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Effect of different level of NPK, zinc and Vermicompost on the Soil Health Parameters and the Yield of White Maize (*Zea mays* L.) *var.* HM-12

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Abstract
An experiment was conducted during in Kharif season (July 2023 - August 2023) to study the "Effect of different level of N, P, K, Zinc and Vermicompost on Soil Health Parameter and Yield of White Maize (*Zea mays* L.) Var. HM-12 in Prayagraj". A randomized block design was used to set up the experiment, with three levels of NPK (0%, 50%, and 100% NPK), three levels of zinc (@ 0%, @ 50%, and @ 100% zinc) and three levels of Vermicompost (@ 0%, @ 50%, and @ 100% vermicompost). The results shows that inorganic fertilizer application had a non-significant effect on soil physical-chemical parameters (BD, PD, pH, EC and OC) and significant increase in pore space, water holding capacity, available nitrogen, phosphorus, potassium, zinc and vermicompost in treatment T_9 - [NPK @ 100% + Zinc @ at 100% +Vermicompost @ 100%] that found to be best than any other treatments.

Keywords: NPK, physical, chemical properties, soil health, zinc, vermicompost etc.

Introduction
Soil is a natural body consisting of layers (soil horizon) of mineral constituents of variable thickness which different from the parent material in their morphological, physical, chemical and mineralogical characteristics. White maize serves as a staple food for millions of people worldwide, especially in regions of Africa, Latin America, and parts of Asia. Maize belongs to family Gramineae and popularly known as corn, ranking third among the food crops, next to rice and wheat in the world and ranking fourth after rice, wheat and sorghum in India. The crop has high genetic yield potential and hence, it is called as Miracle crop and as the "Queen of cereals". In India occupying 8.80 m ha area with production of 22.56 million tones and productivity status of 2563 kg ha^{-1}, respectively (FAI, 2018-19). Nutritional Value: Maize is a rich source of carbohydrates, essential minerals such as phosphorus and magnesium, and vitamins like niacin and folate. Despite its nutritional value, deficiencies in essential amino acids, particularly lysine and tryptophan, present challenges in addressing malnutrition, especially in communities heavily reliant on maize-based diets. Nitrogen fertilizer plays an essential role in improving soil fertility and increasing crop productivity. Nitrogen fertilizer increases grain yield and biomass in the crop. It contributes an 18-34% increase in soil residual N. Sole residue incorporation or combination with N fertilizer has positive effects on plant growth and production and soil physico-chemical properties. Nitrogen is an essential nutrient that plants require. It increases the growth and development of all living tissues and protein content in pulses. Phosphorus (P) is an important nutrient element among the three primary macronutrients that plants must require for their best growth and development. Phosphorus plays a vital role in photosynthesis, respiration, energy storage, root growth, cell elongation and improves the quality of crops. Potassium is the most abundant inorganic cation and it is important for ensuring optimal plant growth. Potassium has been referred to as "quality element" and "master cation" that are indispensable for the plant's growth and development. Zinc plays major role in many physiological processes *viz*., chlorophyll formation, pollen formation, fertilization, protein synthesis, cell elongation, etc. Hence, Zn nutrition favorably influences the growth, yield, physiological parameters in cereals.

Vermicompost may be defined as the product of composting using various worms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast. Vermicomposting technology also involves the biological conversion of organic wastes into vermicasts and sometimes by the utilization of vermi wash utilizing earthworms.

Materials and Methods

The present experiment is to be entitled "Effect of different level of NPK, Zinc and Vermicompost on Soil Health Parameter and Yield of White Maize (*Zea mays* L.) HM-12". It is conducted on Soil Science Research Farm, SHUATS Prayagraj during Kharif season (July-Sept. 2023). The experiment is being conducted at the Soil Science Research Farm of SHUATS, Prayagraj (U.P.), which is located at 250 24'30" N latitude, 810 51'10" E longitude and 98 m above the mean sea level and is situated 6 km away on the right bank of Yamuna river. Representing the Agro-Ecological Sub Region [North Alluvium plain zone (0-1% slope)] and Agro Climatic Zone (Upper Gangetic Plain Region). Agro-climatically, Allahabad, District represents the subtropical belt of the South East of Uttar Pradesh, and is with extremely hot summer and fairly cold winter. The average rainfall of this area is around 1100mm annually. The soil of experimental area falls in order of Inceptisol. The soil of experimental plot is alluvial. The soil samples before sowing of crops will be collected randomly from the experimental field to ascertain nutrients status of field and after harvest from each plot of the experiment at a depth of 0-15 cm. The size of the soil sample will be reduced by air dry and hammering with the wooden hammer and then pass through a 2 mm sieve, conning and quartering to prepare the composites soil sample for physical and chemical analysis. M.L. Jackson assessed the soil pH with a pH meter, and Wilcox measured the electrical conductivity (EC) with a conductivity meter. The available nitrogen (N) was calculated using the Subbiah and Asija method (1956), the phosphorus (P) was calculated using the Olsen *et al.* method (1954) [21], the potassium (K) was calculated using the Toth and Prince method (1949), and the zinc (Zn) was estimated using the Lindsay and Norvell method (1978) [18]. The soil organic carbon (SOC) was estimated using the Walkley and Black method (1947) [30].

Result and Discussion

Physical Properties of Soil

Bulk density (Mg m^{-3})

The response on the soil bulk density found to be non-significant. The maximum bulk density of soil was found 1.288 Mg m^{-3} and 1.295 Mg m^{-3} in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and the minimum was 1.244 Mg m^{-3} and 1.251 Mg m^{-3} found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%) respectively. It was also observed the bulk density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Kumar *et al*., Bhattacharya *et al*., (2004) [4].

Particle density (Mg m^{-3})

The mean value of particle density of soil (Mg m^{-3}) was found non-significant. The maximum particle density was 2.520 Mg m^{-3} and 2.527 Mg m^{-3} found in T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum was 2.476 Mg m^{-3} and 2.483 Mg m^{-3} found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%) respectively. It was also observed the particle density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Hussain *et al*. (2022) [13], Dangi *et al*. (2020) [7].

Pore Space (%)

The response pore space of soil was found to be significant in levels of NPK and Zn. The maximum pore space of soil was recorded 49.10% and 49.52% found in T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum pore space of soil was recorded 38.60% and 39.42% found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%) respectively. It was also observed the pore space of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by: Azadi *et al.* (2013) [1].

Water Holding Capacity (%)

The response water holding capacity of soil was found to be significant in levels of NPK and Zn. The maximum water holding capacity of soil was recorded 39.78% and 37.57% found in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum water holding capacity of soil was recorded 34.55% and 32.48% founds at of depths 0-15 to 15-30 cm in treatment T_1 [Control (NPK @ 0% + Zn @ 0% + Vermicompost @ 100%)] respectively. It was also observed the water holding capacity (%) of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Azadi *et al*. (2013) [1].

Chemical Properties of Soil

Soil pH (1:2.5) w/v

The response pH of soil was found to be non-significant in levels of NPK and Zn. The maximum pH of soil was recorded 7.03 and 7.04 found in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum pH of soil was recorded 6.91 and 6.92 found at of depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%)] respectively. It was also observed the pH of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Chandrakar (2018) [5], Jha *et al. (*2015) [16].

Soil EC (dS m^{-1})

The response EC of soil was found to be non-significant in levels of NPK and Zn. The maximum EC of soil was recorded 0.4764 dS m^{-1} and 0.470 dS m^{-1} founds in treatment. T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum EC of soil was recorded 0.432 dSm-1 and 0.436 dS m-1 found at of depths at 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%)] respectively. It was also observed that EC of soil were gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram (2016) [19], Habib *et al.* (2018) [11].

Organic Carbon (%)

The maximum organic carbon of soil was found 0.413 and 0.407 in T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum was measured 0.372 and 0.367%at soil depths 0-15 and 15- 30 cm in treatment T_1 (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%) respectively. It was also observed that organic carbon of soil was gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram (2016) [19], Habib *et al.* (2018) [11].

Available nitrogen (kg ha^{-1})

The response available Nitrogen of soil was found to be significant in levels of NPK, Zn and Vermicompost. The maximum Available Nitrogen of soil was recorded 313.70 kg ha^{-1} and 284.10 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum Available Nitrogen of soil was recorded 256.60 kg ha^{-1} and 216.40 kg ha^{-1} at soil depths 0- 15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0% + Vermicompost @ 100%)] respectively. The nitrogen has its major significantrole in completion of crop life cycle. Balanced use of nitrogen (N) fertilizers could play a pivotal role in increasing the yields. In addition to supplying a nutrient for plant growth, N application could enhance drought tolerance of plant to increase yield. Similar result has been recorded by Sharma *et al*. (2009) [25], Javeed *et al.* (2017) [15].

Available phosphorus (kg ha^{-1})

The maximum Available Phosphorus of soil was recorded 16.25 kg ha^{-1} and 15.32 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum Available Phosphorus of soil was recorded 11.03 kg ha^{-1} and 10.69 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%) respectively. The mean value of Available Phosphorus (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma *et al*. (2009) [25], Javeed *et al.* (2017) [15].

Available potassium (kg ha^{-1})

The maximum Available Potassium of soil was recorded 209.70 kg ha^{-1} and 206.78 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100% + Vermicompost @ 100%) and minimum available Potassium of soil was recorded 184.20 kg ha^{-1} and 181.22 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0% + Vermicompost @ 100%)] respectively. The mean value of Available Potassium (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma *et al*. (2009) [25], Javeed *et al.* (2017) [15].

Available zinc (ppm)

The mean value of available Zinc (ppm) of soil was found significant. The maximum available zinc of soil was recorded 0.362 ppm and 0.353 ppm found in treatment T_9 (NPK @ 100% + Zn @ 100% +Vermicompost @ 100%) and minimum available zinc of soil was recorded 0.287 ppm and 0.290 ppm at soil depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0% +Vermicompost @ 100%)] respectively. Similar result has been recorded by Tripathi *et al*. (2011-13) [29], Bameri *et al*. (2012, 2019-23) [3] and Chaudhary *et al.* (2014) [6].

Table 1: Effect of NPK, zinc and vermicompost on soil physical properties

Treatment	BD (Mg m^{-3})		PD (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
[Absolute control]	1.244	1.251	2.476	2.483	38.60	39.42	34.55	32.48
[NPK @ 0% + Zn @ 0% + vc @ 50%]	1.250	1.256	2.480	2.488	41.62	42.52	35.80	33.55
[NPK @ 0% + Zn @ 0% + vc @ 100%]	1.255	1.263	2.486	2.493	43.02	44.23	36.26	34.80
[NPK @ 50% + Zn @ 50% + vc @ 0%]	1.260	1.267	2.490	2.498	44.20	46.10	36.82	35.55
[NPK @ 50% + Zn @ 50% + vc @50%]	1.266	1.273	2.495	2.505	45.24	46.42	37.10	35.69
[NPK @ 50% + Zn @ 50% + vc @ 100%]	1.272	1.279	2.502	2.510	46.42	47.29	37.83	36.26
[NPK @ 100% + Zn @ 100% + vc @0%]	1.277	1.285	2.507	2.516	47.46	48.20	38.22	37.10
[NPK @ 100% + Zn @ 100% + vc @50%]	1.283	1.290	2.513	2.521	48.80	49.01	39.25	37.42
[NPK @ 100% + Zn @ 100% + vc @ 100%]	1.288	1.295	2.520	2.527	49.10	49.52	39.78	37.57
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed. (±)	-	-	-	-	0.62	0.48	0.68	0.55
C.D. at 0.5%	-	-	-	-	1.32	0.99	2.06	1.65

Table 2: Effect of different level NPK, Zinc and Vermicompost on soil chemical properties

Treatment	pH		EC (dS m^{-1})		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
[Absolute control]	6.91	6.92	0.432	0.436	0.372	0.367
[NPK @ 0% + Zn @ 0% + vc @ 50%]	6.93	6.94	0.437	0.439	0.378	0.371
[NPK @ 0% + Zn @ 0% + vc @ 100%]	6.94	6.95	0.441	0.443	0.382	0.376
[NPK @ 50% + Zn @ 50% + vc @ 0%]	6.96	6.97	0.444	0.446	0.387	0.382
[NPK @ 50% + Zn @ 50% + vc @50%]	6.98	6.98	0.448	0.453	0.392	0.387
[NPK @ 50% + Zn @ 50% + vc @ 100%]	6.99	7.00	0.450	0.457	0.396	0.392
[NPK @ 100% + Zn @ 100% + vc @0%]	7.01	7.01	0.455	0.461	0.401	0.398
[NPK @ 100% + Zn @ 100% + vc @50%]	7.02	7.03	0.460	0.465	0.408	0.403
[NPK @ 100% + Zn @ 100% + vc @ 100%]	7.03	7.04	0.464	0.470	0.413	0.407
F-Test	NS	NS	NS	NS	NS	NS
S.Ed. (±)	-	-	-	-	-	-
C.D. at 0.5%	-	-	-	-	-	-

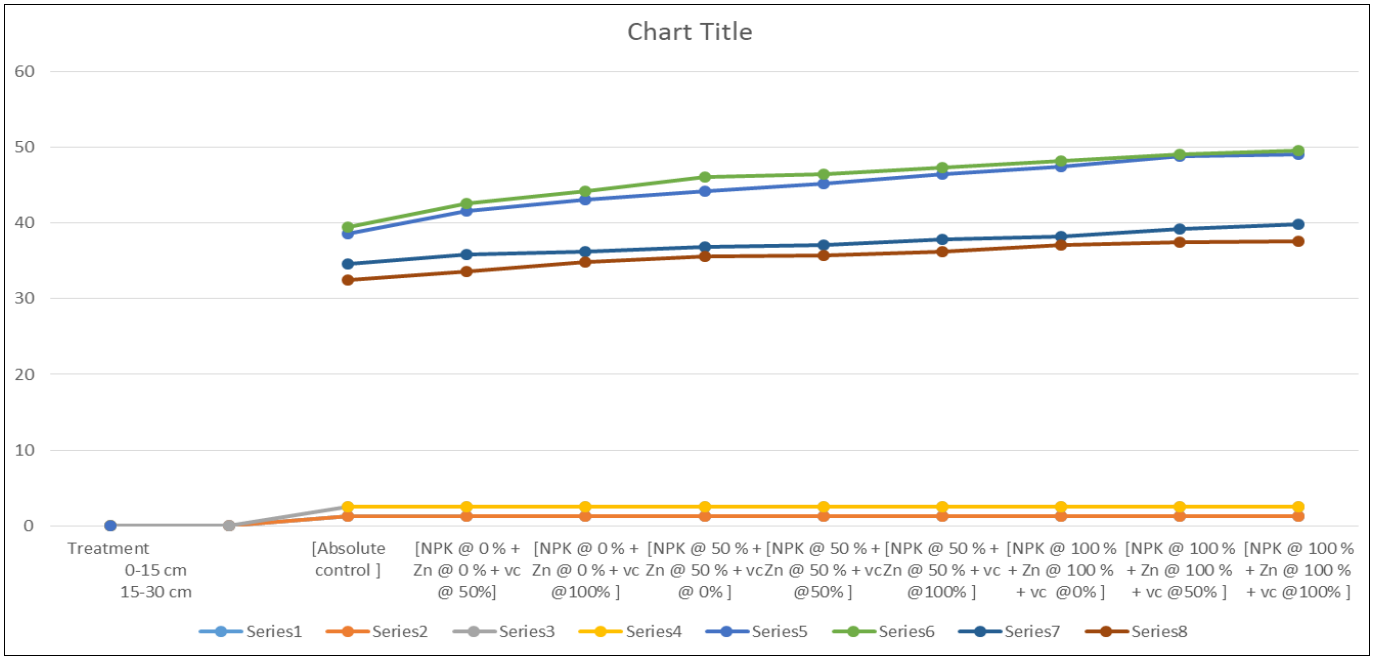

Fig 1: Effect of NPK and vermicompost on soil physical properties

Table 3: Effect of different level of NPK, Zinc and Vermicompost on soil chemical properties

Treatment	Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})		Available Zinc (ppm)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
[Absolute control]	256.6	216.4	11.03	10.69	184.2	181.22	0.298	0.304
[NPK @ 0% + Zn @ 0% + vc @ 50%]	266.3	220.2	11.56	11.02	187.3	184.30	0.340	0.344
[NPK @ 0% + Zn @ 0% + vc @ 100%]	269.2	222.4	12.52	11.86	190.6	187.63	0.364	0.368
[NPK @ 50% + Zn @ 50% + vc @ 0%]	286.7	232.7	12.99	12.02	193.4	192.45	0.324	0.328
[NPK @ 50% + Zn @ 50% + vc @50%]	291.2	237.4	13.43	13.11	197.8	196.84	0.338	0.341
[NPK @ 50% + Zn @ 50% + vc @ 100%]	294.5	240.5	14.12	13.78	202.7	199.75	0.346	0.351
[NPK @ 100% + Zn @ 100% + vc @0%]	307.2	258.7	14.62	14.22	205.4	203.46	0.320	0.325
[NPK @ 100% + Zn @ 100% + vc @50%]	304.5	271.2	15.33	14.84	207.6	204.64	0.332	0.337
[NPK @ 100% + Zn @ 100% + vc @ 100%]	313.7	284.1	16.25	15.32	209.7	206.78	0.353	0.359
F-Test	S	S	S	S	S	S	S	S
S.Ed. (±)	2.18	1.80	1.10	0.68	1.75	1.41	0.12	0.15
C.D. at 0.5%	4.42	3.62	2.23	1.40	3.28	1.85	0.27	0.32

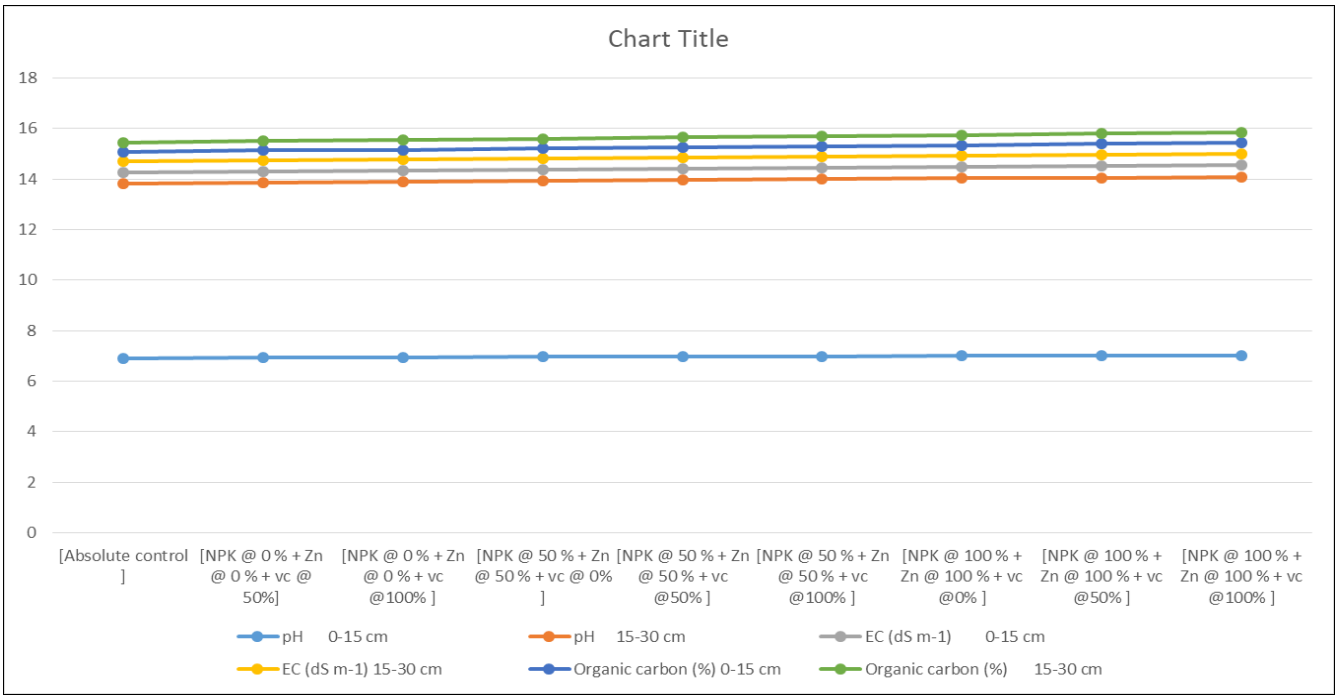

Fig 2: Effect of different level of Zinc on soil chemical properties

Conclusion

From the trial it was concluded that the various level of N, P, K, Zn and Vermicompost used from different sources fertilizers in these trial gave the best physical and chemical result in the treatment T_9 (NPK @ 100% + Zn @ 100 % +Vc @100%) followed by T_8 (NPK @ 100% + Zn @ 100 % + Vc @50%) and the soil health parameters retained the suitable soil properties, yield attributes and yield of White Maize and gave highest net profit of ₹ 1,67,423.00 ha^{-1} with highest benefit cost ratio is 2.31. Therefore, it can be recommended for farmers to obtain best combination treatment (T_9) for higher farm income and sustainable agriculture.

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