



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

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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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 Soil 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

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randomized block design with varying levels of NPK (0%, 50%, & 100%), FYM (20, 25, & 30 t ha⁻¹), 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 [1] 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 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 [2] and later refined by Ramamoorthy et al. [3] 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 [4]. 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) [5].

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 [6]. 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 [7]. Okra is rich in iodine, vital minerals, and vitamins, with mucilage containing polysaccharides like galacturonic and glucuronic acids [8]. 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. [9]. 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. [10]. "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. [11].

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 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 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, 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” [12].

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 soil Bulk density and Particle density was found to be non-significant (Table 2). 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 [13] and Alam et al.

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” [12]. 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 (2.8 $mg kg^{-1}$) 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 were recorded in treatment T0 [control]. The consequences of the current investigation are additionally in concurrence with the investigation of [14], [15,16].

Table 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)
	30DAS	60DAS	90DAS	30DAS	60DAS	90DAS	30DAS	60DAS	90DAS		
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 physical properties of soil at post-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 at post-harvest

Treatment	Available Nitrogen (kg ha ⁻¹)	Available phosphorous (kg ha ⁻¹)	Available potassium (kg ha ⁻¹)	Available Fe (mg ha ⁻¹)	Available Zn (mg ha ⁻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

3.3 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 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 T₉ 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" [17].

3.4 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 T₉ 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 [18].

3.5 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 T₉ at 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 vegetables like okra should be encouraged as it is beneficial for the physical growth of okra plants [19-22].

3.6 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 T₉ and minimum number of fruits plant⁻¹ was recorded as 14.0 in T1- [Absolute control] [23-25].

Potassium is one of the three major nutrient elements (N, P and K) required by plants [26]. Potassium imparts vigour and disease resistance to the plant and plays an important role in crop productivity Ginindza et al. [27]

3.7 Yield of Fruits q ha⁻¹

Highest yield of fruits due to influence of NPK, FYM and Fe & Zn was recorded as 178.50 in T₉ and 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 with FYM provides additional substances that are not found in chemical fertilizers" Mal et al. [28].

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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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