Soil Test Crop Response on Soil Health Parameters and Yield Attributes of Okra (*Abelmoschus esculentus* L.) var. Kuber

ABSTRACT

The investigation was conducted on Soil Test Crop Response (STCR) based Integrated Plant Nutrient System (IPNS) technology, where the fertilizer doses are customized according to the anticipated crop yield, considering the crop's nutrient requirements and the contributions from soil, fertilizers, and organic manures. The field trial took place at the S~~s~~oil ~~s~~Science research farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the zaid season of 2023. The soil under experimentation had a sandy loam texture. The setup followed a randomized block design with varying levels of NPK (0%, 50%, & 100%), FYM (20, 25, & 30 t ha^{-1}), ~~and~~ Fe and Zn (15, 20, & 25 kg ha^{-1}) respectively. The outcomes from the T9 treatment - [115:112:75 Kg ha^{-1} + 25 t ha^{-1} FYM + 25 kg ha^{-1} Fe and Zn] exhibited superior plant height, number of branches plant^{-1}, number of leaves plants^{-1}, number of fruits plant^{-1}, and overall fruit yield. No significant differences were noted in the yield and growth of okra under the control conditions. The application of organic manures alone or in combination with full NPK substantially enhanced the growth and total yield parameters of okra. Among all treatments, the simultaneous application of 100% NPK, 100% FYM, and 100% Fe & Zn displayed the most remarkable influence on the growth of okra.

Keywords: NPK: Nitrogen, Phosphorus, Potassium, FYM: Farm Yard Manure, Yield attributes etc.

1. INTRODUCTION

Food security, environmental quality, and soil health pose significant challenges for farmers in the 21st century. Over the past fifty years, there has been a noticeable decline in most soil-based farming systems in India. Despite the growing demand for food, crop productivity and response to fertilizers in intensive cropping systems are steadily decreasing. **Simonson (1989)** eloquently stated that soil, regardless of its depth, color, or composition, serves as the vital link between the earth's core and the life thriving on its surface, making it essential for

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plant growth and the primary focus of our soil-related endeavors. The concept of the Targeted Yield Model is a practical method for the efficient utilization of fertilizers. The formulation of optimal fertilizer recommendations for targeted yields was first introduced by **Troug (1960)** and later refined by **Ramamoorthy *et al.* (1967)** into the Inductive-cum Targeted Yield Model. By incorporating site-specific Integrated Nutrient Management (SSINM), a balanced fertilization approach is achieved through the application of both inorganic and organic nutrient sources. Within the realm of site-specific nutrient management, the Soil Test Crop Response (STCR) method has gained significant attention for determining the appropriate fertilizer dosage to achieve targeted crop yields. The annual NPK nutrient depletion in Indian agriculture amounts to 10 Mt on a net basis **(Satish, 2013).** Addressing this negative balance logically involves adopting an Integrated Nutrient Management strategy that combines inorganic and organic sources. The Integrated Plant Nutrient System (IPNS) encourages the combined usage of fertilizers, organic manures, and biofertilizers, not only to boost major crop productivity but also to enhance soil health in a cost-effective manner. India leads the world in okra production, producing 6416.0 thousand metric tonnes (74% of global production) across 523 thousand ha. Okra cultivation is also prominent in Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico, and Cameroon. Gujarat stands as the top okra producer in India, yielding around 1019.42 thousand tons from 85.15 thousand hectares, with a productivity of 11.97 t ha^{-1}, followed by Uttar Pradesh (335.86 thousand tonnes from 24.80 thousand hectares at 13.54 tonnes ha-1 productivity) (National Horticulture Board, 2021).

Okra is a significant vegetable crop that provides high nutritional value. The green pod of okra, per 100g of edible portion, contains 89.6g of moisture, 6.6g of carbohydrates, 1.9g of protein, 0.2g of fat, 1.2g of fiber, 0.7g of minerals, 66mg of calcium, 43mg of magnesium, 56mg of phosphorus, 103mg of potassium, 0.07mg of thiamine, 0.1mg of riboflavin, 0.6mg of nicotinic acid, 13mg of vitamin-C, and 8mg of oxalic acid (Choudhary et al., 2015). Okra fruit –is primarily consumed when freshly cooked and serves as a significant source of vitamins A, B, C, minerals, iron, iodine, and viscous fiber. It is known for being low in sodium, saturated fats, and cholesterol (Singh et al., 2015). Okra is rich in iodine, vital minerals, and vitamins, with mucilage containing polysaccharides like galacturonic and glucuronic acids (Singh and Ram, 2018). Nitrogen is an essential macronutrient crucial for the growth and development of crop plants. It plays a pivotal role in the synthesis of chlorophyll, proteins, nucleic acids, hormones, and vitamins. Nitrogen aids in cell division, cell elongation, and the increased yield of green pods in okra **Das *et al.* (2014**). Organic manure enhances the cation exchange capacity, water retention, phosphate availability, fertilizer efficiency, and microbial population of the soil. It also reduces nitrogen loss through gradual nutrient release **Tadesse *et al.* (2013).** Phosphorus is a fundamental element in the creation of high-energy compounds like AMP, ADP, and ATP, essential for photosynthesis and respiration. It is a crucial component of nucleic acids and phospholipids. Plants primarily absorb phosphorus in the form of orthophosphate ions (H_2PO_4). Phosphorus supports the early stages of crop development, synchronizes germination, and improves final yields, especially in phosphorus-deficient soils **Meena *et al.* (2017).**

2. METHODOLOGY

A field experiment was conducted in the year 2023 during the Zaid season at research farm of Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj (Allahabad) 211007 U.P., India. The soil of experimental area falls in order Inceptisol and the experimental field is alluvial in nature.
The design applied for statistical analysis was carried out with 3^2 factorial randomized block design having three levels of NPK @ 0, 50 and 100 % ha^{-1}, three levels of FYM @ 15, 20 and 25 t ha^{-1}and three levels of Fe & Zn @ 15, 20 and 25 kg ha^{-1} respectively. The details of the treatment combinations are given below Table No.1. and observation were recorded, plant height, number of leaves plant^{-1}, number of branches plant^{-1}, number of fruits and total yield of fruits. The source of inorganic nutrients were ~~sources as~~ Urea, SSP, MoP and organic nutrients sources as FYM and Fe & Zn. Basal dose of fertilizer was applied in respective plots according to treatment allocation in furrows opened by about 5cm depth before sowing seeds in soil at the same time of sowing of seeds was shown on well-prepared beds in shallow furrows, at the depth of 5 cm, row to row distance was maintained at 30 cm and plant to plant distance was 45 cm, during the course of experiment, observations were recorded as mean values of the data. Nutrient management practices were **T1**- Absolute Control, **T2**- NPK @ 0% + FYM @ 20 t ha^{-1} + Fe & Zn @ 15 kg ha^{-1}, **T3**-NPK @ 0% + FYM @25 t ha^{-1} + Fe & Zn @ 15 kg ha^{-1}, **T4-**NPK @ 50% + FYM @30 t ha^{-1} + Fe & Zn @15 kg ha^{-1}, **T5**-NPK @ 50% + FYM @20 t ha^{-1} + Fe & Zn @20 kg ha^{-1}, **T6**- NPK @ 50% + FYM @25 t ha^{-1}+ Fe & Zn @20 kg ha^{-1}, **T7**- NPK @ 100% + FYM @30 t ha^{-1}+ Fe & Zn @20 kg ha^{-1}, **T8**- NPK @ 100% + FYM @20 t ha^{-1}+ Fe & Zn @285 kg ha^{-1}, **T9**- NPK @ 100% + FYM @25 t ha^{-1} + Fe & Zn @25 kg ha^{-1}.where, RDF- Recommended dose of fertilizers (120:60:40 kg ha^{-1}), STCR- Soil Test Crop Response (115:112:75 kg ha^{-1}). All the experimental plants were provided same cultural practices i.e., fertilizer application, irrigation, gap filling, earthing-up,

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weed management, haulm cutting and plant protection measures during whole period of investigation. Soil samples from each plot at 0-15 cm depth were collected at different stages were air- dried, grind and passed through 2 mm sieve and finally stored in polythene bags for analysis of different physico-chemical parameters and changes in available N, P, K, and % Organic carbon content. The soil sample was analyzed for Bulk density, particle density, % pore space, soil texture, pH, Available N, P, K and Fe & Zn.

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3. RESULTS AND DISCUSSION

3.1 Physical Properties of Soil

The statistical analyses of the recorded data revealed that the response of different levels of fertilizer recommendation based on soil test values on It is obvious from the data given in Table 2 clearly shows that responsesoil Bulk density and Particle density of soil was found to be non-significant (Table 2) in different levels of fertilizer recommendation based on soil test values. The maximum Bulk density (1.31 Mg m^{-3}) and Particle density (2.53 Mg m^{-3}) of soil was recorded in treatment T2 [RDF 0% +FYM 20 t ha^{-1} + Fe & Zn 15 kg ha^{-1}] and minimum Bulk density (1.28 Mg m^{-3}) and Particle density (2.51 Mg m^{-3}) of soil was recorded in T9 [RDF 100% + FYM 25 t ha^{-1}+ Fe & Zn 25 kg ha^{-1}]. The response of soil pore space and water retaining capacity (WRC) was found to be significant in different levels of fertilizer recommendation based on soil test crop response. The maximum soil pore space (49.06 %) and maximum WRC (48.79%) was recorded in treatment T9 [RDF 100% + FYM 25 t ha^{-1}+ Fe & Zn 25 kg ha^{-1}] and minimum soil pore space (48.02 %) and minimum WRC (48.21%) was recorded in treatment T8 [RDF 50% + FYM 20 t ha^{-1}+ Fe & Zn 25 kg ha^{-1}]. The results of the present investigation are also in agreement with the findings of **Ahmadi and David** and **Alam** ***et al*.**

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3.2 Chemical Properties of Soil

An appraisal of the data given in Table 3 clearly shows that available N, P, K, Fe & Zn in soil increased significantly with the increase in different levels of fertilizer recommendation based on soil test values. The maximum available N (271.13 Kg ha^{-1}), available P (22.73 Kg ha^{-1}), available K (210.30 Kg ha^{-1}), available Fe (2.8mg kg^{-1}) and available Zn (1.2 mg kg^{-1}) in soil was recorded in treatment T9 [RDF 100% + FYM 25 t ha^{-1}+ Fe & Zn 25 kg ha^{-1}] and the minimum available N (233.15 Kg ha^{-1}), available P (22.14 Kg ha^{-1}), available K (189.7 Kg ha^{-1}), available Fe (2.5 mg ha^{-1}) and Zn (0.8 mg ha^{-1}) in soil wereas recorded in

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treatment T0 [control]. The consequences of the current investigation are additionally in concurrence with the investigation of **Upadhyay *et al.*,Rajput *et al.*** and **P. Dey**.

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3.1 Plant height

The response of plant height of okra recorded at 30 DAS, 60 DAS and 90 DAS detailed results were in shown in Table 2 as influenced by different levels of NPK, FYM and Fe & Zn. The plant height of okra was found to be ~~have increased~~ significantly increased with the age of plants and increase in the levels of inorganic fertilizers and organic manures application. The maximum plant height was recorded as 23.6 cm, 90.2 cm and 117.2 cm in T_9 at 30 DAS, 60 DAS and 90 DAS respectively and the minimum plant height was recorded as 20.9 cm, 83.0 cm and 107.0 cm in T1- [Absolute control] at 30 DAS, 60 DAS and 90 DAS respectively. Inorganic fertilizer and organic manure play an important role in increasing production, improving quality of vegetables and sustaining soil fertility. Organic manure contains all nutrients which are required for healthy growth of crops and helps to improve physical, chemical and biological properties of soil. **Ola *et al.* (2018)**

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3.2 Number of leaves plant^{-1}

The number of leaves of okra at different days after sowing (DAS) at 30, 60 and 90 detailed results were in shown in Table 2. as influenced by different levels of NPK, FYM and Fe & Zn were found significantly in treatment T_9 was 18.6, 44.2 and 45.2 respectively. While the minimum values of the result were found in treatment T1- [Absolute control] 12.2, 36.8 and 39.4 respectively. The effect of different doses of NPK fertilizers on growth of okra regarding number of leaves and height of plant had significant superiority over other means. **Khetran *et al.*(2016).**

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3.3 Number of branches plant^{-1}

The response of number of branches plant^{-1} recorded at 30 DAS, 60 DAS and 90 DAS detailed results were in shown in Table 2 as influenced by different levels of NPK FYM and Fe & Zn. The Number of branches plant^{-1} of okra was found to have increased significantly with the age of plants and increase in the levels of inorganic fertilizers and organic manures. The maximum number of branches plant^{-1} was recorded as 1.8, 2.4 and 2.6 in T9at 30 DAS, 60 DAS and 90 DAS respectively and the least number of branches was recorded as 0.6, 0.8 and 1.0 in T1- [Absolute control] at 30 DAS, 60 DAS and 90 DAS respectively. Concluded that the use of organic manure in combination with inorganic fertilizers in the production of

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vegetables like okra should be encouraged as it is beneficial for the physical growth of okra plants. **Gayathri *et al.*(2013)**

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3.4 Number of fruits plant^{-1}

The response of number of fruits plant^{-1} recorded and detailed results were in shown in Table 2 as influenced by different levels of NPK FYM and Fe & Zn. The number of fruits plant^{-1} of okra was found to have increased significantly with the application of inorganic fertilizers and organic manures. The maximum number of fruits plant^{-1} was recorded as 23.2 in T9andminimum number of fruits plant^{-1} was recorded as 14.0 in T1- [Absolute control]. Potassium is one of the three major nutrient elements (N, P and K) required by plants. Potassium imparts vigour and disease resistance to the plant and plays an important role in crop productivity. **Ginindza *et al.* (2015)**

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3.5 Yield of fruits q ha^{-1}

Highest yield of fruits due to influence of NPK, FYM andFe & Zn was recorded as 178.50 in T9and minimum yield was recorded as 110.81 in T1- [Absolute control].

The requirements of fertilizers in okra are important for the early growth and total yield of fruit. Integrated use of Organic and Inorganic fertilizers can improve crop productivity. The soil enriched withFYM provides additional substances that are not found in chemical fertilizers. **Mal *et al.*(2014)**.

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4. CONCLUSION

It is being revealed by the trial that application of FYM and inorganic fertilizers in treatment T9 was found best in increasing growth and yield of Okra. The maximum bulk density (Mg m^{-3}) 1.30 Mg m^{-3}, particles density (Mg m^{-3}) 2.53 Mg m^{-3} were recorded in T1. The maximum porosity (%) 49.06 %, water holding capacity (%) 48.79, available nitrogen (kg ha^{-1}) 271.13 Kg ha^{-1}, available phosphorous (kg ha^{-1}) 22.73 Kg ha^{-1}, available potassium (kg ha^{-1}) 210.3 Kg ha^{-1} and available sulphur (mg kg^{-1}) 4.8 Kg ha^{-1} was recorded in T9. Based on the results emanated from present investigation, it could be concluded that STCR based integrated nutrient management not only gave higher crop yield but also provide highest nutrient content in okra. The results also highlight that STCR-IPNM based nutrient application is effective tool for sustaining soil health. Therefore, STCR-IPNM based nutrient management can be recommended as an effective tool for balanced fertilization.

It revealed from the trial that application of NPK FYM and Fe & Zn in treatment T9 was found best in increasing growth and yield of okra. Since the results is based on one season experiment, further trail is needed to substantiate the result.

Comment [A33]: Please rewrite the conclusion with innovative findings and recommendation

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Table No.1. Effect of different level of NPK FYM and Fe & Zn on Yield attributes of Okra

Treatment	Plant height (cm)			Number of leaves			Number of branches			Number of fruits	Yield of fruits (q ha^{-1})
	30D	60D	90D	30D	60D	90D	30D	60D	90D		

	AS	AS	AS	AS	AS	AS	AS	AS	AS		
T_1	20.2	83.0	107.0	12.2	36.8	39.4	0.6	0.8	1.0	14.0	110.81
T_2	21.2	84.0	107.6	13.0	37.4	40.0	0.8	1.0	1.2	14.2	117.84
T_3	20.8	85.2	108.0	13.4	38.4	40.0	0.8	1.2	1.4	14.6	120.56
T_4	21.6	86.4	109.8	14.0	39.2	40.8	1.0	1.4	1.6	15.4	122.38
T_5	22.0	87.2	111.0	14.8	39.2	41.8	1.2	1.6	1.8	16.2	130.60
T_6	22.0	87.4	111.4	15.4	41.0	42.4	1.4	1.8	2.0	18.0	136.70
T_7	22.4	87.8	112.6	16.0	41.8	43.0	1.4	1.8	2.2	19.6	150.35
T_8	23.0	89.0	115.6	17.2	43.2	44.2	1.6	2.0	2.4	20.8	174.55
T_9	23.6	90.2	117.2	18.6	44.2	45.2	1.8	2.4	2.6	23.2	178.50
F-test	S	S	S	S	S	S	S	S	S	S	S
S.Em. (±)	0.35661	1.15136	1.55396	0.30157	0.54027	0.75387	0.01611	0.02102	0.01669	0.23018	1.61692
C.D. (P= 0.05)	1.13091	3.46592	4.67787	0.90781	1.62638	2.26938	0.0485	0.06327	0.05024	0.69291	4.8674

Table 2. Response of FYM and inorganic fertilizers based on STCR of okra on physicalproperties of soil after crop harvest

Treatment	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Pore space (%)	WRC (%)

T_1	1.30	2.52	48.54	45.25
T_2	1.31	2.53	48.57	45.48
T_3	1.29	2.52	48.67	45.83
T_4	1.29	2.52	48.71	46.23
T_5	1.29	2.52	48.67	45.83
T_6	1.29	2.52	48.83	47.32
T_7	1.28	2.52	48.94	48.73
T_8	1.28	2.51	48.02	48.21
T_9	1.28	2.51	49.06	48.79
F-test	NS	NS	S	S
S.Em. (±)	0.01728	0.04261	0.88487	0.82364
C.D. (P= 0.05)	0.05202	0.12828	2.66372	2.47939

Table 3. Response of FYM and inorganic fertilizers based on STCR of okra on Chemical Properties of soil after crop harvest

Treatment	Available Nitrogen (kg ha^{-1})	Available phosphorous (kg ha^{-1})	Available potassium (kg ha^{-1})	Available Fe (mg ha^{-}	Available Zn (mg ha^{-1})

				^{1})	
T_1	233.15	22.14	189.7	2.5	0.8
T_2	236.33	22.63	198.6	2.5	0.9
T_3	243.35	22.46	202.0	2.6	0.9
T_4	249.44	22.71	203.0	2.6	0.8
T_5	250.31	22.78	205.3	2.5	1.0
T_6	258.40	22.49	205.6	2.7	1.0
T_7	262.20	22.56	206.7	2.6	1.1
T_8	264.42	22.60	209.0	2.7	0.9
T_9	271.13	22.73	210.3	2.8	1.2
F-test	S	S	S	S	S
S.Em. (±)	4.62058	1.05795	4.79221	0.11	0.80
C.D. (P= 0.05)	9.83537	0.49702	10.2007	0.32	2.33