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Effect of nutrient management on soil fertility and productivity of Indian mustard (*Brassica juncea* L.) in typic haplustepts

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Abstract
A field experiment entitled "Effect of Nutrient Management on Soil Fertility and Productivity of Indian Mustard (*Brassica juncea* L.) in Typic Haplustepts" was conducted at Instructional Farm, Agronomy, Rajasthan College of Agriculture, Udaipur during *rabi* 2020-21. The experiment was laid out in Randomized 'Block' Design with three replications and having eight treatment combinations. The significant increase in plant height, number of branch plant^{-1}, leaf area index, number of siliqua plant^{-1}, number of seeds siliqua^{-1}, seed weight, seed yield, stover yield, biological yield was observed with the application of T_8 (75% RDF 20 kg S ha-1 + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash) as compared to control.

Keywords: Soil fertility, typic haplustepts, mustard, foliar spray of vermiwash

1. Introduction
Indian mustard (*Brassica juncea* L.) belongs to family "Cruciferae" is one of the most important oilseed crop in India. The rapeseed-mustard is an important group of oilseed crops in India. During 2018-19, it contributes 24.7% to total area and 29.4% to total production of oilseeds. Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal, Assam and Gujarat are the main rapeseed-mustard growing states in India, accounting for 92.7% of the area and 95.8% of production in 2017-18, with Rajasthan alone accounting for 36.6% and 40.9% of the area and production, respectively (*Anonymous*, 2019) [1]. Chemical fertilizers alone may not be able to keep up the maintaining soil health for sustaining productivity. Concerns about the sustainability of oilseed-based cropping systems, combined with increasing chemical fertilizer prices, and has reawakened interest in organic manure usage. Though organic manures are not new in terms of nutrient recycling, their economic importance has increased in recent years. Because of their use as a renewable energy source, their effects on soil fertility and increased nutrient use efficiency, improving soil physical conditions and their role in achieving crop yields that are sustainable. Sulphur and organic manure application has been shown to improve oil content and mustard productivity while also maintaining soil fertility and holding soil in good condition (Das *et al*., 2016) [2]. Sulphur is an essential important component in deciding the seed yield of mustard. The amount of oil content and tolerance to various biotic and abiotic stresses (Rathore *et al*., 2015) [10].
Vermiwash contains enzymes, nutrients and secretions of earthworms and it assists in pest control by destroying or repelling pests prior to foliar spray application (Sulaiman *et al*., 2020) [11]. Vermicompost has a high availability of nutrients, which allows for not only a limited supply of plant nutrients but also reserves for future crops (Jat and Ahlawat 2006) [4]. As an organic fertilizer, vermicompost is mineralized, releasing nutrients into the soil solution. Since vermicompost has a lower C/N ratio, it is ideally suited for use as a soil amendment (Prabha, 2009) [9]. A sufficient and timely supply of organic and inorganic fertilizers improves morphological parameters such as plant height, branches plant^{-1} and leaf area index in mustard (Pathak 2016) [7].

2. Materials and Methods

2.1 Description of the study area

The experiment was conducted during *rabi* season of 2020-21 at Instructional Farm, Agronomy, Rajasthan College of Agriculture, Udaipur. The experimental site is situated at South–Eastern part of Rajasthan at 24˚34' N latitude and 73˚42' E longitude at an altitude of 582.17 m above mean sea level. The region falls under the agro-climatic zone Ⅳ-a of Rajasthan. The maximum and minimum temperature ranged between 32.3˚C and 4.1˚C. Mean weekly maximum and minimum relative humidity ranged between 90.6% and 22.7% respectively and the total rainfall received during the crop period is 12.6 mm. The soil analysis confirmed that soil of experimental field was clay loam belongs to *Typic Haplustepts*, neutral alkaline in reaction, low available nitrogen, medium in phosphorus, and high in available potassium, sufficient in zinc, iron, copper and manganese.

2.2 Experimental details

The experiment was laid out in Randomized 'Block' Design with three replications and having eight treatment combinations *viz*. T_1 (control),T_2 (100% RDF), T_3 (50% RDF + 20 kg S ha^{-1}), T_4 (50% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash), T_5 (50% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash), T_6 (75% RDF + 20 kg S ha^{-1}, T_7 75% RDF 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash), T_8 (75% RDF 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash), the mustard crop variety Giriraj was sown on 29 october 2020. by placing 2 seeds at a depth of 3–4 cm. Thinning was done after 25-30 days after sowing maintaining row to row and plant to plant distance 30 x 10 cm. In order to minimize weed competition, a hand weeding was done at the time of thinning. Three irrigations were given to mustard crop according to the treatments. Recommended dose of Nitrogen (60 kg ha^{-1}), Phosphorus (40 kg ha^{-1}) and Sulphur (40 kg ha^{-1}) was applied as basal dose. Half dose of Nitrogen and full dose of Phosphorus and sulphur was drilled in soil before sowing, remaining half dose of Nitrogen as top dressing was applied at the time of first irrigation. Nitrogen will be applied through urea and DAP, phosphorus through diammonium phosphate and Sulphur through gypsum. The foliar spray of vermiwash was applied at 30 and 45 days after sowing of the crop. Growth, yield attributes and yield were recorded and statistically analysed.

3. Results and Discussion

3.1 Effect of Organic and inorganic nutrient management on Growth parameter

Findings in previous chapter presented in Table 1 shows that significant improvement in plant height, branches $plant^{-1}$ and leaf area index were significantly influenced due to combined application of different organic and inorganic fertilization over control. The highest plant height, branches $plant^{-1}$ and leaf area index were observed with combined application of 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash. The plant height, branches $plant^{-1}$ and leaf area index were increased to an extent of 24.69, 92.64 and 31.39 per cent due to combined application of different organic and inorganic fertilization over control, respectively. A sufficient and timely supply of organic and inorganic fertilizers improves morphological parameters such as plant height, branches $plant^{-1}$ and leaf area index in mustard (Pathak 2016) [7].

Application of vermicompost and vermiwash can play important role in improving availability of macro and micro nutrients at initial stage through organic sources in addition to nutritional benefits from vermicompost. The vermicompost and vermiwash contain essential plant nutrients, vitamins, growth hormones, enzymes, microbial load and plant growth promoting substances. In addition to supply of nutrients it also helps in enhanced plant growth, metabolic activities and resistant to diseases and pest attacks (Nath and Singh, 2012) [5]. Combined application of organic and inorganic fertilizers has enhanced leaf area index, crop growth rate, photosynthetic rate and biochemical attributes such as total chlorophyll, sugar and proline content of physiologically active leaves of mustard crop (Mondal *et al.*, 2017) [3]. Application of sulphur with RDF and vermicompost has reduced soil pH and promote the availability of P, Zn, Fe and Mn (piri *et al*, 2019) [8]. These nutrient combinations enhance the growth and development of the plant. Sulphar also plays an important role in the activation of various enzyme activities, which help in the biochemical and metabolic reactions in the plant.

3.1.2 Effect of Organic and inorganic nutrient management on Yield attributes and Yield

The data presented in Table 2 and 3 showed that yield and yield attributes of mustard increased significantly with appication of 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash when compared to control except harvest index. The highest yield and yield attributing characters *viz.* siliquae $plant^{-1}$, seeds $siliquae^{-1}$ and test weight were observed under treatments T_8 (75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash) compared to control. The seed, stover and biological yield of mustard crop increased by 122.10, 92.03 and 98.10 per cent due to application of T_8 (75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1}+ 10% foliar spray of vermiwash) over control, respectively.

The combined application of organic and inorganic fertilizers has proved to increase the activities of N fixing bacteria which tends to increase the rate of humification. The organic and inorganic fertilization increase the availability of both added and native nutrients in soil and resulting in enhanced crop growth, yield attributes and yield of the crop as well as increase supply of phosphorus in soil. Phosphorus is major structural element of cell as it help in cell elongation, photosynthesis, metabolism and developed reproductive structures which promote yield attributes and yield of crop. These results were in line with Nurhidayati *et al.*, (2018) [6].

Table 1: Effect of organic and inorganic fertilization on plant height, branches plant^{-1}, and LAI

Treatment	plant height (cm)	branches plant^{-1}	LAI
T_1 Control	162.00	10.33	2.23
T_2 100% RDF	175.00	13.92	2.53
T_3 50% RDF + 20 kg S ha^{-1}	174.00	12.96	2.50
T_4 50% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	188.00	16.40	2.69
T_5 50% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	189.00	17.21	2.72
T_6 75% RDF + 20 kg S ha^{-1}	176.10	14.72	2.56
T_7 75% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% Foliar Spray of vermiwash	201.00	18.22	2.91
T_8 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% Foliar Spray of vermiwash	202.00	19.88	2.93
SEm±	3.911	0.281	0.042
C.D. (P = 0.05)	11.862	0.853	0.126

Table 2: Effect of organic and inorganic fertilization on Siliqua plant^{-1}, seed siliqua^{-1} and test weight (g)

Treatment	Siliqua plant^{-1}	Seeds siliqua^{-1}	test weight (g)
T_1 Control	99.73	10.10	3.06
T_2 100% RDF	106.37	11.24	3.45
T_3 50% RDF + 20 kg S ha^{-1}	106.02	11.22	3.42
T_4 50% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	114.14	12.40	4.04
T_5 50% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	114.36	12.42	4.06
T_6 75% RDF + 20 kg S ha^{-1}	106.85	11.26	3.47
T_7 75% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% Foliar Spray of vermiwash	120.02	13.56	4.25
T_8 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% Foliar Spray of vermiwash	120.21	13.58	4.27
S.Em±	1.627	0.368	0.061
C.D. (P = 0.05)	4.936	1.116	0.184

Table 3: Effect of organic and inorganic fertilization on seed yield, stover yield, biological yield, harvest index and oil content

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Oil content (%)
T_1 Control	919.67	2500.00	3419.67	26.93	35.12
T_2 100% RDF	1230.00	3070.00	4300.00	28.53	36.36
T_3 50% RDF + 20 kg S ha^{-1}	1145.00	2862.00	4007.00	28.84	36.51
T_4 50% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	1620.00	4050.01	5670.01	28.57	38.03
T_5 50% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	1626.67	4250.00	5876.67	27.67	38.08
T_6 75% RDF + 20 kg S ha^{-1}	1240.00	3100.00	4340.00	28.57	36.65
T_7 75% RDF + 20 kg S ha^{-1} + 2 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	1970.00	4625.00	6595.00	29.87	39.45
T_8 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash	2040.00	4800.00	6840.00	29.78	39.68
S.Em±	50.910	104.089	193.641	0.861	0.392
C.D. (P = 0.05)	154.420	315.721	587.349	NS	1.190

4. Conclusion

On the basis of statistical data, it can be concluded that farmers of Zone IVa (sub -humid Southern Plains and Aravalli Hills of Rajasthan), can get significantly higher seed yield, stover yield, net return and B:C ratio with the application of 75% RDF + 20 kg S ha^{-1} + 4 t vermicompost ha^{-1} + 10% foliar spray of vermiwash

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