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Response of foliar feeding of Bioregulator and Micro nutrient on soil health and yield attributes of mustard (*Brassica juncea* L. Czern) var. Nandi-321

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Abstract
An experiment was carried out at Soil Science and Agricultural Chemistry Research farm, Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during rabi season 2020-21 is located at 25^0 24' 42" N latitude and 81^0 50' 56" E longitudes at 98 m altitude above the mean sea level, trial was laid out in 3×3 factorial randomized block design with three replications, consisting of nine treatments. Treatment T_9 (@ 100% RDF+$ZnSO_4$ @ 10 kg ha^{-1}+NC @ 500g ha^{-1}) was found to be best. The pH, EC, OC, available Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}) @ Potassium (kg ha^{-1}), Sulphur (ppm) and Zinc (ppm) which were as 7.44, 0.27, 069, 325.82,30.67,205.06and1.51 respectively. The soil physical properties as the texture (Sandy loam), bulk density (Mg m^{-3}), particle density (Mg m^{-3}) and Pore space (%) were found to be significant. Soil Health can be maintained with integrated management practices.

Keywords: Sulphur, zinc, neem cake, soil physico-chemical properties and mustard

Introduction
Agriculture is the back bone of Indian gross domestic production. Oilseeds are the second most important determinant of the agricultural economy after cereals. India is the fifth largest vegetable oil economy in the world, along with the United States, China, Brazil and Argentina, it accounts for 7.4% of world oilseed production and 6.1% of oilseed production., 3.9% of world meal exports, 5.8% of vegetable oil production, 11.2% of world oil imports and 9.3% of world edible oil consumption (DRMR, 2013) [5] India is the fourth major base of the global rapeseed and rapeseed economy 28.6% of the total oilseed production among the seven edible oilseeds grown in India, second only to peanuts and accounting for 27.8% of the Indian oilseed economy (Singh *et al.*, 2017) [16]. Vegetable (edible) oils play an essential position in human nutrition. As a high-energy food component, cooking oil plays an important role in meeting human caloric needs.

India will produce 89.5 thousand mustard seeds during the current rabi season: (COOIT) The Central Organization of Petroleum Industry and Trade (COOIT, 2020) [4] estimates that 89.5 thousand mustard seeds will be grown in the country in the current rabi season. (2020) compared to 750,000 tons recorded last year. Indian mustard (*Brassica juncea* L. Czern) belongs to family Cruciferae or Brassicaceae, genus Brassica and species juncea popularly known as rai, raya, laha and sarson. The area, production and yield of nine oilseeds in India is about 26.48 million hectares, 30.94 million tons and 1168 kg per hectares, respectively, while the area under rapeseed crops in India is 6.36 million hectares with a yield of 8.03 million tons. In India, 1262 kg per hectares [General Directorate of Economics and Statistics, Ministry of Agriculture and Cooperation, (2012-13)] [7]. The country shares about 23% of the world production of rapeseed and mustard. Indian mustard (*Brassica juncea* L.) is mainly grown in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh and Gujarat, as well as in some unconventional areas in southern India such as Karnataka, Tamil Nadu and Andhra Pradesh. Rajasthan and Uttar Pradesh occupy about 80% of the country's area and production. The oil content of mustard seeds ranges from 35 to 48% and 37 to 42% of the meal protein [(NIIR, Board; Nagaraj, (1995)] [13] An important group of edible oilseeds, accounting for about 26.1% of the total oilseed production and about 85% of the total crop oilseeds: total mustard production produced in India [Meena *et al.*, (2011)]. The India is first position in area and second position in Production after that china.

Nutrients

Optimum amount and balanced fertilization is critically required for achieving higher yield from improved variety of Indian mustard. Primary nutrients i.e. nitrogen, phosphorus and potassium play a vital role in crop yield. The importance of micronutrients application in increasing crop production has been recognized in India [Dubey *et al.*, (2013)] [6]. The major nutrients sulphur and zinc plays an important role in mustard, which are insufficient in most of Indian soil. Zinc play important role in the correct functioning of many enzyme systems, the synthesis of nucleic acids and auxin (plant hormones) metabolisms, protein analysis and normal crop development and growth [Mengel *et al*., (1987)] [11]. Sulphur plays a key role in the production of sulphur containing amino-acid, vitamins synthesis of protein and glycosides synthesis. It is a constituent of glutathione (a compound supposed to be associated with the plant respiration) and in the synthesis of essential oils. Sulphur also plays a vital role in chlorophyll formation.

Bioregulator

Neem (*Azadirachta indica*) is a completely beneficial tree on has marshal significance in our each day lifestyles and currently in agriculture. Neem cake has an ok amount of (NPK) in natural shape for plant growth. Being a very botanical product it incorporates 100% herbal NPK content material and other (Plant nutrients Macronutrients important micro nutrients) as N (Nitrogen 2.0% to 5.0%), P (Phosphorus 0.5% to 1.0%), K (Potassium 1.0% to 2.0%), Ca (Calcium 0.5% to 3.0%), Mg (Magnesium 0.3% to 1.0%), S (Sulphur 0.2% to 3.0%), Zn (Zinc 15 ppm to 60 ppm), Cu (Copper 04 ppm to 20 ppm), Fe (Iron 500ppm to 1200 ppm), Mn (Manganese 20 ppm to 60 ppm). It is wealthy in each sulphur compounds and bitter (limuloids).The organic matter in Neem seed cake (646.64 kg^{-1}), suggested the ability of Neem seed cake to improve the physical, chemical and biological properties in the soil [Garba *et al*., (2014)] [9]. It also acts as a natural fertilizer with pesticide properties. Neem cake improves the organic matter of the soil, soil texture, and water holding capacity. The Neem cake is an eco-friendly organic solid waste manure management for agriculture.

Materials and Methods

Experimental site and climatic condition

The experiment was carried out during winter season (2020-21) at research farm of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, and it is situated 5km away on the right bank of Yamuna river, Prayagraj district of Uttar Pradesh (India).Which is located at 25^0 24' 42" N latitude and 81^0 50' 56" E longitudes at 98 m altitude above the mean sea level. The normal period for onset of the monsoon in this region is second and third week of June and its end of September or sometimes extends to the first week of October and average rainfall in this region is around 500 to 1200 mm annually and out of which about more than 70 percent is received by south-west monsoon season, 5 to 10 percent rains received in the Rabi season and 10-15% in summer and 5-10 percent under the post monsoon season, while annual potential evapo-transpiration is about 1200 mm. The temperature begins to rise from the month of February and its reaches maximum in May and June month.

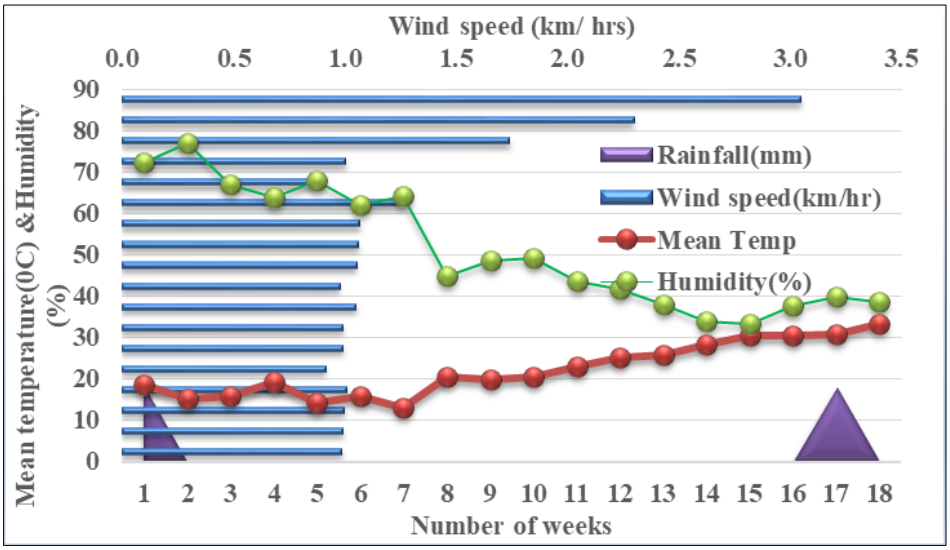

Fig 1: Climatic conditions of Rabi seasons crop duration of mustard

Soil characterization of experimental field

The soil of the experimental site belongs to inceptisols and alluvial soils, mainly soils with low fertility are found, possibly due to the low content of organic matter in the soil in this area. The soil of the experimental field is of alluvial origin. The depth of the soil sample (0-15) cm was originally taken from randomly selected parts of the field prior to planting. The amount of soil sample was reduced to 500 gm by quartering technique. The sample is then subjected to mechanical and chemical analysis to determine the type of texture and fertility. Soil samples were taken from a depth of (0-30) cm from the soil, air dried and sieved (2 mm) for soil analysis.

As depicted in Table 3 shows that the maximum bulk density of soil (g cm^{-3}), was found in T9-(100% RDF+Zn10 kg ha^{-1}+NC500 g ha^{-1}) which was 1.21 and minimum was found in T1-(absolute control) which was 1.03 (g cm^{-3}). The interaction effect of sulphur and zinc with NPK on bulk density (g cm^{-3}) of soil were found significant.

The results shows in Table 3 that the maximum particle density of soil (g cm^{-3}), was found in T9-(100% RDF+Zn10 kg ha^{-1}+NC500g ha^{-1}) which was 2.82 and minimum was found in T1-(absolute control) which was 2.05 (g cm^{-3}). The interaction effect of sulphur and zinc with NPK on particle

density (g m^{-3}) of soil were found significant.

The results shows in Table 3 that the maximum pore space (%) of soil, was found in T9-(100% RDF+Zn10 kg ha^{-1}+NC500g ha^{-1}) which was 56.30 and minimum was found in T5-(Absolute control) which was 49.32.The interaction effect of sulphur and zinc with NPK on pore space (%) of soil were found significant.

Table 1: Soil parameters analysed with these protocols

S. No.	Particulars	Methods employed	Scientist
1.	Soil pH (1:2)	Digital pH meter	Jackson (1958) [10]
2.	Soil EC (dS m^{-1})	Digital EC meter	Wilcox (1950) [21]
3.	Organic Carbon (%)	Wet oxidation	Walkley and Black (1934)
4.	Available Nitrogen (kg ha^{-1})	Alkaline permanganate	Subbaih and Asija (1956) [17]
5.	Available Phosphorus (kg ha^{-1})	Photoelectric colorimeter	Olsen *et al*., (1954) [15]
6.	Available Potassium (kg ha^{-1})	Flame photometer	Toth and Price, (1949) [19]
7.	Sulphur (kg ha^{-1})	Turbidimetric	Bardsley and Lancaster (1960)
8.	Zinc (kg ha^{-1})	Spectrophotometer	Shaw and Dean (1952)

***Source*:** Soil, Plant, water And Fertilizer Analysis (Gupta 2007)

Chemical parameters

Response on pH and EC at 25 ℃ (dSm^{-1}) of soil after crop harvest

The result depicted in Table 4 shows that the pH and EC shows that the maximum pH and EC at 25℃ (dSm^{-1}) of soil was found in T_9-(100% RDF+Zn10 kg ha^{-1}+NC500g ha^{-1}) which were 7.44and 7.01 and minimum was found in T_1-(Absolute control) which were 0.27 and 0.19. The interaction effect of sulphur and zinc with Neem cake on pH and EC was found significant.

Table 2: Physical and Chemical parameters of pre-soil analysis

Particulars	Values
Mechanical parameters	
Sand (%)	64.47
Silt (%)	21.71
Clay (%)	13.82
Textural class	Sandy loam
Soil Colour	Pale brown
Physical and chemical parameters	
Soil pH (1:2)	7.39
Soil EC (dS m^{-1})	0.37
Bulk density (Mg m^{-3})	1.45
Particle density (Mg m^{-3})	2.51
Pore Space (%)	46.53
Organic Carbon (%)	0.5
Available Nitrogen (kg ha^{-1})	262.53
Available Phosphorus (kg ha^{-1})	19.86
Available Potassium (kg ha^{-1})	202.56
Available Sulphur (kg ha^{-1})	9.22
Available Zinc (kg ha^{-1})	0.67

Table 3: Response of Foliar Feeding of Bio Regulator (Neem Cake) and Micro-Nutrient on Physical Properties of Post-harvest Soil.

Treatment	Bulk density (g cm^{-3})	Particle density (g cm^{-3})	Pore space (%)
T_1	1.03	2.05	49.32
T_2	1.08	2.40	50.75
T_3	1.09	2.46	51.72
T_4	1.09	2.47	52.31
T_5	1.12	2.51	53.45
T_6	1.13	2.65	53.74
T_7	1.15	2.63	54.44
T_8	1.19	2.80	55.10
T_9	1.21	2.82	56.30
F - test	S	S	S
SEM(±)	0.019	0.089	0.822
CD at (5%)	0.058	0.269	2.466

Table 4: Response of Foliar Feeding of Bio regulator (Neem Cake) and Micro-Nutrient on Chemical Properties of Post-harvest Soil.

Treatment	pH (w/v)	EC (dSm^{-1})	Organic carbon (%)	Nitrogen (Kg ha^{-1})	Phosphorous (Kg ha^{-1})	Potassium (Kg ha^{-1})	Zinc (ppm)	Sulphur (ppm)
T_1	7.01	0.196	0.38	283.52	22.47	167.31	0.89	9.71
T_2	7.13	0.216	0.42	296.04	24.74	176.17	0.93	10.83
T_3	7.18	0.23	0.46	305.55	25.58	185.05	1.02	11.16
T_4	7.20	0.236	0.47	304.78	23.69	181.88	1.27	11.76
T_5	7.22	0.243	0.50	311.00	25.90	184.34	1.25	12.53
T_6	7.18	0.250	0.51	316.29	27.86	187.51	1.37	13.07

T_7	7.27	0.253	0.54	310.27	26.73	186.32	1.39	13.45
T_8	7.35	0.256	0.59	316.99	28.50	194.58	1.41	13.75
T_9	7.44	0.270	0.69	325.82	30.67	205.06	1.51	15.22
F - test	S	S	S	S	S	S	S	S
SEM(±)	0.053	0.010	0.05	6.08	0.58	3.9	0.04	0.22
CD at (5%)	0.159	0.031	0.15	18.24	1.76	11.7	0.14	0.68

Response of Organic Carbon (%), Available Nitrogen, Phosphorus, Potassium, Sulphur and Zinc (kg ha^{-1}) of soil after crop harvest

In result it is depicted in table 4 shows that the maximum OC(%), available Nitrogen, Phosphorus, Potassium, Sulphur and Zinc (kg ha^{-1}) in soil were found in T_9-(100% RDF+ Zn 10 kg ha^{-1}+NC 500 g ha^{-1}) which were 0.69, 325.82, 30.67, 205.06, 1.51, 15.22 kg ha^{-1}respectively and minimum was found in T_0-(Absolute control) which were 0.38, 283.52, 22.47, 167.31, 0.89, 4.71 kg ha^{-1}respectively. The interaction effect of Sulphur and Zinc with Neem cake on Available Nitrogen and Potassium was found significant and the interaction effect of Sulphur and Zinc with NPK on OC (%), available phosphorus, sulphur and Zinc was found significant. Combined application of Sulphur and Zinc NPK brings significantly increase in available nitrogen and available potassium. The results are conformity with the finding of [Upadhyay *et al.*, (2016)].

It is concluded that Treatment comb0ination T_9 (100% RDF+Zn10 kg ha^{-1}+NC500g ha^{-1}) was to be best in pH, EC (dSm^{-1}), O.C(%), available Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}), Potassium (kg ha^{-1}), Sulphur (ppm) and Zinc (ppm) which were as 0.69, 325.82, 30.67, 205.06, 1.51, 15.22 kg ha^{-1} respectively. Soil chemical properties as pH, EC, available N and K were found to be significant. Soil physical properties as Bulk density (g cm^{-3}), Particle density (g cm^{-3}), and Pore space (%) were found to be significant.

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