nitrogen and sulphur on plant growth and yield of mustard crop

The result in the table 4 shows that the plant height was increased with the increase of FYM, Nitrogen and Sulphur. The highest plant height at 30 DAS (30.30 cm), 60 DAS (74.82 cm), 90 DAS (136.33 cm) was in treatment T_8 (@100% NS + @10 t ha^{-1} FYM). Number of branches per plant at 30 DAS (3.96), 60 DAS (7.83) and 90 DAS (12.37) was also obtained in T_8 (@100% NS +@ 10 t ha^{-1} FYM). The maximum seed siliqua per plant and seed yield was also obtained in T_8 (@100% NS +@ 10 t ha^{-1} FYM) which was 180.78 siliqua per plant and 29.98 q ha^{-1} as compared to other treatment combinations. Highest fresh weight was 89.27g in T_8 (@100% NS +@ 10 t ha^{-1} FYM) and minimum 17.20g in T_0 (control), maximum dry weight 24.52g in T_8 (@100% NS +@ 10 t ha^{-1} FYM) and minimum 6.74 in T_0 (control).

This may be due to the interaction effect of Nitrogen and Sulphur at different levels significantly influenced the increase in plant height, number of branches, fresh weight, dry weight, siliquae and yield. Nitrogen application upto 80 kg ha^{-1} significantly increase the yield attributes and seed yield Tomar *et* al. (2007) [17], oil seed crops respond to sulphur application remarkably Bharose *et al.* (2010) [4]. Similar results were also reported by Parmar *et al*. (2010).

Response of FYM, Nitrogen and Sulphur on Soil Physico-chemical Properties on Soil of Mustard crop

The result in the table 3 shows that the maximum bulk density of soil was found 1.33Mg m^{-3} in T_8 (@ $N_{40}S_{20}$ + 10 t ha^{-1} FYM) and minimum was found 1.05 Mg m^{-3} in T_0 (control). The interaction of FYM, Nitrogen and Sulphur were found significant. The maximum particle density of soil was found 2.63 Mg m^{-3} in T_8 (@ $N_{40}S_{20}$ + 10 t ha^{-1} FYM) and minimum 2 in T_0 (control). The interaction of FYM, Nitrogen and Sulphur were also found significant. The results also shows maximum pore space (%) in T_8 (@ $N_{40}S_{20}$ + 10 t ha^{-1} FYM) was 70.22 and minimum 54.40 in T_0 (control).The maximum soil pH 7.65 and EC 0.83 dSm^{-1} have been recorded with the treatment T_8 (@100%NS + 10 t ha^{-1} FYM) and the minimum pH 7.17 and EC 0.59 dSm^{-1} was recorded in T_0 (control).This may be due to the increase levels of FYM and Sulphur leading to improving soil structure and sustainability Sipai *et al.* (2015) [15]. Similar findings was also reported by Alam *et al.* (2014) [1].

The maximum soil O.C% was found maximum in T_8 (@100%NS + 10 t ha^{-1} FYM) i.e, 0.40% and minimum in T_0 (control) i., 0.28%. This may be due to due the presence of all the essential nutrients present in FYM as it serves as soil organic matter, FYM resulted in maximum carbon percentage in soil Khanday *et al.* (2012). Similar finding was also reported by Alam *et al.* (2014) [1].

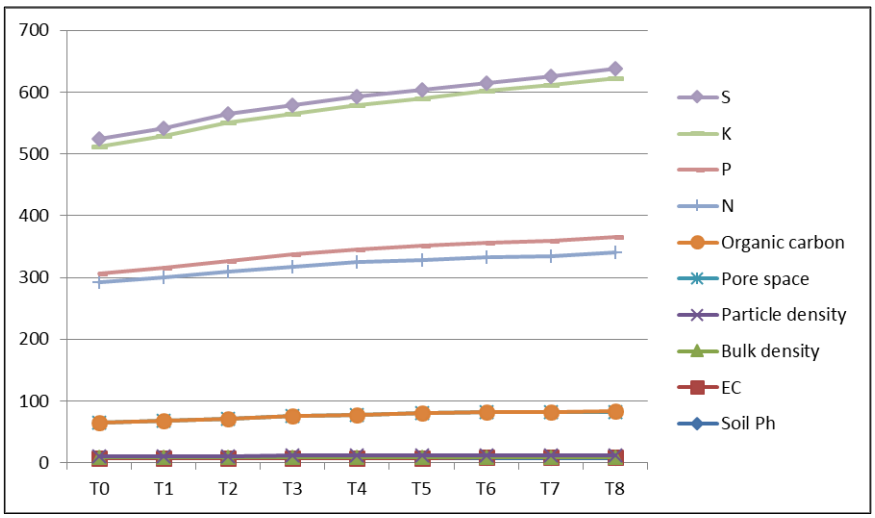

Fig 1: Effect of FYM Nitrogen and Sulphur on Soil Physico-chemical properties of Mustard.

The available N 257.04 kg ha^{-1}, available P 25.03kg ha^{-1}, available K 257.77 kg ha^{-1} and available S 14.27 ppm have been recorded with the treatment T_8 (@100%NS + 10 t ha^{-1} FYM) and the minimum available N 227.04 kg ha^{-1}, available P 14.50kg ha^{-1}, available K 205.33 kg ha-1 and available S 12.61 ppm was recorded in T_0 (control). The interaction of FYM, Nitrogen and Sulphur on available nitrogen (kg ha^{-1}), phosphorous (kg ha^{-1}), potassium (kg ha^{-1}) and sulphur (ppm) was found to be significant with increase of this treatment combinations.

This may be due to the combined effect of Nitrogen and Sulphur, the increased nitrogen and sulphur content enhanced the total uptake of N and S Singh *et al.* (2004) [14]. Similar findings was also reported by Alam *et al.* (2014) [1].

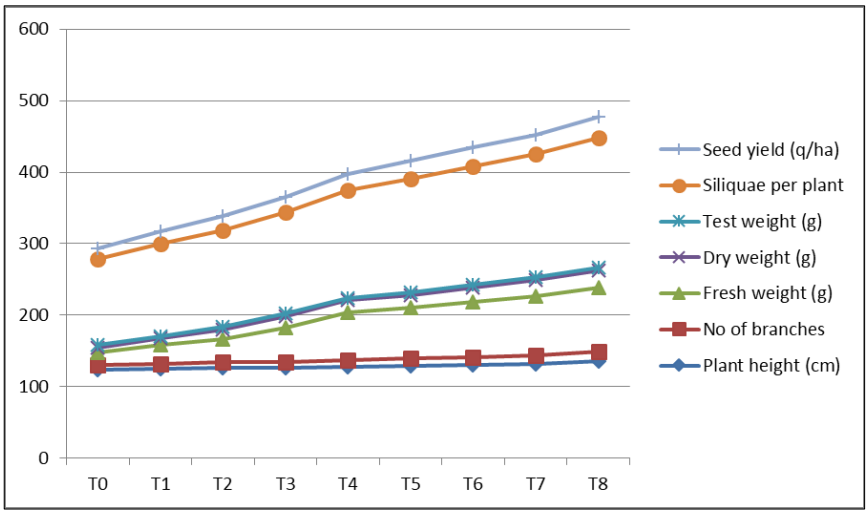

Fig 2: Effect of FYM Nitrogen and Sulphur on growth and Yield of Mustard.

Conclusion

On the basis of the above findings, it is concluded that the treatment combination T_8 (@100%$N_{40}S_{20}$+@ 10 t ha^{-1} FYM) out yielded in comparison to other treatment combinations. The effect of soil bulk density, porosity, pH and EC (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorous (kg ha^{-1}), available nitrogen (kg ha^{-1}), sulphur (ppm) of soil were significantly improved at increase levels of FYM, Nitrogen and Sulphur, growth parameters and seed yield was also significantly improved. This treatment also resulted in maximum gross return, net return and B: C ratio (2.53) respectively.

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