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Effect of different levels of nano fertilizer and FYM on soil physico-chemical properties and yield of mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted during the *Rabi* season 2024-25 at Research Farm, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj (UP) on sandy loam soil to investigate the effect of nano fertilizer and FYM on soil physico-chemical properties and yield of mustard. The factors include 4 levels of nano fertilizer *viz*. 0%, 35%, 75% and 100% and 3 levels of FYM *viz*. 0 t/ha, 12.5 t/ha and 25 t/ha. The experiment was laid out in randomized block design with twelve treatments replicated thrice. Study revealed that the application of different levels of nano fertilizer and FYM significantly influenced soil physico-chemical properties as well as yield of mustard. Treatment T_{12} (Nano fertilizer @ 100% + FYM @ 25 t/ha) significantly enhanced percent pore space, WHC (%), OC (%) and available nutrients NPK (Kg/ha).

Keywords: Nano fertilizer, FYM, physico-chemical properties, yield, mustard

Introduction
Repeated use of chemical fertilizers and its low Nutrient Use Efficiency (NUE) hinder soil ecosystem which reduce soil productivity and hence decrease crop yield Subramanian *et al*., (2015) [26]. Higher application of inorganic fertilizers obviously enhance crop yield but negatively affect soil physico-chemical properties, beneficial microbes and cause pollution (Soil, water and air) Geisseler *et al*., (2014) [11].

Nano fertilizer due to it high bioavailability of nutrients for the crops which enhance NUE and its controlled release of nutrients prevents from soil, air and water pollution Naderi *et al.*, (2013) [18].

Due to continuous and intensive cropping along with unbalanced fertilization cause nutrients deficiency in soil and hence reduce soil efficiency for crop production Lakkineni *et al*., (1994) [16]. Application of FYM in the field does not just provide all the necessary nutrients but also improves soil physical, chemical and biological properties Singh *et al*., (2015) [24].

Rapeseeds-mustard (27%) is the major grown edible oilseed crop in India along with soybean (34%) and groundnut (27%) (Anonymous, 2017) [5] and 3rd biggest producing country after Canada and China FAOSTAT, (2016) [10]. Globally it contributes only 9.54% in oilseed production due to decline in the productivity caused by highly dependent on inorganic fertilizers, improper nutrient management and reduction in cultivable land Anonymous, (2018) [4].

Keeping the facts in the experiment entitled ‘‘Effect of different levels of nano fertilizer and FYM on soil physico-chemical properties and yield of mustard (*Brassica juncea* L.)’’.

Materials and Methods
The experiment was performed at Research Farm, Department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj during the *Rabi* season 2024-25. The factors include 4 levels of nano fertilizer *viz*. 0%, 35%, 75% and 100% and 3 levels of FYM *viz*. 0 t/ha, 12.5 t/ha and 25 t/ha. The experiment was laid out in RBD with twelve treatments which were replicated thrice.

Treatment combination

Symbol	Treatment combination
T_1	Absolute control
T_2	Nano fertilizer @ 0% + FYM @ 12.5 t/ha
T_3	Nano fertilizer @ 0% + FYM @ 25 t/ha
T_4	Nano fertilizer @ 35% + FYM @ 0 t/ha
T_5	Nano fertilizer @ 35% + FYM @ 12.5 t/ha
T_6	Nano fertilizer @ 35% + FYM @ 25 t/ha
T_7	Nano fertilizer @ 75% + FYM @ 0%
T_8	Nano fertilizer @ 75% + FYM @ 12.5 t/ha
T_9	Nano fertilizer @ 75% + FYM @ 25 t/ha
T_{10}	Nano fertilizer @100% + FYM @ 0 t/ha
T_{11}	Nano fertilizer @ 100% + FYM @ 12.5 t/ha
T_{12}	Nano fertilizer @ 100% + FYM @ 25 t/ha

Physical and chemical analysis of post-harvest soil samples

S. No.	Particulars	Method employed
(A)	**Physical properties**	
1.	Bulk density (g cm^{-3})	Graduated cylinder, (Mthuvel *et al*., 1992)
2.	Particle density (g cm^{-3})	
3.	Pore space (%)	
4.	Water holding capacity (%)	
(B)	**Chemical properties**	
5.	pH	Digital pH meter, (Jackson, 1958) [13]
6.	EC (dSm^{-1})	Digital EC meter. (Wilcox,1950) [33]
7.	Organic carbon (%)	Wet oxidation method, (Walkley & Black, 1934) [32]
8.	Available N (Kg/ha)	Alkaline potassium permanganate method, (Subbiah and Asija, 1956) [27]
9.	Available P (Kg/ha)	Colorimetric method, (Olsen *et al*., 1954) [19]
10.	Available K (Kg/ha)	Flame photometric method, (Toth & Prince, 1949) [29]

Results and Discussion

A. Physical properties

Bulk density, particle density, pore space and water holding capacity (WHC)

The application of different levels of nano fertilizer and FYM non-significantly influenced bulk density and particle density while pore space and water holding capacity were significantly influenced at both depths (0-15 and 15-30 cm), depicted in table 1.

Minimum bulk density 1.19 and 1.22 g cm^{-3} at 0-15 and 15-30 cm depth was observed in T_{12} followed by 1.23 and 1.25 g cm^{-3} in T_{11} and the maximum bulk density 1.31 and 1.34 g cm^{-3} at 0-15 and 15-30 cm depth was found in T_1 respectively. Addition of OM through FYM enhanced OC content in soil, improved aggregation, increased root growth and biopores resulting decrease in bulk density (Tiraks *et al*., 1974) [28]. Similar finding was observed by Arya *et al*., (2022) [6].

Minimum particle density 2.35 and 2.38 g cm^{-3} at 0-15 and 15-30 cm depth was observed in T_{12} followed by 2.39 and 2.41 g cm^{-3} in T_{11} and the maximum particle density 2.56 and 2.59 g cm^{-3} at 0-15 and 15-30 cm depth was found in T_1 respectively. The formation of more stable aggregates due to increment in OC content by application of FYM and increase in organic matter in the soil might cause decrease in particle density (Tiraks *et al*., 1974) [28]. Similar finding was observed by Singh *et al*., (2023) [25] and P.K *et al*., (2018) [21].

The maximum pore space 49.74 and 47.86% at 0-15 and 15-30 cm was observed in T_{12} followed by 47.32 and 46.44% in T_{11} and minimum pore space 39.20 and 36.23% was found in T_1 respectively. The decomposed products of FYM i.e. polysaccharides and bacterial gums might be the reason for improved percent pore space of soil as they are known as the particle binding agents (Bhatia *et al*., 1982) [8]. Similar finding was observed by Arya *et al*., (2022) [6].

The maximum WHC 38.35 and 36.73% at 0-15 and 15-30 cm depth was observed in T_{12} followed by 37.83 and 35.62% in T_{11} and minimum WHC 29.53 and 27.26% at 0-15 and 15-30 cm depth was found in T_1 respectively. Addition of OM, silt and clay through FYM might be the reason for enhanced WHC (Pratap *et al*., 2016) [22]. Similar finding was observed by Kumar *et al*., (2018) [15] and Alam *et al*., (2014) [3].

B. Chemical properties

pH, Electrical conductivity (EC) and Organic carbon (OC)

pH, EC and percent organic carbon of soil were significantly influenced at both depths (0-15 and 15-30 cm), depicted in table 2.

Minimum pH 6.85 and 6.88 at 0-15 and 15-30 cm depth was observed in T_{12} followed by 6.89 and 6.93 in T_{11} and the maximum pH 7.20 and 7.24 at 0-15 and 15-30 cm depth was found in T_1 respectively. Organic acid and CO_2 might be the reason to decrease in soil pH which is released during decomposition of farm yard manure (Grewal *et al*., 1981) [12]. Similar finding was observed by Al-Meekh *et al*., (2024) [2].

The maximum EC 0.35 and 0.38 dSm^{-1} at 0-15 and 15-30 cm depth was observed in T_{12} followed by 0.33 and 0.35 dSm^{-1} in T_{11} and minimum EC 0.16 and 0.18 dSm^{-1} at 0-15 and 15-30 cm depth was found in T_1 respectively. Due different nutrients and decomposition of OM which were added by huge quantity of FYM might be the cause to enhanced electrical conductivity of soil (Babu *et al*., 2007) [7]. Similar finding was observed by Choudhary *et al*., (2022) [9] and Singh *et al*., (2021) [23].

The maximum OC 0-51 and 0.47% at 0-15 and 15-30 cm depth was observed in T_{12} followed by 0.48 and 0.45% in T_{11} and minimum OC 0.35 and 0.34% at 0-15 and 15-30 cm depth was found in T_1 respectively. The increase in OC might be due to OM addition by the application FYM and leaf shedding (Acharya *et al*., 1988) [1]. Similar finding was observed by Kumar *et al*., (2025) [14].

Available nutrients NPK

The available nutrients NPK (Kg/ha) of soil were significantly influenced at both depths (0-15 and 15-30 cm), depicted in table 3.

The maximum available nitrogen 272.03 and 266.97 kg/ha at 0-15 and 15-30 cm depth was observed in T_{12} followed by 269.00 and 264.70 kg/ha in T_{11} and minimum available nitrogen 248.23 and 245.59 kg/ha at 0-15 and 15-30 cm depth was found in T_1 respectively.

The maximum available phosphorus 32.03 and 29.40 kg/ha at 0-15 and 15-30 cm depth was observed in T_{12} followed 30.40 and 27.37 kg/ha in T_{11} and minimum available phosphorus 16.36 and 14.40 kg/ha at 0-15 and 15-30 cm depth was found in T_1 respectively.

The maximum available potassium 229.79 and 223.47 kg/ha at 0-15 and 15-30 cm depth was observed in T_{12} followed by 223.24 and 217.16 kg/ha in T_{11} and minimum available potassium 188.56 and 182.73 kg/ha at 0-15 and 15-30 cm depth was found in T_1 respectively.

FYM adds nutrients to soil along with its beneficial role for microbes which help in mineralization of the nutrients cause increase in available nutrients in the soil (Urkurkar *et al*., 2010) [31]. Similar finding was observed by Kumar *et al*., (2025) [14] and Pandey *et al*., (2020) [20].

Table 1: Effect of different levels of nano fertilizer and FYM on bulk density (g cm^{-3}), particle density (g cm^{-3}), pore space (%) and WHC (%) of soil at 0-15 and 15-30 cm depth.

Treatment	Bulk density (g cm^{-3})		Particle density (g cm^{-3})		Pore space (%)		WHC (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1	1.31	1.34	2.56	2.59	39.2	36.23	29.53	27.26
T2	1.29	1.31	2.51	2.54	42.14	39.22	32.22	30.14
T3	1.27	1.29	2.46	2.48	45.32	42.38	34.46	31.43
T4	1.30	1.33	2.54	2.57	39.86	37.56	30.12	28.48
T5	1.28	1.30	2.49	2.53	43.38	41.36	32.73	30.62
T6	1.26	1.28	2.44	2.46	46.22	44.65	35.53	32.86
T7	1.29	1.32	2.50	2.54	40.25	38.65	31.34	29.32
T8	1.25	1.28	2.45	2.48	44.45	42.24	33.42	31.92
T9	1.24	1.26	2.40	2.42	46.94	45.34	36.2	34.52
T10	1.27	1.29	2.48	2.51	42.87	43.12	32.55	29.82
T11	1.23	1.25	2.39	2.41	47.32	46.44	37.83	35.62
T12	1.19	1.22	2.35	2.38	49.74	47.86	38.35	36.73
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed	0.03	0.04	0.07	0.07	3.04	3.28	2.54	2.63
C.D at 5%	0.07	0.08	0.14	0.15	6.31	6.81	5.27	5.45

Table 2: Effect of different levels of nano fertilizer and FYM on pH, Electrical conductivity (dSm^{-1}) and organic carbon (%) of soil at 0-15 and 15-30 cm depth.

Treatment	pH (1:2.5) w/v		Electrical conductivity (dSm^{-1})		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1	7.20	7.24	0.16	0.18	0.35	0.34
T2	7.12	7.16	0.24	0.27	0.37	0.35
T3	6.99	7.05	0.28	0.30	0.39	0.37
T4	7.17	7.22	0.17	0.19	0.36	0.34
T5	7.09	7.13	0.26	0.28	0.40	0.39
T6	6.95	6.98	0.30	0.33	0.43	0.41
T7	7.15	7.19	0.19	0.21	0.41	0.38
T8	7.05	7.10	0.28	0.31	0.45	0.42
T9	6.92	6.94	0.32	0.34	0.46	0.44
T10	7.13	7.16	0.21	0.23	0.42	0.40
T11	6.89	6.93	0.33	0.35	0.48	0.45
T12	6.85	6.88	0.35	0.38	0.51	0.47
F-Test	S	S	S	S	S	S
S.Ed	0.05	0.04	0.03	0.04	0.01	0.01
C.D at 5%	0.10	0.08	0.07	0.09	0.02	0.02

Table 3: Effect of different levels of nano fertilizer and FYM on available N (Kg/ha), available P (Kg/ha) and available K (Kg/ha) of soil at 0-15 and 15-30 cm depth

Treatment	Available nitrogen (Kg/ha)		Available phosphorus (Kg/ha)		Available potassium (Kg/ha)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T1	248.23	245.59	16.36	14.40	188.56	182.73
T2	252.05	248.13	18.48	15.63	195.37	189.99
T3	256.04	252.07	20.48	18.50	201.06	196.01
T4	251.27	246.67	17.62	16.27	193.65	190.63
T5	257.00	253.13	22.53	19.45	207.68	198.17
T6	259.21	255.48	24.59	22.15	212.86	205.94
T7	254.20	251.50	21.45	20.20	205.63	195.44
T8	261.81	258.70	26.63	23.39	215.14	208.44
T9	265.63	261.59	29.90	25.52	220.17	215.48
T10	260.56	257.67	23.95	22.60	216.37	211.52
T11	269.00	264.70	30.40	27.37	223.24	217.16
T12	272.03	266.97	32.03	29.40	229.79	223.47
F-Test	S	S	S	S	S	S
S.Ed	1.79	1.07	0.71	0.89	1.01	1.96
C.D at 5%	3.72	2.22	1.47	1.85	2.09	4.06

Conclusion

Results revealed that the application of different levels of nano fertilizer and FYM significantly influenced soil physico-chemical properties and yield as well. Treatment T_{12} (Nano fertilizer @ 100% + FYM @ 25 t/ha) significantly enhanced percent pore space, WHC (%), OC (%) and available nutrients NPK (Kg/ha).

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