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Comparative Study of Different Integrated Nutrient Management on Okra *(Abelmoschus esculentus* (L.) Moench) cv. Arka Anamika under Terai Zone of West Bengal

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ABSTRACT

Nutrient management through integration of different organic and inorganic fertilizers provide a superior result than using each component separately. Thus, to investigate the outcome of integrated nutrient management in okra cv. Arka Anamika, an experiment was conducted at the experimental field of Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during Kharif season of 2019. The 15 integrated treatment combinations were arranged in Randomised Block Design with 3 replications where various growth and yield parameters were observed. Growth attributing characters like days to 50% flowering commenced early (40.33) in treatment T_6 whilst, plant height (76.46 cm at first harvest and 141.19 cm at last harvest), stem girth (14.17 mm) and number of primary branches (3.47) was observed to be influenced positively by the treatment T_5. As regards to the yield parameters, concurrently all yield contributing parameters like length of pod (11.46 cm), width of pod (14.60 mm), individual fresh weight of pod (14.98 g), number of pods (20.92), fresh yield per plant (331.96 g) and fresh yield per hectare (23.42 t ha^{-1}) showed maximal values in the plants which received the treatment T_5. While treatment T_{15} (Control) was found to be less benignant towards the growth and yield of okra. Presumably, these observation has lead to the undisputed conclusion that T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) might have a salutary effect on okra cv. Arka Anamika under the terai region of West Bengal.

Key words: *Integrated nutrient management, Inorganic sources, Organic sources, Okra.*

Introduction

Okra *Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop of the family malvaceae grown in tropical and sub-tropical parts of the world (Singh *et al*., 2014). It is one of the oldest cultivated crops and is suitable for cultivation in a kitchen garden as well as on commercial level. It is one of the cheapest green vegetable of India which is quite popular because of easy cultivation, consistent yield and adaptability to various climatic situations. Okra is commonly grown during summer and rainy seasons for its green, non-fibrous tender fruits (Rana *et al*., 2020). Fruits are rich in vitamins, calcium, potassium and other mineral matters like iodine which is useful in the treatment of simple goiter (Meena

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and Meena, 2018). Apart from these, young leaves can be cooked as a vegetable or can be used as cattle feeds. The seed of okra contains a good amount of oil and protein of a superior nutritional quality and could be processed to extract edible oil (about 20%). Seeds are also used as the substitutes for coffee (Singh *et al*., 2014). In India, okra mucilage is also used as a clarifying agent in sugar cane juice for making molasses (Chauhan, 1972). Its mature fruit and stems contain crude fibre, which is used in the paper industry (Singh *et al.,* 2018).

India is number one producer of okra in Asia as well as in the world with a share of 73.25 % in World Agriculture having an area of 528'000 Ha and production of 6146'000 MT/Ha (2016-17). Okra is grown in almost every part of India but West Bengal is the leading state with production of around 913.32'000 MT (Anon. 2017).

Though India is a 2nd largest producer of vegetables and number one producer of okra in the world there is a major challenge faced by mankind i.e., reducing yield and ever expanding world population. The rate of yield gain in crop improvement programme must be in proportion to the rate of population growth so, as to avoid malnutrition and hunger. The chemical fertilizers play an important role but its unceasing use has an adverse impact, both on natural resources and human health (Thirunavukkarasu and Balaji, 2015). Application of imbalanced nutrients led to declining nutrient-use efficiency making fertilizer consumption uneconomical, poor quality of vegetables and producing adverse effects on atmosphere and groundwater quality (Amiry *et al.,* 2018; Sachan *et al.,* 2017). While organic methods has a great potential but the nutrient needs of Indian agriculture are so large that organic manures alone cannot fullfill the nutrition requirement of crop (Wagh *et al*., 2014). Therefore, a judicious combination of organic and chemical fertilizers may help to maintain the soil health and to augment the efficiency of nutrients improving the productivity of crop (Wagh *et al.,* 2014). The long picking period of okra demands a continuous and proper nutrient supply while deep root system prefers a good soil condition for the roots, therefore the growth and yield of okra can be improved by appropriate nutrient management practices (Singh *et al.,* 2007; Suchitra and Manivannan, 2012; Iqbal *et al.,* 2014). Keeping all this in view, the present investigation was carried out to study the effect of different nutrient management on okra cv. Arka Anamika under terai zone of West Bengal.

Materials and Methods

The experiment was executed during the Kharif season of 2019 from the month of April to August at the experimental field of the Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, India. Geographical location of the area is 26^0 40' N latitude and 89^0 38' E longitudes with elevation of 43 meter above sea level. It falls under the Terai zone of West Bengal with temperature range of 5-6^0 C to 24-34^0 C and high rainfall between 2500–3300 mm. The soil was sandy loam with medium water holding capacity, good organic matter content and low pH. The experiment consisting of fifteen treatment applied to cv. Arka Anamika was conducted in a RBD with three replications in plot size of 2.1 m × 2.7 m maintaining the spacing of 45 cm × 30 cm. Treatment combination were as follows; T_1 100% Recommended Dose of Fertilizer, T_2 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost, T_3 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost, T_4 100% Recommended Dose of Fertilizer + Biofertilizer (PSB and *Azatobacter*), T_5 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer (PSB and *Azatobacter*), T_6 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer (PSB and *Azatobacter*), T_7 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure, T_8 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure, T_9 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure + Biofertilizer (PSB and *Azatobacter*), T_{10} 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure+ Biofertilizer (PSB and *Azatobacter*), T_{11} 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha, T_{12} 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Jeevamrutha, T_{13} 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{14} 50% Recommended Dose of Fertilizer + 50% Recommended

Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{15} Control. In recommended dose of fertilizer (100:50:50 kg/ha) source of N, P and K was urea, SSP and MOP respectively. Full dose of P, K and N in 2 splits were applied (30 and 60 days after sowing). Biofertilizer (PSB and *Azatobacter*) was used as a seed treatment while, Jeevamrutha was prepared as per the method given by Devakumar *et al.* (2014) and used for soil drenching at 30 DAS. Farm yard manure, vermicompost and poultry manure were incorporated 12 days prior to sowing at the experimental plot.

All the recommended cultural operations were followed to raise a healthy crop and data on days to 50% flowering, number of primary branches at last harvest, height of the plant at 1st harvest, stem girth at 1st harvest, length of pod (cm), width of pod (mm), number of pods, individual fresh weight of pods (g), fresh yield per plant (g), fresh yield per ha (tons) and physiological weight loss were recorded during the study. Harvesting was done on an alternative day basis in order to harvest the pods before it becomes fibrous. All the parameters were statistically analyzed using analysis of variance (ANOVA) under Randomized Block Design as described by Panse and Sukhatme (1985).

Results and Discussion

Growth parameters: The difference exerted by the various treatments on the days to 50% flowering is detailed in Table 1. Among the 15 treatment, T_6 (50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost+ Biofertilizer) induced earliest days to 50% flowering (40.33 DAS) in okra which is at par with treatment T_3, T_5, T_9 and T_{10}. Amiry *et al.* (2017), Singh *et al.* (2018) and Saurabh *et al.* (2021) also reported that the days to flowering in okra was earliest in the treatment consisting integration of synthetic and organic sources rather than control. It may be due tothe combined effect of chemical fertilizer along with vermicompost and biofertilizer which aided in balanced nutrient supply and improved availability of food material leading to differentiation of bud and initiation of flowers within a short period of time (Amiry *et al.*, 2017; Rana *et al.*, 2020; Mal *et al.*, 2013). Additionally, plant growth-regulating substances (PGRs) present in vermicompost, particularly gibberellin, which play a major role in the regulation of flowering could explain the early flower initiation (Rosales and Galinato, 2018; Kist *et al.*, 2019).

The maximum height of okra at 1st harvesting (76.46 cm) and at last harvesting (141.19 cm) was obtained in the treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer). It was succeeded by the treatment T_6 and T_9 while, minimum height was acquired in plants with no treatment (T_{15} Control) at both the stages. This result is closely confined with the findings of Sachan *et al.* (2017); Meena and Meena (2018). The increased height of the plants in treatment T_5 is attributable to the availability of higher levels of nitrogen throughout the period of plant growth initially from inorganic source and succeeding requirements from organic sources, enhanced available phosphorus from supplemented biofertilizer and growth hormones like auxin from added vermicompost (Abha *et al.*, 2019). Further, considerable amount of microorganisms present in vermicompost nourishes the roots to assimilate nutrients which stimulate the plant growth (Kist *et al.*, 2019).

The stem girth exhibited significant differences due to the treatments provided (Table 1). The maximum stem girth of 14.17 mm was observed in treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) which is at par with treatment T_6 and T_9. Likewise, the least stem girth of 8.63 mm was obtained in control (T_{15}). Meena and Meena (2018); Singh and Ram (2018) reported higher stem diameter in okra which received the treatment consisting of RDF along with vermicompost. The steady source of nutrients and attainability of growth-promoting agents through integration of fertilizers in all the treatments except control (T_{15}) mayhap increased the multiplication and enlargement of cells thereby increasing the stem thickness (Meena and Meena, 2018; Chaudhari *et al.*, 2018).

From the table 1 it is evident that the treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) excelled in comparison to other treatments regarding the number of primary branches. The treatment T_5 is at par with treatments T_6, T_9 and T_{10}. Meanwhile, treatment T_{15} (control) produced least number of primary branches (2.00). The balanced supply of all the major nutrients necessary for the growth and development of plant parts from different sources might have increased the number of primary branches in these treatments through the active photosynthesis (Thirunavukkarasu and Balaji, 2015). The nutrient source consisting the mixture of organic and synthetic fertilizer enhances the branch number in okra Singh *et al.* (2018); Sachan *et al.,* (2017) and Ghuge *et al.,* (2015).

Yield parameters: Influence of the various nutrient sources and their combination on the yield attributes of okra has been summed up in the table 2. It is evident that treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) was significantly superior and exerted highest value in all of the parameters. Quite the reverse effect on these parameters was obtained in treatment T_{15} (control).

The maximum length, width and fresh weight of pods (11.46 cm, 14.60mm and 14.98 g respectively) was obtained in treatment T_5 on the other hand, the treatment without any nutrient source (T_{15} Control) produced the pods of minimum length, width and weight (9.06 cm, 11.37 mm and 10.87 g). Mal *et al.* (2013) also reported highest length, girth and single weight a fruit when RDF from chemical means was incorporated along with the vermicompost and biofertilizer. The improved nutrient and structural status of the soil may have increased the availability of NPK and water at the crucial periods of crop growth, which may have contributed to enhanced vegetative growth and increases photosynthesis and photosynthate translocation from source to sink, which in turn accelerated the development of longer

Table 1. Average performance of okra as influenced by different nutrient combination.

Treatment	Days to 50% flowering (DAS)	Height of the plant at 1st harvest (cm)	Height of the plant at last harvest (cm)	Stem girth (mm)	Number of primary branches
T_1	48.67	60.49	108.45	11.10	2.20
T_2	44.00	71.65	126.12	11.80	2.87
T_3	42.00	55.19	115.24	10.04	2.67
T_4	45.33	69.79	121.07	11.61	2.80
T_5	40.67	76.46	141.19	14.17	3.47
T_6	40.33	73.05	140.11	13.24	3.27
T_7	45.67	69.34	124.42	11.48	2.80
T_8	43.67	53.43	115.07	9.68	2.60
T_9	41.67	71.93	134.43	13.05	3.13
T_{10}	41.33	71.74	133.14	12.63	3.07
T_{11}	46.67	56.39	117.29	10.11	2.73
T_{12}	46.00	53.36	112.61	8.80	2.53
T_{13}	43.33	62.52	132.69	11.38	3.07
T_{14}	42.67	59.17	130.25	10.84	3.00
T_{15}	52.67	44.91	98.21	8.63	2.00
SE(m)	0.81	0.41	0.59	0.42	0.15
CD (5%)	2.32	1.17	1.68	1.19	0.42

$T_1$100% Recommended Dose of Fertilizer, $T_2$75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost, $T_3$50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost, $T_4$100% Recommended Dose of Fertilizer + Biofertilizer (PSB and *Azatobacter*), $T_5$75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost+ Biofertilizer (PSB and *Azatobacter*), $T_6$50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost+ Biofertilizer (PSB and *Azatobacter*), $T_7$75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure, $T_8$50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure, $T_9$75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure+ Biofertilizer (PSB and *Azatobacter*), T_{10}50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure+ Biofertilizer (PSB and *Azatobacter*), T_{11}75% Recommended Dose Of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha, T_{12}50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Jeevamrutha, T_{13}75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{14}50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{15}Control and wider fruits (Mal *et al*., 2013; Kumar *et al*., 2013).

Likewise, other yield attributes such as; number of pods (20.92) and fresh yield per plant (331.96 g) was highest in the treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) which was followed by treatment T_6, T_9 and T_{10} hence, in these treatments the fresh yield per hectare was superior. Meanwhile, the treatment T_{15} (control) produced the least number of pods (15.38) and fresh yield per plant (167.15 g) consequently diminishing the fresh yield per hectare (11.79 t ha^{-1}). Mal *et al.*, (2013) and Chaudhari *et al*., (2018) also found an increment in yield parameters as an outcome of incorporating vermicompost and biofertilizer.

The number of pods/fruits in a plant is a key factor for determining the final yield of a crop, inclusion of nutrient in organic and synthetic form has boost up the pods number in okra plant. Perhaps improved soil physical characteristics from the integrated use of nutrient sources increased the capacity of soil to hold water and nutrients, resulting in higher nutrient availability and uptake by plants. Increased physiological and meristematic activity in plants as a result of better nutrient availability leads to the production of more photo assimilates, which aid in the plant's ability to produce more flowers and minimise the flower drop, thereby increasing the number of fruits per plant (Vishwajith and Devakumar *et al.,* 2018; Mishra *et al.,* 2019).

Conclusion

With the support of the above findings an undisputed conclusion can be drawn that the integration of nutrients at an appropriate ratio offers a better

Table 2. Average performance of okra as influenced by different nutrient combination.

Treatment	Length of pod (cm)	Width of pod (mm)	Individual fresh weight of pods (g)	Number of pods	Fresh yield per plant (g)	Fresh yield per ha (Tons)
T_1	10.04	12.83	12.90	17.11	220.77	15.57
T_2	10.90	13.87	13.83	19.28	266.61	18.81
T_3	10.56	13.47	13.07	18.83	246.02	17.36
T_4	10.79	13.63	13.47	19.02	256.19	18.07
T_5	11.46	14.60	14.98	20.92	331.96	23.42
T_6	11.26	14.45	14.67	20.90	313.57	22.12
T_7	10.80	13.68	13.70	19.20	263.03	18.56
T_8	10.27	13.00	13.03	17.88	233.14	16.45
T_9	11.10	14.17	14.50	20.05	290.58	20.50
T_{10}	11.05	14.11	14.17	19.92	282.21	19.91
T_{11}	10.60	13.55	13.33	18.90	252.07	17.78
T_{12}	10.13	12.93	13.00	17.80	231.30	16.32
T_{13}	11.02	13.97	13.93	19.72	274.77	19.38
T_{14}	10.92	13.88	13.90	19.43	270.04	19.05
T_{15}	9.06	11.37	10.87	15.38	167.15	11.79
SE(m)	0.18	0.29	0.10	0.22	3.17	0.22
CD (5%)	0.50	0.83	0.28	0.63	9.05	0.64

T_1 100% Recommended Dose of Fertilizer, T_2 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost, T_3 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost, T_4 100% Recommended Dose of Fertilizer + Biofertilizer (PSB and *Azatobacter*), T_5 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer (PSB and *Azatobacter*), T_6 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer (PSB and *Azatobacter*), T_7 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure, T_8 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure, T_9 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Poultry manure+ Biofertilizer (PSB and *Azatobacter*), T_{10} 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Poultry manure+ Biofertilizer (PSB and *Azatobacter*), T_{11} 75% Recommended Dose Of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha, T_{12} 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Jeevamrutha, T_{13} 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{14} 50% Recommended Dose of Fertilizer + 50% Recommended Dose of Nitrogen through Jeevamrutha + Biofertilizer (PSB and *Azatobacter*), T_{15} Control.

setting for the growth, development and yield of a crop. Likewise, in the present experiment treatment T_5 (75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer) delivered an optimum condition which enhances the growth and yield of a crop. Hence, such treatment i.e. T_5 compraising of 75% Recommended Dose of Fertilizer + 25% Recommended Dose of Nitrogen through Vermicompost + Biofertilizer can be used for obtaining fruitful yield in okra cv. Arka Anamika under terai zone of West Bengal.

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