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RESEARCH ARTICLE II

Influence of Soil Test Crop Response Based Integrated Plant Nutrient Management on Quality of Okra [*Abelmoschus esculentus* (L.) Monech]

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ABSTRACT

In Soil Test Crop Response (STCR) based Integrated Plant Nutrient System (IPNS) technology, the fertilizer doses are tailored as per the requirements of estimated crop yield taking into account the nutrient requirement of the crop, and the contribution of nutrients from the soil, fertilizers and organic manures. In this study, a field experiment was carried out in the Bahour soil series of Puducherry to study the quality of Okra in response to STCR-based manure and fertilizer application. The experiment was carried out with ten treatments *viz*., farmer's practice, FYM alone @ 12.5 t ha^{-1}, blanket recommendation, STCR-NPK alone @ 160, 170, and 180 q ha^{-1}, and STCR-IPNS @ 160, 170, and 180 q ha^{-1} and control replicated thrice. The fruit samples were collected at 5th, 12th, and 19th pickings and were analyzed for quality parameters. Application of STCR + IPNS – 180 q ha^{-1} improved the quality parameters such as mucilage (4.54%), protein (1.84%), and starch (4.95%) and ascorbic acid (13.99 mg per100g) content of Okra. The STCR-IPNS technology ensures sustainable crop production and economical use of expensive fertilizer.

Keywords: *Health; Improve; Productivity; Quality; Sustainable*

INTRODUCTION

Food security, environmental quality, and soil health are among the significant challenges faced by agriculturists in the 21st century. During the last five decades, mostsoil-based production systems in India are showing a declining trend. In contrast to the increasing food demand, crop productivity and rate of response to applied fertilizers under intensive cropping systems are reducing continuously. Okra, conversantly known as lady's finger or okra (*Abelmoschus esculentus* (L.) Moench) belonging to the family Malvaceae, is an important vegetable crop in tropics, subtropics and mildly temperate regions of the world. As okra is known for its nutritional and medicinal value, there is a need to increase its production and quality. Okra is a , short-duration vegetable crop whose growth, yield, and qualityare highly influenced by fertilizer application. Okra contains proteins, carbohydrates, and vitamin C (Gopalan *et al.*, 2007) and is considered vital in the human diet(Kahlon *et al.*,2007). The best way to meet food and vegetable requirements for our country is to produce more from limited land area resources with viable technologies. The balance sheet of NPK in Indian agriculture shows an annual nutrient depletion of 10 Mt NPK on a net basis (Satish Chander, 2013). The most logical way to meet this negative balance is by adopting an integrated nutrient management approach involving both inorganic and organic sources. Integrated Plant-Nutrient System (IPNS) involves the combined use of fertilizers, organic manures and biofertilizers not only helps in improving the productivity of the major crops but also helps in the maintenance of better soil health on cost-effective basis.

Based on the aforementioned discussion, the current study was conducted to investigate the quality of Okra based on applications of STCR-based organic and inorganic fertilizers on bahour soil series of Puducherry.

MATERIALS AND METHODS

DETAILS OF THE FIELD EXPERIMENT

A field experiment was conducted during the Kharif season of 2019 in Karikalampakkam village in Nettapakkam commune of Pondicherry district, U.T of Puducherry. According to agro climatic zonal

classification, the study area is located at 11°56' North latitude and 79°66' East longitude. The experiment was carried out with ten treatments viz., farmer's practice, FYM alone @ 12.5 t ha^{-1}, blanket recommendation, STCR-NPK alone @ 160, 170, and 180 q ha^{-1}, and STCR-IPNS @ 160, 170, and 180 q ha^{-1} and control each replicated thrice. The soil of the experimental field was sandy loam in texture, neutral in pH, and non-saline. The fertility status of the soil was low in $KMnO_4$-N (212 kg ha^{-1}) and organic carbon (4.20 g kg^{-1}) and medium in Olsen-P (20.60 kg ha^{-1}) and NH_4OAc-K (196 kg ha^{-1}). The representative fruit sample from each plot was collected at 5th, 12th, and 19th picking and analyzed for quality parameters viz., the content of mucilage, starch, protein, crude fibre, and ascorbic acid. Each of the above parameters was considered n important criteria for evaluating the various treatment efficiency.

QUALITY PARAMETERS

MUCILAGE CONTENT

The mucilage content of fresh fruits collected at different stages was found by employing the method suggested by Sadasivam and Manickam (1992). The following formula was used for the estimation of mucilage content.

$$\text{Per cent mucilage} = \frac{\text{Weight of mucilage}}{\text{Weight of sample (g)}} \times 100$$

STARCH CONTENT

Starch content of the fresh fruit samples collected at different stages of the harvest was estimated by the method suggested by Sadasivam and Manickam (1992).

PROTEIN CONTENT

The protein content in the fresh fruits collected at different stages was found out by employing the method suggested by Sadasivam and Manickam (1992) using folin-ciocalteau reagent.

CRUDE FIBRE

The crude fiber content of the dried fruit sample was analyzed by oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin. (Sadasivam and Manickam 1992).

ASCORBIC ACID

The ascorbic acid content in the fresh fruit samples was estimated by spectrophotometric analysis. The intensity of color was measured at 540 nm. (Sadasivam and Manickam 1992).

RESULTS AND DISCUSSION

MUCILAGE CONTENT

The content of mucilage was found to be the highest in the treatment that received FYM (12.5 t ha^{-1}) alone i.e., (4.65 per cent), and was nonsignificant in the treatments that received STCR+IPNS combination, farmer's practice, and blanket recommendation treatments (Figure 1). The lowest was recorded in control (2.92 per cent). Sanni and Adesina (2012) reported higher mucilage content of Okra in addition to organic manures which could be attributed to the supply of micronutrients and traces of secondary metabolites that act as stimulants for mucilage synthesis. The interaction of various treatments with different picking stages was found to be insignificant.

The simple correlation revealed that mucilage content was positively correlated with the concentration of ascorbic acid (r = 0.939**) and negatively correlated to crude fibre (r= - 0.820**) at 19th picking (Table 4). The mucilage content of fruit was positively correlated to starch content at 19th stage of picking. The mucilage of Okra consists of the metabolic product of carbohydrates like galacturonic acid, glucose, and galactose that increases the synthesis of starch.

STARCH CONTENT

The starch content of the fresh fruit was higher in treatments that received STCR+IPNS combination at various doses and they were insignificant to the treatments that received blanket recommendation and FYM (12.5 t ha^{-1}) alone treatments (Figure 2). The least starch content was recorded in control followed by STCR-NPK alone and farmer's practice treatments. In STCR-IPNS treatments, the synergistic effect of N and P helped in higher chlorophyll content and photosynthetic activities, resulting in a higher rate of starch synthesis (Singaram and Kamalakumari, 1999). The simple correlation studies revealed that the starch content was positively correlated with mucilage, protein, and ascorbic acid at 19th picking (Table 4).

PROTEIN CONTENT

The protein content of fresh fruit was numerically higher (1.84 per cent) in the plot that received STCR + IPNS – 180 q ha^{-1}. The lowest protein content (1.42 per cent) was observed in control followed by STCR-NPK alone treatment (Table 1). It was observed that

STCR-NPK alone treatment followed an increasing trend with the advancement of crop growth as compared to other treatments but the increase was less pronounced. The addition of organic manure along with fertilizer resulted in higher protein content which might be due to the supply of N from organics and S supply from SSP forming an integral part of amino acids. This observation is in line with the results of Akande *et al*. (2010), who revealed that the application of inorganic fertilizers along with organic manure increased the abundant supply of available nutrients, which favours the protein synthesis in the metabolism of the Okra crop The improved protein content in STCR-IPNS treatments could be ascribed to the cumulative effect of FYM and inorganic fertilizers based on soil test and yield targets. Similar results were also reported by Singaram and Kamalakumari (1999) and Pavan Yadave *et al*. (2006). The simple correlation revealed that the protein content was positively correlated with mucilage, starch, and ascorbic acid content at 19th picking (Table 6).

CRUDE FIBRE

The content of crude fiber was significantly higher in the fruits harvested in the control plot (15.63 per cent) followed by STCR-NPK alone treatment and least in the plots that received STCR+IPNS treatments followed by FYM (12.5 t ha^{-1}) alone treatment (Table 2). The crude fibre content increased as the crop attained maturity. The content of crude fibre is an important fruit quality parameter as it directly reflects the quality of cooked vegetables. Asha and Geetha (2001) reported that the low crude fibre content had a positive influence in improving keeping quality. The crude fibre is the indigestible fraction of the carbohydrates consisting of cellulose, hemicelluloses and lignin of the cell wall. Both mucilage and crude fibre are the derivatives of carbohydrates. In the plant system, if the photosynthetic carbon source is undergoing the synthesis of mucilage content by the action of any metabolites from the organic sources resulting in the low crude fiber in the fruit.

The significant and negative relation of crude fibre with mucilage, protein, starch, and ascorbic acid content in the present study also lends support to the above findings. Similar negative relation of crude fibre was reported by Kuppusamy, (2008) (Table 4).

ASCORBIC ACID

The ascorbic acid content was found to be higher (13.99 mg per 100g) in the treatment that received STCR + IPNS –180 q ha^{-1} (Table 3). Numerically lower ascorbic acid content was recorded in control plots (10.86 mg per 100g). As ascorbic acid is synthesized from glucose, thus any factor that induces carbohydrates synthesis would also improve ascorbic acid content. Nanthakumar and Veeraragavathatham (1999) reported that the application of organic manures not only supplies major and micro nutrients that favour photosynthetic activity but also results in higher sugar content which is duly accompanied by an increase in ascorbic acid content. The above finding was also reported by Sankaran *et al.* (2005) and Kuppusamy (2008). The highest amount of ascorbic acid content might be due to the balancing effects of nutrients available to the plants under the conditions of integrated application of inorganic fertilizers with organics as reported by Suchithra and Manivannan (2012).

The simple correlation studies reveal that the ascorbic acid content was positively correlated with mucilage, starch, and protein and negatively correlated with crude fibre content at 19th picking stage. The finding was confirmed by the positive relationship between starch and ascorbic acid content of fruit at 19th stage of picking (Table 4).

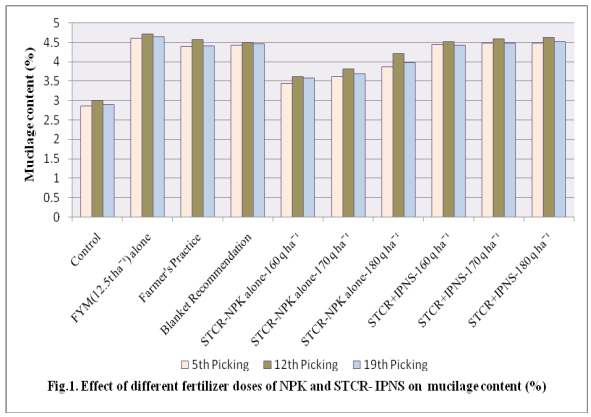

Fig.1. Effect of different fertilizer doses of NPK and STCR- IPNS on mucilage content (%)

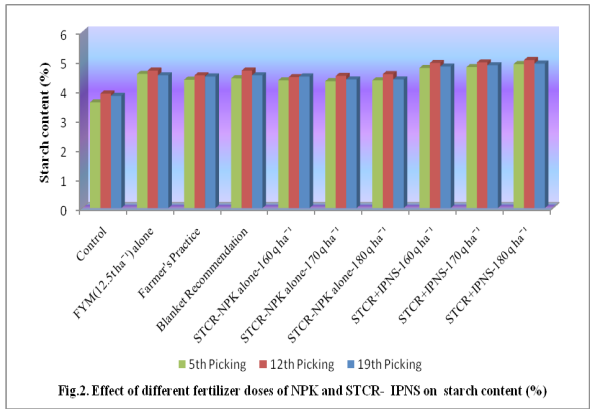

Fig.2. Effect of different fertilizer doses of NPK and STCR- IPNS on starch content (%)

Table1.Effect of different treatments on protein content (per cent)

Treatments	5th picking	12th picking	19th picking	Treatment Mean
T1-Control	1.41	1.43	1.44	1.42
T2- FYM (12.5 t ha^{-1}) alone	1.58	1.69	1.77	1.68
T3-Farmer's Practice	1.55	1.67	1.63	1.61
T4-Blanket Recommendation	1.60	1.67	1.70	1.65
T5-STCR-NPK alone-160 q ha^{-1}	1.45	1.47	1.50	1.47
T6-STCR-NPK alone-170 q ha^{-1}	1.45	1.48	1.50	1.47
T7-STCR-NPK alone-180 q ha^{-1}	1.48	1.51	1.53	1.50
T8-STCR+IPNS-160 q ha^{-1}	1.76	1.78	1.77	1.77
T9-STCR+IPNS-170 q ha^{-1}	1.80	1.80	1.79	1.79
T10-STCR+IPNS-180 q ha^{-1}	1.85	1.85	1.82	1.84
Days Mean	1.59	1.63	1.64	
	T	D	T X D	
S.Ed	0.02	0.01	0.03	
C.D(0.05)	0.04	0.02	0.07	

Table 2.Effect of different treatments on crude fibre content (per cent)

Treatments	5th picking	12th picking	19th picking	Treatment Mean
T1-Control	15.26	15.53	16.12	15.63
T2- FYM (12.5 t ha^{-1}) alone	12.12	12.36	12.70	12.39
T3-Farmer's Practice	12.38	12.60	12.81	12.59
T4-Blanket Recommendation	12.60	12.88	12.98	12.82
T5-STCR-NPK alone-160 q ha^{-1}	13.30	13.48	13.58	13.45
T6-STCR-NPK alone-170 q ha^{-1}	13.22	13.42	13.50	13.38
T7-STCR-NPK alone-180 q ha^{-1}	13.18	13.40	13.52	13.36
T8-STCR+IPNS-160 q ha^{-1}	10.34	10.56	10.64	10.51
T9-STCR+IPNS-170 q ha^{-1}	10.3	10.56	10.60	10.48
T10-STCR+IPNS-180 q ha^{-1}	10.18	10.42	10.48	10.36
Days Mean	12.28	12.52	12.69	
	T	D	T X D	
S.Ed	0.12	0.06	0.20	
C.D(0.05)	0.24	0.13	NS	

Table 3.Effect of different treatments on ascorbic acid content (mg $100gm^{-1}$)

Treatments	5th picking	12th picking	19th picking	Treatment Mean
T1-Control	10.86	10.93	10.81	10.86
T2- FYM (12.5 t ha^{-1}) alone	13.69	14.10	13.98	13.92
T3-Farmer's Practice	13.00	13.28	13.50	13.26
T4-Blanket Recommendation	13.28	13.96	13.80	13.68
T5-STCR-NPK alone-160 q ha^{-1}	11.45	11.78	11.60	11.61
T6-STCR-NPK alone-170 q ha^{-1}	11.48	11.82	11.58	11.62
T7-STCR-NPK alone-180 q ha^{-1}	11.40	11.80	11.52	11.57
T8-STCR+IPNS-160 q ha^{-1}	13.60	13.94	13.86	13.80

T9-STCR+IPNS-170 q ha^{-1}	13.65	14.00	13.92	13.85
T10-STCR+IPNS-180 q ha^{-1}	13.85	14.12	14.02	13.99
Days Mean	12.62	12.97	12.85	
	T	D	T X D	
S.Ed	0.18	0.10	0.31	
C.D(0.05)	0.36	0.20	NS	

4.Results of simple correlation between quality parameters of Okra at 19th picking (n=10)

	Mucilage (%)	Starch (%)	Protein (%)	Crude fibre (%)	Ascorbic acid (mg 100 gm^{-1})
Mucilage	1.000				
Starch	0.826**	1.000			
Protein	0.899**	0.845**	1.000		
Crude fibre	-0.820**	-0.980**	- 0.880**	1.000	
Ascorbic acid	0.939**	0.798**	0.961**	- 0.820**	1.000

CONCLUSION

The STCR-IPNS technology ensures quality and sustainable crop production and economic use of fertilizer inputs. Fertilizer schedules should therefore be based on the magnitude of crop response to applied nutrients at different fertility levels and therefore, soil test-based fertilizer prescription plays a vital role in ensuring balanced nutrition to crops.

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. If anything is required from the MS, certainly, this will be extended by communicating with the corresponding author through corresponding official mail; mageshsmart2@gmail.com.

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