International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(7): 153-158
www.biochemjournal.com
Received: 04-05-2024
Accepted: 09-06-2024

Rohan Rajput
MSc Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Arun Alfred David
Associate Professor and Head, Department of Soil Science And Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Anupriya Paul
Assistant Professor, Department of Mathematics and Statistics, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Abhishek Uplawdhiya
MSc Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Raghvendra Kumar Kushwaha
MSc Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Rohan Rajput
MSc Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Response of integrated nutrient management on soil health and yield of mustard (*Brassica juncea* L.) var. Varuna

Rohan Rajput, Arun Alfred David, Anupriya Paul, Abhishek Uplawdhiya and Raghvendra Kumar Kushwaha

DOI: https://doi.org/10.33545/26174693.2024.v8.i7Sc.1476

Abstract

An experiment titled "Response of integrated nutrient management on soil health and yield of mustard (*Brassica juncea* L.) var. varuna" was carried out, research farm of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj. The experiment was conducted with nine treatments (T_1: RDF NPK 100% + PM @ 2t ha^{-1} + Sulphur @15 kg ha^{-1}, T_2: RDF NPK 100% + PM @2t ha^{-1} + Sulphur @30 kg ha^{-1}, T_3: RDF NPK 100% + PM @2t ha^{-1}+ Sulphur @45 kg ha^{-1}, T_4: RDF NPK 100% + PM @5t ha^{-1} + Sulphur @15 kg ha^{-1}, T_5: RDF NPK 100% + PM @5t ha^{-1} + Sulphur @30 kg ha^{-1}, T_6: RDF NPK 100% + PM @5t ha^{-1} + Sulphur @45 kg ha^{-1}, T_7: RDF NPK 100% + PM @7.5t ha $^{-1}$ + Sulphur @15 kg ha^{-1}, T_8: RDF NPK 100% + PM @7.5t ha^{-1} + Sulphur @30 kg ha^{-1}, T_9: RDF NPK 100% + PM @7.5t ha $^{-1}$ + Sulphur @45 kg ha^{-1},) in a randomized block design with three replication of each treatment. Before harvesting, measurements of growth parameters (plant height, number of leaves per plant) were made at intervals of 30, 60, and 120 days after sowing (DAS). The number of siliquae per plant, the length of the siliqua (cm), the number of grains per siliqua, the 1000 seed weight (gm), the grain yield (q/ha), the stover yield (q/ha), and the harvest index (%) were all recorded after the harvest. According to the findings, there was an improvement in yield and yield characteristics when RDF NPK 100% + PM @7.5t ha^{-1} + Sulphur @45 kg ha^{-1} (T_9) combinations were applied.

Keywords: Mustard, integrated nutrient management, poultry manure, NPK, soil health, growth and yield of mustard etc.

Introduction

Soil health has been defined as the "the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal, and human health".

Soil health is the capacity of soil to function as a living system, with ecosystem and land use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots; recycle essential plant nutrients; improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production" (FAO 2008) [7]. To this definition one might want to add an ecosystem perspective: A healthy soil does not pollute its environment and does contribute to mitigating climate change by maintaining or increasing its carbon content.

Soil physical component

There are biological, chemical, and physical components to soil. The well-researched physical components of soil are made up of minerals and rocks that have crumbled into tiny sand, silt, and clay particles over time. These substances are routinely measured in order to categorize the soil's texture. The coarsest material in a soil sample, sand has gritty particles that are plainly visible or felt. It ranges in size from 50 µm (microns) to 2 mm. The size of silt particles ranges from 2 to 50 µm, whereas clay particles are much smaller, measuring less than 2 µm.

The US Soil Texture Triangle illustrates the relative amounts of sand, silt, and clay that define the soil textural classification. The arrangement of textures of soil is dictated by the processes involved in soil formation, which are controlled by variables such as temperature, time, topography, living things, and the parent material-such as the underlying rock. Limestone is a common parent material in southeast Kansas. Erosion is the source of some soils. Alluvial (water-borne) and loess (wind-blown) soils are created when dirt is carried by wind and water and deposits it in new locations. There are 20-50% sand, 75-90% silt, and 0-30% clay in a silt loam soil. As opposed to this, a silty clay loam has 60-70% sand and 0-20% clay, and 25-40% silt.

Soil Chemical Component

In addition to the mineral elements of the soil, other components of the soil, particularly the biological components, significantly influence the chemical and physical composition of the soil. A significant portion of the soil is made up of plant roots, soil microorganisms (fungi and bacteria), and decomposing plants, which all contribute to the soil's structure. A well-structured soil will provide stable aggregates that make it simple for rainwater to penetrate. Water will be held in the soil aggregates and then released to increase plant availability. Although till- ageing initially expands the pore space in the soil, it breaks apart soil aggregates, interferes with the networks of fungal hyphae and plant roots, and decreases the amount of available soil space. organic materials.

This loss of soil structure leads to increased compaction of tilled soils over time. On the other hand, no-till farming produces soils with stable aggregates, boosts the amount of organic matter in the soil, and protects the fungal and plant networks. Water is easily absorbed by organic matter, which includes soil organisms and plant debris, and is stored until plant roots require it.

More soil organic matter increases the ability of the soil to absorb rain water rather than having it run off. As the organic matter in the soil increases, the plant-available water also increases. It has been estimated that for every 1% increase in soil organic matter, the plant-available water in the soil increases by more than 20,000 gallons per acre (NRCS, 2013; Bryant, 2015) [12, 3].

Soil Biological Component

The biological component of soil is the last element that is essential to its whole productive potential to support a "vital living ecosystem." The elements influencing soil biology and their significance for soil health are becoming increasingly clear to us. The soil's flora, fauna, insects, nematodes, arthropods, bacteria, fungus, and protozoa are all considered to be a part of the biological component. One crucial aspect of soil health is the biological community. Much of the biological community in the soil may be viewed, including earthworms, even if much of it is too small to be seen without magnification. The majority of the nutrient and water recycling and transport that takes place in this microscopic community, known as the microbiome, Measuring biological activity in soil is more difficult than measuring physical or chemical properties. According to Hsiao *et al.*, (2018) [8], microbial activity varies depending on the type of production system. For example, soils from cultivated fields have a nearly tenfold lower microbial biomass than soils from hay meadows. An increase in enzyme activity within the clay layer (>12 inches depth in the soil profile) indicated that the grasses were also more active at lower soil profiles. Grass builds intricate networks in the soil by Ecosystems can more effectively utilize a larger portion of the soil profile, drawing in more water and nutrients for plant growth (K-STATE).

INM

Most of the rapeseed mustard varieties grown in India contain high glucosinolates (4.0-13.0%) which adversely affect palatability due to its pungent smell. The usual effect of nitrogen fertilizer on the glucosinolate content of rapeseed is to depress it (Zhao *et al*., 1993 and Wetter *et al*., 1970) [21, 18]. In summary, integrated use of 100% recommended fertilizer dose with organic sources of nutrient gives higher number of branches/plants, number of siliquae/branches, seeds/siliqua and seed yield of mustard, beside higher content of Palmitic acid, Oleic acid, Linoleic acid, Linolenic acid, Eicosenoic acid and Erucic acid and lower content of Glucosinolate than the application of chemical fertilizers alone.

The oil content was decreased with increase in fertilizer levels while further increase was recorded with addition of organic sources of nutrient supply in addition to fertilizers. These results are in close conformity with the findings of Prasad (2000) [15] and Kandpal (2001) [10]. Wither (1992) [20] and Tomar *et al*., (1992) [17} observed increase in protein content and decrease in oil content with successive increase in NPK fertilization. This may be due to the fact that the availability of nitrogen increases the proportion of protein substances in the seed leaving a potential deficiency of carbohydrates to be degraded to acetyl Co-A for the synthesis of fatty acids.

Production status

The estimated area, production and yield of rapeseed-mustard in the world was 36.59 million hectares (mha), 72.37 million tonnes (mt) and 1980 kg / ha, respectively, during 2018-19. Globally, India account for 19.8% and 9.8% of the total acreage and production (USDA). During the last eight years, there has been a considerable increase in productivity from 1840 kg/ha in 2010-11 to 1980 kg/ha in 2018-19 and production has also increased from 61.64 m t in 2010-11 to 72.42 m t in 2018-19.

Rapeseed-mustard crops in India are grown in diverse agro climatic conditions ranging from north-eastern / north western hills to down south under irrigated/rainfed, timely/late sown, saline soils and mixed cropping. Indian mustard accounts for about 75-80% of the 6.23 m ha under these crops in the country during 2018-19 crop season.

Poultry manure

Poultry manure is rich in N and the nutrient value of the manure is reduced by loss of N through ammonia volatilization and denitrification. Good quality poultry manure can be obtained by mixing the poultry waste with selective carbonaceous material such as coirpith and inoculation with suitable microorganism. It can be used as an eco-friendly technique for the conversion of poultry waste into valuable compost.

It has nitrogen (4.55 to 5.46%), phosphorus (2.46 to 2.82%), potassium (2.02 to 2.32%), calcium (4.52 to 8.15%), magnesium (0.52 to 0.73%) and appreciable quantities of micronutrients like Cu, Zn, Fe, Mn etc. In addition to this cellulose (2.26 to 3.62%), hemicelluloses (1.89 to 2.77%) and lignin (1.07 to 2.16%) are also present in poultry waste. These components upon microbial action can be converted to value added compost with high nutrient status. In poultry droppings, nearly 60%of nitrogen which is present as uric acid and urea is lost through ammonia volatilization by hydrolysis. This loss of nitrogen reduces the agronomic value of the product, besides causing atmospheric pollution. Composting with amendment seems promising in conservation of nitrogen in poultry droppings.

Methodology

The detailed treatment combination was shown in Table 1 and field experiment has been conducted during the rabi season 2024 central research farm of department of soil science and agricultural chemistry, Naini Agricultural Institute, Prayagraj (Allahabad) 211 007, (U.P.), located at 25°24'30'' North latitude 81°51'10'' East longitude and 98m above mean sea level. Representing the Agro-ecological sub region [North Alluvium plain zone (0-1% slop)] and Agro-climatic zone (Upper gangetic plain region). "Argo climatically, Prayagraj district represents the subtropical belt of the South East of (U.P.), and is endowed with extremely hot summer and fairly cold winter. The maximum temperature of the location ranges between 46°C and seldom falls below 4°C-5°C. The relative humidity ranges between 20-94%. The average rainfall of this area is around 1100mm annually". The soil samples will be randomly collected from one site in the experiment plot prior to tillage operation from a depth of 0-15 cm. The volume of the soil sample will be reduced by conning and quartering the composites soil sample will be air dried and passed through a 2 mm sieve by way of preparing the sample for physical and chemical analyses. Soil physical analysis is done after post-harvest operation. After 60 days crop harvest soil sample was collected from field. Physical properties textural class, soil colour, bulk density Mg m^{-3}, particle density Mg m-3, pore space%, water holding capacity% were analysed. Soil chemical analysis is done after post-harvest operation were following, pH, EC dS m^{-1}, organic carbon%, available N kg ha^{-1}, P kg ha^{-1}, K kg ha^{-1} the trial was laid out in a randomized block design with three replications; plot size was 2 x 1 m for crop seed rate is 4-6 kg ha^{-1}

Table 1: Particular of the treatment combination for mustard

S. No.	Treatments	Dosage	Symbol
1.	Level of N.P.K.	N, P, K, @ 100%	L_1
2.	Level of Poultry manure	PM @ 2.5 t ha-1	P1
		PM @ 5 t ha-1	P_2
		PM @ 7. 5 t ha-1	P_3
3.	Level of Sulphur	S @ 15 kg ha^{-1}	S_1
		S @ 30kg ha^{-1}	S_2
		S @ 45 kg ha^{-1}	S_3

Table 2: Treatment Combination for Mustard

S. No.	Treatment combination	Symbol
T_1	RDF NPK @100%+ PM @ 2 t ha^{-1} + Sulphur @15 kg ha^{-1}	$L_1P_1S_1$
T_2	RDF NPK @100%+ PM @ 2 tha^{-1} + Sulphur @30 kg ha^{-1}	$L_1P_1S_2$
T_3	RDF NPK @100%+ PM @ 2 tha^{-1}+ Sulphur @45 kg ha^{-1}	$L_1P_1S_3$
T_4	RDF NPK @100%+ PM @ 5 t ha^{-1}+ Sulphur @15 kg ha^{-1}	$L_1P_2S_1$
T_5	RDF NPK @100%+ PM @ 5 t ha^{-1}+ Sulphur @30 kg ha^{-1}	$L_1P_2S_2$
T_6	RDF NPK @100%+ PM @ 5 t ha^{-1} + Sulphur @45 kg ha^{-1}	$L_1P_2S_3$
T_7	RDF NPK @100%+ PM @ 7.5t ha^{-1} + Sulphur @15 kg ha^{-1}	$L_1P_3S_1$
T_8	RDF NPK @100%+ PM @ 7.5 t ha^{-1}+ Sulphur @30 kg ha^{-1}	$L_1P_3S_2$
T_9	RDF NPK @100%+ PM @ 7.5 t ha^{-1} + Sulphur @45 kg ha^{-1}	$L_1P_3S_3$

Results and Discussion

As reported in table 3 composition of N, P, K, S, and Poultry manure have significant increasement on the soil parameters. The increasement of pore space%, water holding capacity%, organic carbon, available nitrogen, phosphorus, potassium, with the improvement of soil parameters, table 2Revealed that application of different level s of Poultry manure and N, P, K have following roll, on soil. In treatment T_1 lowest data observed particle density 2.20 and 2.21 Mg m^{-3}, pore space 41.8 and 38.5%, water holding capacity 40.82 and 36.81% and T_9 shows the highest particle density 2.396 and 2.417 Mg m^{-3}, pore space 45.4% and 42.9%, water holding capacity 44.64% and 34.08% at 0-15cm and 15- 30cm depth of soil respectively. Also, in table 3. Shown bulk density with highest in T_9 is 1.08 and 1.10 with lowest in T_1 1.08 and 1.10 respectively in 0- 15cm and 15-30 cm depth of soil. Table4. shown that in Treatment T_1 have highest pH 7.5 and 7.3 and T_9 have lowest pH 6.7 and 6.2, T_9 have highest EC 0.80 and 0.78 dS m^{-1}, T_9 have highest organic carbon 0.46 and 0.39%, nitrogen 240.23 and 225.2 kg ha^{-1}, phosphorus 34.58 and 22.73 kg ha^{-1}, Potassium 259.9 and 258.12 kg h^{-1} and Sulphur 37.4 kg ha $^{-1}$ 36.4 kg ha^{-1} T_9 have highest amount of fertilizer and parameters result The T_9 treatment is found to be best, followed by T_8 and T_7, as depicted by their respective physical and chemical properties. The application of N, P, K, S, and poultry manure eventually proves to have a positive impact on the soil, helping to maintain its fertility. T_1 demonstrates the least effect on soil parameters among the treatments.

Table 2: Effect of different level of N, P, K, S and poultry manure on Bd Pd Pore space and Water Holding Capacity post-harvest soil

Treatments	Bulk density ($Mg\ m^{-3}$)		Particle density ($Mg\ m^{-3}$)		Pore space (%)		Water holding capacity (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	1.08	1.10	2.20	2.21	41.8	38.5	40.82	36.81
T_2	1.12	1.13	2.220	2.223	41.9	38.8	40.91	37.02
T_3	1.14	1.15	2.260	2.701	42.1	39.1	41.32	37.08
T_4	1.15	1.16	2.275	2.278	42.4	39.4	41.64	38.01
T_5	1.17	1.18	2.305	2.309	42.6	39.9	41.91	38.05
T_6	1.19	1.19	2.322	2.320	43.2	38.9	42.57	36.02
T_7	1.22	1.23	2.338	2.328	43.8	40.7	42.88	36.06
T_8	1.24	1.25	2.368	2.370	44.6	41.5	43.22	35.01
T_9	1.27	1.28	2.396	2.417	45.4	42.9	44.64	34.08
F-test	S	S	S	S	S	S	S	S
S. Em. (±)	0.13	0.01	0.01	0.07	0.11	0.11	0.36	0.18
C.D.@%	0.28	0.01	0.01	0.15	0.24	0.8	0.77	0.39

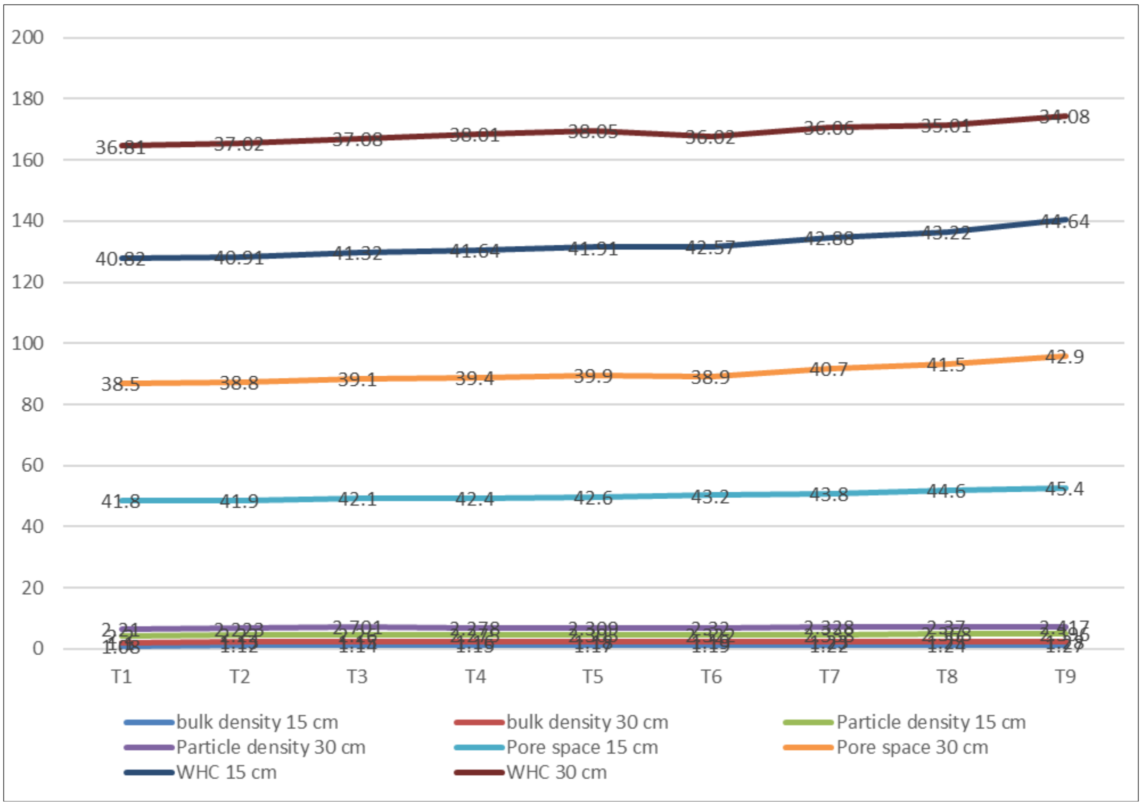

Fig 1: Effect of N, P, K, and poultry manure bulk density, particle density, pore space, water holding capacity on post-harvest soil

Table 3: Effect of different level of N, P, K, S and poultry manure on chemical Nitrogen, phosphorus, potassium and Sulphur on post-harvest soil

Treatment	pH		EC $dS\ m^{-1}$		Nitrogen $kg\ ha^{-1}$		Phosphorus $kg\ ha^{-1}$		Potassium $kg\ ha^{-1}$		Sulphur $kg\ ha^{-1}$	
	15cm	30cm	15cm	30cm	15cm	30cm	15cm	30cm	15cm	30cm	15cm	30cm
T_1	7.5	7.3	0.56	0.55	150.20	145.3	24.60	20.14	230.3	228.5	34	33.2
T_2	7.4	7.2	0.60	0.58	160.53	152.4	25.70	21.95	235.4	233.3	33.6	32.1
T_3	7.4	7.1	0.61	0.59	170.55	162.1	26.85	22.26	238.6	236.2	32.5	31.4
T_4	7.3	6.8	0.62	0.60	180.31	177.2	27.95	21.21	240.2	238.7	33.4	32.4
T_5	7.2	6.6	0.65	0.63	185.32	180.2	28.85	21.48	242.3	239.6	33.9	32.8
T_6	7.1	6.5	0.69	0.68	190.10	187.7	30.52	23.69	248.6	246.15	34.5	33.8
T_7	6.9	6.4	0.70	0.69	220.65	210.5	31.98	23.96	250.1	248.36	35.6	34.2
T_8	6.8	6.3	0.74	0.72	229.9	215.6	33.78	22.60	253.6	251.28	36.1	35.1
T_9	6.7	6.2	0.80	0.78	240.23	225.2	34.58	22.73	259.9	258.12	37.4	36.4
F-test	S	S	S	S	S	S	S	S	S	S	S	S
S. Em. (±)	0.05	0.06	0.01	0.01	41.13	0.68	0.62	0.56	0.54	0.57	0.43	0.52
C.D.@5%	0.12	0.12	0.02	0.02	87.18	1.44	1.31	1.19	1.15	1.20	0.91	1.10

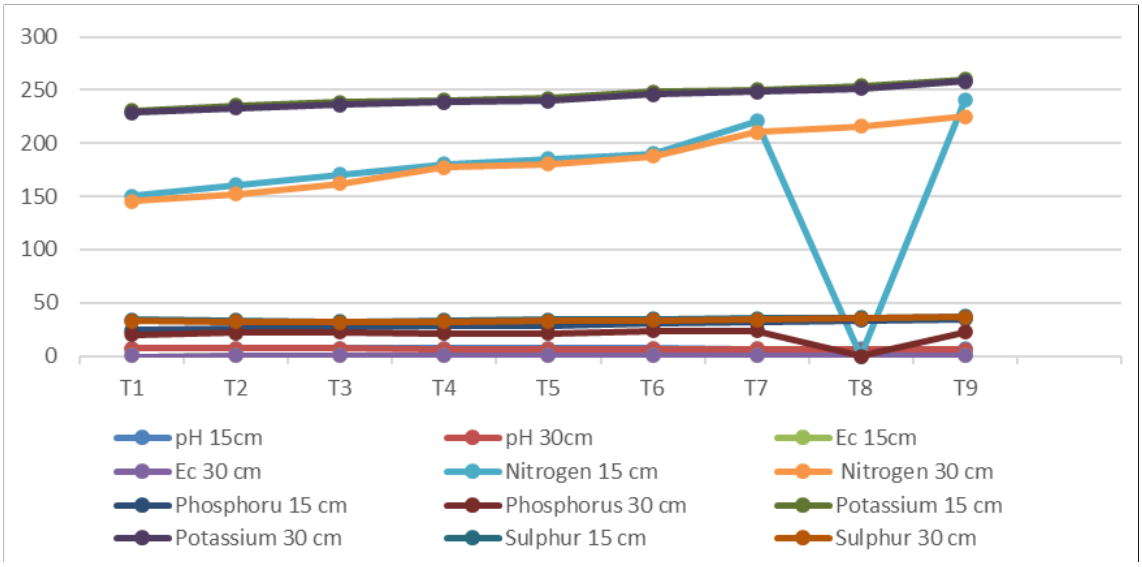

Fig 2: Effect of N, P, K, and poultry manure pH, EC, Nitrogen, Phosphorus, Potassium, Sulphur on chemical properties on post-harvest soil.

Economics of Cultivation (mustard)

The maximum gross return (Rs 224500 ha^{-1}) and net profit (RS 162685) was recorded with the treatment of T_9 (@R100%RDF NPK+ @ 7.5 t ha^1 PM + S @45 kg ha^{-1}) followed by T_8 (@100% RDF NPK+ @7.5 t ha^{-1} PM + S 30 kg ha^{-1}) with a gross return of (Rs. 201000 ha^{-1}). However, the highest benefit cost ratio (3.63) was recorded with the treatment T_9.

Table 4: Effect of different treatment combination on cost benefit ratio (C: B) of mustard

Treatment	Seed Yield (q ha^{-1})	Market price (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Total Cost (₹ ha^{-1})	Net profit (₹ ha^{-1})	Benefit Cost ratio (B:C)
T_1	22.1	50000	110500	36014.1	74485.9	3.06
T_2	25.6	50000	128000	40664.1	87335.9	3.14
T_3	28.9	50000	144500	45314.1	99185.9	3.18
T_4	30.00	50000	150000	45014.1	104985.9	3.33
T_5	33.5	50000	167500	49664.1	117835.9	3.37
T_6	36.4	50000	182000	52514.1	129485.9	3.44
T_7	37.5	50000	187000	54314.1	132685.9	3.46
T_8	40.2	50000	201000	57164.1	143835.9	3.51
T_9	44.9	50000	224500	61814.1	162685.9	3.63

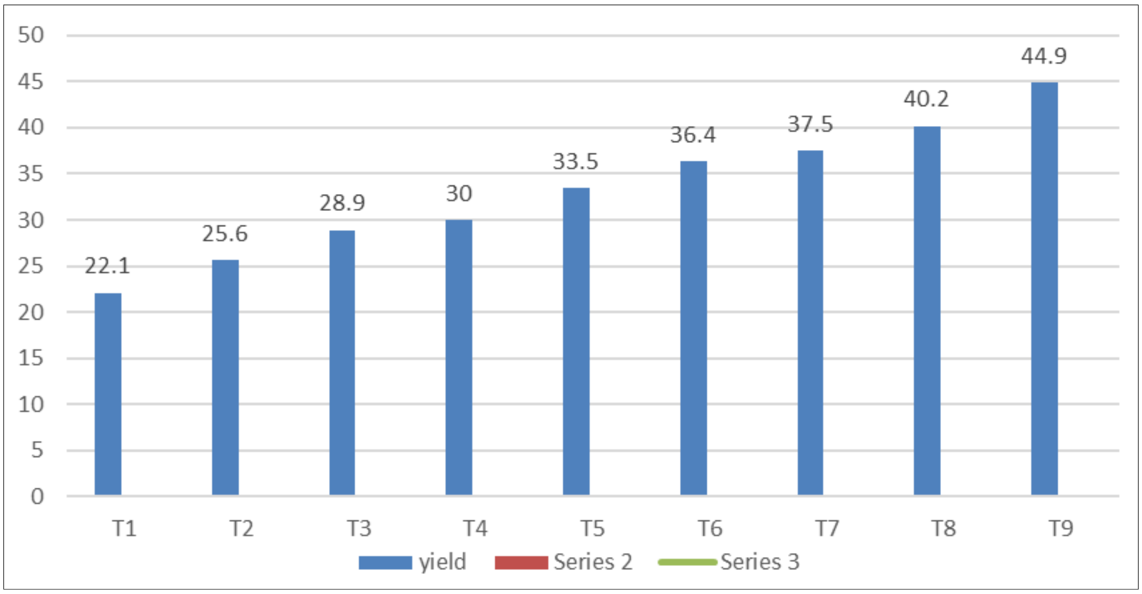

Fig 3: Graphical representation of Treatment Combination VS Yield of mustard

Conclusion

It revealed from trial that the various level of N, P, K, S, and Poultry manure used in the experiment, the treatment combination T_9 [100%RDF N, P, K, + 7.5 t ha^{-1} poultry manure + Sulphur 45 kg ha^{-1}] was found to be the best treatment with highest gross return of ₹ 224500 which gave benefit of ₹162685.9 with highest cost benefit ratio 1:3.63 for mustard. Therefore, T_9 can be recommended for profitable production of mustard *var.* Varuna and it is also found that treatment T_9 has shown significance results over soil physical and chemical properties. Therefore, Combination of N, P, K, poultry manure and Sulphur is found to be better among all treatments for both soil health and mustard production.

Acknowledgement

During my academic journey and research, my advisor and the Head of the Department of Soil Science and Agricultural Chemistry at NAI, SHUATS, have been valuable sources of support.

References

1. Black CA. Methods of soil analysis. Vol. 2. American Society of Agronomy, Madison, Wisconsin, U.S.A; c1965.
2. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soils. Soil Science. 1927;23:393-395.
3. Bryant L. Organic matter can improve your soil's water holding capacity; c2015. Available from: https://www.nrdc.org/experts/lara-bryant/organic-matter-can-improve-your-soils-water-holding-capacity
4. Chesnin L, Yien CH. Turbidimetric determination of sulphate. Soil Science Society Proceedings. 1950;15:149-151.
5. Prasanthrajan M. TNAU, Coimbatore, Tamil Nadu Agricultural University; c2018.
6. Fisher RA. Technique of analysis of variance. Handbook of Agricultural Statistics. 1950;B:29-110.
7. FAO. An international technical workshop investing in sustainable crop intensification: the case for improving soil health. Integrated Crop Management. 2008;6:22-24.
8. Hsiao CJ, Sassenrath GF, Rice C, Hettiarachchi G, Zeglin L. Soil health profile in claypan soils. 2018 Southeast Agricultural Research Center Field Report. Kansas Agricultural Experiment Station Research Reports, 2018, 4(3).
9. Jackson ML. Soil Chemical Analysis. 2nd ed. Prentice Hall of India, New Delhi; c1958.
10. Kandpal BK. Integrated nutrient management in relation to growth, yield and quality of *Brassica carinata* A. Braun and its residual effect on succeeding rice. PhD Thesis, G.B.P.U.A.&T., Pantnagar; c2001.
11. Muthuvel P, Udayasoorian C. Soil, plant, water and agrochemical analysis. Tamil Nadu Agricultural University, Coimbatore, India; c1992.
12. NRCS. Soil Health Key Points; c2013. Available from: https://www.nrcs.usda.gov/Internet/FSE-DOCUMENTS/stelprdb1082147.pdf
13. NRCS. Soil Health; c2018. Available from: https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/
14. Olsen SR, Cole CV, Watnahe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Department of Agriculture Circular; c1954. p. 939.
15. Prasad B. Performance of mustard varieties under different fertility levels. MSc Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar; c2000.
16. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soils. Current Science. 1956;25:259-260.
17. Tomar S, Tomer S, Subey Singh, Singh S. Effect of irrigation and fertility levels on growth, yield and quality of mustard (*Brassica juncea*). Indian Journal of Agronomy. 1992;37(1):76-78.
18. Wetter LR, Ukrainetz H, Downey RK. The effect of chemical fertilizers on the content of oil, protein and glucosinolates in *Brassica* including rapeseed. Proceedings of the International Conference on Rapeseed & Rapeseed Products. St. Adele, Canada; c1970. p. 92-112.
19. Wilcox LV. Electrical conductivity. American Water Works Association; c1950.
20. Wither PJA. Winter oilseed: effects of sulphur on seed glucosinolate content and seed yield. HGCA Oilseeds Project Report. 1992;2:21.
21. Zhao W, Nelson KD, Che J, Quo J, Lu D, Wu C, *et al*. Deep seismic reflection evidence for continental underthrusting beneath southern Tibet. Nature. 1993 Dec 9;366(6455):557-559.