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Impact of integrated nutrient management on vegetative growth, flowering and economic yield of Okra (*Abelmoschus esculentus* (L.) Moench) *cv*. Arka Anamika

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Abstract
The supply of nutrients to the crops for efficient crop production is the most important factor in agriculture, next to the irrigation. Currently, agricultural production is at torpor because the genetic potential of different vegetable crops or varieties is being used to the maximum extent possible by application of recommended dose of fertilizers (RDF). Finding a suitable advancement to address this issue is the biggest challenge that our scientific community is facing at present. Among the many strategies which are being currently investigated, nutrient management through the combination of organic and inorganic fertilizers is crucial for boosting vegetable production. Continuous use of inorganic fertilizers alone degrades soil, pH imbalance and pollutes the ecosystem. Thus, the adoption of an integrated nutrient management method is the best alternative system for the long-term and economically viable management of soil fertility and crop productivity. A field experiment was carried out at the experimental unit of Department of Horticulture, Tilak Dhari Post Graduate College, and Jaunpur (U.P.), to evaluate the influence of "Impact of integrated nutrient management on vegetative growth), flowering and economic yield of Okra (*Abelmoschus esculentus* (L.) Moench) *cv*. Arka Anamika". Eleven treatments of 50%, 75% and 100% RDF with a combination of FYM, Vermicompost, and Town Compost were used in the replicated trial. The application (100% NPK) in T_2 produced the maximum plant height (119.24 cm), number of leaves per plant (32.36), number of branches per plant (2.92), number of internodes per plant (20.87), whereas the application of (75% NPK + 25% VC) in T_4 produced the highest intermodal length (7.65). On the other hand, the application of (50% NPK + 50% VC) in T_7 resulted in the minimum number of days to first flowering (40.31 days), maximum number of flowers per plant (21.20), days to first fruit set (42.01 days), number of fruits per plant (17.20), fruit weight (16.33 g), fruit yield per plot (5.62 kg), fruit yield per hectare (187.31 q/ha) with good quality okra and highest net income (Rs. 425252) and B:C ratio (4.10:1). Thus, the best approach to increase productivity and economic yield of okra is to combine the use of organic and inorganic sources.

Keywords: Integrated nutrient management, vegetative growth, flowering and economic yield

Introduction
Organic products are one of the most frequently discussed topics in modern agriculture today due to the current trend towards healthy eating habits. Furthermore, the agricultural community is now concerned about climate variability due to problems like extreme weather, desertification, and water stress, all have a negative impact on health. Excessive use of chemical fertilizers to increase yield led to several risks to the soil, like the mining of micronutrients (Kanwar and Randhawa, 1978) [7], under developed plant characters like root and shoot systems, reproductive parts, and nutrient imbalance (Chandini *et al*., 2019) [4], which ultimately led to low crop yields. Adopting organic agriculture in these conditions can maintain a well-established practice because it limits its scope to nutrient exploitation, mining, and boosts soil organic matter content. (Babu *et al*., 2017) [3].

Okra (*Abelmoschus esculentus* (L.) Moench), is a vegetable crop with significant commercial importance that thrives in tropical and subtropical regions of the globe. It evolved in tropical Africa and is a member of the Malvaceae family. For its tender pod, it is cultivated in India during the summer and rainy seasons. Okra is one of the most consumed vegetables across world because of its bounty of nutrients, flavor, health benefits, and industrial applications. It is an abundant source of iodine as well as other essential minerals and vitamins. Okra contains polysachharides like galacturonic and glucuronic acids as mucilage.

Okra seed is high in protein and unsaturated fatty acids like linoleic acid (Gurbuz, 2003) [6]. It also has medical applications like it used as a plasma replacement or blood volume expander and binds cholesterol and bile acid carrying toxins dumped into it by the liver (Gemede *et al*., 2015) [5]. Additionally, it is an excellent source of potassium and calcium.

With an increase in population comes a significant increase in crop demand, which emphasizes the use of chemical fertilizers. As a result, growers indiscriminately used inorganic sources of plant nutrients, endangering the health of millions of people around the world as well as the environment and soil. In addition to improving the quality of vegetables, organic manure is a dependable source of macro and micronutrients that improves the physical, chemical, and biological health of the soil, lowers nutrient losses, increases nutrient availability, and promotes nutrient uptake this results in sustainable production that leaves no harmful residues (Acharya and Mandal 2000) [2]. Additionally, combining organic and inorganic nutrient sources may result in productivity that is sustainable over the long run. (Kumar *et al*., 2017) [10]. When organic manures like farmyard manure (FYM), town compost (TC), and vermicompost (VC) are used in plant nutrient management, micronutrients and secondary major nutrients are readily available, whereas they are not available when only the recommended dose of fertilizers (RDF) is used (Singh & Sharma 2016; Kumar *et al*., 2018) [20, 13]. It is essential to have access to secondary major nutrients like Ca, Mg, and S as well as micronutrients like Zn, Cu, and Mn because these processes are closely related to plant growth, biomass output, dry matter production, and quality yield. While taking these points into account the current study was conducted with the objectives of determining the impact of integrated nutrient management on vegetative growth, flowering, and economic yield of okra *cv.* Arka Anamika.

Materials and Methods

The investigation was conducted in the spring of 2021 at the experimental unit of Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh. The Jaunpur area of Uttar Pradesh has a subtropical climate. Jaunpur is located in the northwestern region of Varanasi division. The average yearly rainfall of the area is between (850-1150) mm. The soil of the experimental field was a sandy loam texture with a mild alkaline composition. A randomized block design was used to carry out the experiment, and eleven treatments were replicated three times. There were 33 plots, each measuring a net plot area of $3m^2$, and seeds were sown at intervals of 60 cm between rows and 45 cm between plants. The eleven treatments were: T_1 (control), T_2 (100% NPK), T_3 (75% NPK + 25% FYM), T_4 (75% NPK +25% VC), T_5 (75% NPK + 25% TC), T_6 (50% NPK + 50% FYM), T_7 (50% NPK + 50% VC), T_8 (50% NPK + 50% TC), T_9 (25% NPK + 75% FYM), T_{10} (25% NPK +75% VC), and T_{11} (25% NPK + 75% TC). The soil was given a healthy tilth through tillage and grinding. The seeds were sown directly into the ground, with the irrigation channels and bunds being meticulously maintained. After seedling development, a light irrigation was provided. The organic manures were applied as a base dose prior to sowing in accordance with the treatment. Right before planting, the full doses of phosphorus and potassium and the half dose of nitrogen as directed by treatment were applied. After 30 days of seeding, the second portion of the nitrogen dose was applied. In flat beds, two to three healthy seeds were dibbled 1-2 cm deep maintaining a uniform distance of 60x45 cm. After 20 DAS, the first weeding was done, followed by another at 40 DAS. When observations were made, all cultural customs were consistently followed.

Numerous growth-related attributes, such as plant height, number of branches, number of leaves, number of nodes per plant, and internodal length were observed. In addition, yield related attributes, such as days till first flowering, number of fruits, maximum number of flowers per plant, days to first fruit set, number of fruits per plant, fruit weight, yield in kg per plot, and fruit yield quintal per hectare; while economics of cultivation was estimated for different treatments as net income and benefit-cost (B: C) ratio were calculated. Through the use of OPSTAT software, all the observations made during the research were estimated using one-way ANOVA (Analysis of variances) at a 5% level of significance.

Results and discussion

Effect of integrated nutrient management on growth parameters

Plant height, number of leaves per plant, number of branches per plant, number of internodes per plant, and length of internodes (Table 1) are among the growth parameters that were significantly impacted by the application of both organic and inorganic sources of nutrients together. The maximum plant height (119.24 cm), number of leaves per plant (32.36), number of branches per plant (2.92), and number of internodes per plant (20.87 cm) were obtained in T2 using 100% NPK and the minimal in T_1 (control). The research of vegetative characteristics revealed that a full dose of NPK led to marked increase in growth parameters. It was found that readily available N from inorganic fertilizers was responsible for encouraging better plant height in bhendi and same result was reported by Ray *et al*. (2005) [14] and Patel *et al*. (2009) [12]. Increased vegetative growth of plants was produced by cell elongation and partly by cell division, which together accounted for the majority of the increase in plant height caused by the presence of easily available form of nitrogen in higher quantities. Nitrogen is a crucial component of protoplasm, and its positive impact on leaf chlorophyll content may have increased the synthesis of carbohydrates, amino acids, and other compounds, which in turn led to the production of phytohormones like auxins, gibberellins, cytokinins, and ethylene, which increased plant height concur with these findings (2006).

Rapid cell elongation caused by sufficient N appears to have a positive effect on plant growth. These results are in conformity with findings of Anburani (2004) [24] where the maximum length of internodes (7.65 cm) was recorded in T_4 using 75% NPK + 25% VC, while the minimum was recorded from T_0 (control). Increased nutrient doses as RDF with organic supplements like vermicompost have been found to improve soil and plant nutrient status, which in turn encourages greater metabolic activities and improves biomass production (Singh *et al*., 2014, Singh *et al*., 2018b,c; Ramandeep *et al*., 2018; Lallawmkima *et al*., 2018 a) [19, 16, 13, 11].

Table 1: Effect of integrated nutrient management on growth parameters

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Number of internodes per plant	Internodal length(cm)
T_1	92.15	1.27	19.52	16.47	6.33
T_2	119.24	2.92	32.36	20.87	7.39
T_3	109.28	2.01	26.29	19.01	7.27
T_4	116.20	2.54	30.68	20.13	7.65
T_5	113.54	2.24	28.86	19.51	7.50
T_6	103.20	1.63	23.01	17.62	6.86
T_7	107.12	1.87	25.87	18.49	7.11
T_8	105.10	1.74	24.12	18.02	6.97
T_9	94.14	1.34	20.29	16.95	6.45
T_{10}	101.12	1.51	22.68	17.97	6.71
T_{11}	97.24	1.42	21.17	17.43	6.59
CD at 5%	0.053	0.060	0.158	0.091	0.055
SE(m)±	0.018	0020	0.053	0.031	0.018

Effect of integrated nutrient management on flowering parameters

Table 2 shows the findings of the study on the minimum number of days to first flowering, the maximum number of flowers per plant, and the minimum number of days to fruit initiation in okra.

Application of 50% NPK in combination with 50% VC in T_7 took the minimum number of days to first flowering (40.31 days), and the same treatment also produced the maximum number of flowers per plant i.e. T_7, where 50% NPK in combination with 50% VC were used in the treatment. As documented by Sharma and Bhalla (1995) [25] and Patel *et al.* (2009) [12] in bhendi that significant superiority over control may be caused by enhanced photosynthetic activity and uptake of food nutrients, which results in early flowering.

It was thought that okra's early bud initiation, length of time until first flowering, and quantity of flowers per plant were all genetically controlled traits. However, it is also significantly influenced by other variables, such as cultural practices and plant nutrition (Tripathy and Maity) (2009) [22]. It is evident from the study that, applying organic manures led to an increase in the production of organic acids, which are crucial for the availability of and might have caused flowers to open earlier than their counterparts.

When organic and inorganic fertilizers are applied together, plants grow more vigorously and produce more cytokinin, which may have aided in the movement of this cytokinin and more phosphorus through the xylem vessels, and the accumulation of cytokinin and phosphorus in these axillary buds may have favored the plants transition into reproductive phase. (Dange *et al*., 2002) [26].

The minimum number of days to first fruit initiation was 42.01 days from treatment T_7, which applied 50% NPK along with 50% VC. This may be because treatments were administered with the least number of days to flower bud initiation as well as for the minimum days to first flowering. More photosynthates may have been produced as a consequence of increased foliage, increasing the yield potential. The addition of organic manures may also have improved soil conditions by increasing soil fertility, nutrient mineralization, enhanced the effectiveness of applied N and P, enhanced the activity of microbes and also the release of growth stimulating compounds, and many other factors. Combined use of NPK + organic manures improved the supply of nutrients in a balanced way, resulted in better growth, and decreased the days to first fruit set of okra plants, (Abusaleha and Shanmugavelu, 1988) [1].

Table 2: Effect of integrated nutrient management on flowering parameters

Treatments	Days to first flowering	Maximum number of flowers per plant	Minimum number of days to fruit initiation
T_1	51.32	15.84	57.02
T_2	45.84	16.80	51.02
T_3	50.02	16.02	55.97
T_4	42.91	18.70	46.30
T_5	43.68	17.91	48.33
T_6	48.98	16.21	54.94
T_7	40.31	21.20	42.01
T_8	41.74	19.80	44.24
T_9	47.97	16.43	53.98
T_{10}	44.23	17.11	50.14
T_{11}	46.94	16.56	52.11
CD at 5%	0.302	0.185	0.093
SE(m)±	0.102	0.602	0.031

Effect of integrated nutrient management on yield parameters: Table 3 displays the findings of the study that looked at how integrated nutrient management affected the number of fruits per plant, fruit weight, yield per plant, yield per plot, and yield per hectare of okra.

The maximum number of fruits per plant (17.20), maximum fruit weight (16.33g), maximum fruit yield per plot (5.62 Kg), and maximum fruit yield per hectare (187.31q) were recorded from the treatment T_7, which applied 50% NPK in combination with 50% VC.

The higher production of dry matter, plant height, and branches may be the cause of the higher values for the number of fruits per plant and yield per plant. More photosynthates may have been produced as a consequence of increased foliage, increasing the yield potential. The addition of organic manures may also have improved soil conditions by increasing soil fertility, nutrient mineralization, the effectiveness of applied N and P, the activity of microbes, the release of growth stimulating compounds, and many other factors. Inorganic fertilizer had a noticeable increase in effectiveness when mixed with organic manures (Schuphan, 1974) [27]. Okra plants resulted in better growth and higher yield when NPK and organic manures were used together to increase the supply of nutrients in a balanced way (Abusaleha and Shanmugavelu, 1988) [1]. Combined application of fertilizers led to higher pod yields per plot, which were closely linked to FYM and vermicomposts quick release of macro and micronutrients like N, P, and K Singh *et al*. (2005)

[17], Kulkarni (2004) [9], and Wagh *et al*. (2014) [23] discovered similar outcomes. The use of organic manures, inorganic fertilizers, and their mixtures greatly altered the fruit yield per hectare. According to Tripathy *et al*. (2004) [22]. The vermicompost extends and improves the availability of nutrients during the crop growth phase.

Table 3: Effect of integrated nutrient management on yield parameters:

Treatments	Number of fruits per plant	Fruit weight (g)	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (q)
T_1	11.84	10.92	129.29	2.59	86.32
T_2	12.80	12.52	160.26	3.21	106.98
T_3	12.02	11.28	135.59	2.71	90.32
T_4	14.70	13.90	204.33	4.09	136.31
T_5	13.91	13.48	187.51	3.75	124.98
T_6	12.21	11.58	141.39	2.83	94.32
T_7	17.20	16.33	280.88	5.62	187.31
T_8	16.80	14.70	246.97	4.94	164.65
T_9	12.43	11.90	147.92	2.96	136.31
T_{10}	13.11	13.00	170.43	3.40	113.32
T_{11}	12.56	12.20	153.23	3.06	101.98
CD at 5%	0.026	0.179	0.173	0.137	0.198
SE(m)±	0.009	0.060	0.058	0.046	0.067

Effect of integrated nutrient management on economic yield

The estimates of the economics of okra cultivation using the INM method demonstrate that the application of various organic and inorganic nutrient sources significantly affected net returns (Table 4).

Application of different nutrient sources had a significant impact on the gross and net return. In T7, application of 50% NPK in combination with 50% VC produced a significantly higher gross and net return (Rs. 561930 and Rs. 425252), followed by application of 50% NPK in combination with 50% TC produced a significantly lower gross and net return (Rs. 493950 and Rs. 397272) in T_8. But when compared to the other treatments, T_8 (50% NPK + 50% TC) had the highest B:C ratio (4.10:1), closely followed by T_9 (25% NPK + 75% FYM), which had a B:C ratio of 3.22:1. The higher net return and B: C ratio brought on by an integrated nutrient management strategy may be linked to the high and quality yield of okra products with a good market value **(**Singh *et al*., 2015; Singh & Singh 2015; Singh *et al*., 2018e) [18, 21].

Table 4: Effect of integrated nutrient management on economic yield:

Treatments	Treatment Cost	Total cost	Yield/ha(q)	Gross Income	Net Income	B:C Ratio
T_1	00000	72000	86.32	258960	186960	2.06:1
T_2	9356	81356	106.98	320940	239584	2.94:1
T_3	14517	86517	90.32	270960	184443	2.13:1
T_4	37017	109017	136.31	408930	299913	2.75:1
T_5	17017	89017	124.98	374940	285923	3.12:1
T_6	19678	91678	94.32	282960	191282	2.09:1
T_7	64678	136678	187.31	561930	425252	3.11:1
T_8	24678	96678	164.65	493950	397272	4.10:1
T_9	24839	96839	136.31	408930	312091	3.22:1
T_{10}	92339	164339	113.32	339960	175621	1.07:1
T_{11}	32339	104339	101.98	305940	201601	1.93:1

Conclusion

The catchphrase "integrated nutrient management" is catchy and used frequently, and it's important for the younger population to understand its true significance in addressing environmental pollution and the deterioration of nature. In order to increase soil nutrient concentration and lower environmental pollution, there is a growing demand for the management of traditional nutrient management processes.

The current study verified that the okra cultivar Arka Anamika exhibits the effects of integrated nutrient management on the parameters of vegetative growth, flowering, and economic yield. With the application of 100% NPK, it has an impact on growth parameters such as plant height, number of leaves per plant, number of branches per plant, number of internodes per plant, and length of internodes; whereas, with the application of 75% NPK + 25% VC, it has an impact on maximum intermodal length. In terms of minimum number of days to first flowering, maximum number of flowers per plant, minimum number of days to first fruit initiation, maximum number of fruits per plant, maximum fruit weight, maximum fruit yield per plot, and maximum fruit yield per hectare, Arka Anamika responded favorably to the application of 50% NPK combined with 50% VC. The application of various nutrient sources had a substantial impact on the gross and net return, and the application of 50% NPK in combination with 50% VC resulted in noticeably higher gross and net return. According to the data analysis, the control treatment produced the minimum growth and yield. Therefore, the best solution to boost yield and efficiently manage the resources is to use both organic and inorganic fertilizers together. Finally, I would like to state that integrated nutrient management is the need of the hour in order to preserve both the Earth's natural environment as well as development, yield, and quality factors.

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