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Growth and Yield Improvement on Conjunctive Use of NPK and FYM for Okra Crop

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ABSTRACT: Although using inorganic fertilizer enhances the amount of nutrients in the crops, it also lowers the quality of the produce. As a result, adding organic nutrients to the soil to promote crop growth can enhance crop quality. Farmyard manure is a potential natural nitrogen source for indirectly increasing soil fertility and crop output directly. To determine the effects of farm yard manure, NPK 19:19:19 fertilizer, and a combination of farm yard manure and NPK 19:19:19 fertilizer on the growth and yield of okra (*Abelmoschus esculentus* L) vegetable, field tests were carried out in 2020 and 2021. With 24 plots spaced 45 × 30 cm apart, the total planted area was roughly 5 cents. Using the Random Block Design, six distinct treatment combinations were experimentally evaluated. The combination of farm yard manure (50%) and NPK 19:19:19 (50%) resulted in the highest okra growth and production in 2020 and 2021 compared to alternative treatment alternatives. Additionally, for the same treatment, the growth and yield of okra increased higher in 2021 than in 2020, which resulted from the application of FYM and NPK, which increased the amount of organic matter and minerals in the soil. According to the study, combining FYM with NPK could be a sustainable and environmentally responsible strategy to improve crop quality in growth and production.

Keywords: FYM, Growth Parameters, NPK, Okra, Yield Parameters.

INTRODUCTION

Vegetable growing is among the most profitable forms of agriculture (Dessai *et al.,* 2023). A farmer or agripreneur can turn a profit with a modest investment by engaging in okra farming, a particular sort of agro farming. The majority of the year, India has access to okra, also known as okra or ladies finger, and output can be tailored to meet demand (Dhaliwal *et al.,* 2019). Around the world, okra is a widely consumed vegetable in tropical and subtropical areas. The largest okra producer in the world is India. With a productivity of 12,000 MT/ha and a land area of 509,000 ha, India produces the most okra in the world—60,94,000 MT. With a production of 205.91 thousand MT from a land area of 13.37 thousand ha and a 15.07 MT/ha productivity, Andhra Pradesh is the largest producer of okra (Saxena and Rao 2018).

The key elements of nitrogen (N), phosphorus (P), and potassium (K) available in inorganic NPK fertilizer encourage a more robust and extensive root network for the absorption of available plant nutrients from the soil solution, which results in improved crop growth and yield while at the same time resulting in inferior quality fruits and grains. While organic farming aims to develop healthy soil that supports appropriate energy flows in the soil, crop, water, and environment and keeps the biological life cycle active in the plant systems, it releases nutrients at a slow rate, which could prevent the crop from getting the right nutrients when it needs them. Hence, the present study focused on field experimental investigation to know the conjunctive effect of farm yard manure and NPK 19:19:19 fertilizer on the growth and yield of okra (*Abelmoschus esculentus* L) vegetables during 2020 and 2021 (Singh *et al.,* 2023). The observations were made on the plant height, number of leaves, days to first flowering, days to 50% flowering, days to first harvesting, capsule length, number of capsules per plant, capsule weight, and yield (kg) per plot for this study for the same season in 2020 and 2021. Finally, this study highlights the significance of combining and using FYM and NPK fertilizer to their fullest potential to achieve superior crop development and production.

Wild species with a higher chromosome number, such as *Abelmoschus monihot* and *Abelmoschus tetraphyllus,* have been widely used in okra breeding because they are resistant to the yellow vein mosaic virus (Hazra *et al.,* 2021). The species is a perennial frequently grown annually in temperate climates, reaching heights of roughly 2 m. Cross-pollinated crops are common in the

Malvaceae family. Cotton, cacao, and hibiscus are among its relatives. The palmate lobed leaves are 10–20 cm long and broad, with 5–7 lobes. The flowers have five white to yellow petals with a crimson or purple patch at the base of each petal and are 4–8 cm in diameter. The pollens are spherical, having a diameter of around 188 microns. The fruit is a seed-filled capsule up to 18 cm long with a pentagonal cross-section.

As a fresh vegetable, okra has huge export potential in India, accounting for 30 % of the country's vegetable export revenues. In many nations, okra is primarily consumed as a vegetable for its soft green fruit. Sun-dried okra is mostly consumed all year in Africa and India. Frozen sterilized fruits are also a popular market item, particularly in the United States. When the fruits are immature, they are harvested and consumed as a vegetable. It has a lot of iodine, which is an important micronutrient. Okra is high in both soluble and insoluble fibre and is high in vitamins and minerals. Okra has about 40 % of the daily required vitamin C consumption in 100 g. Okra is an excellent choice for improving blood health and treating and preventing anemia. People who want to lose weight should choose okra. A fibre derived from the stem is used as a jute alternative and in the production of paper and textiles (Abidi *et al.,* 2014).

Organic farming is more than just non-chemical farming; it is a system that integrates relationships among soil, plant, water, soil microflora, and fauna. Organic farming attempts to create healthy soil aids in appropriate energy flows in the soil, crop, water, and environment, and maintains the biological life cycle alive in the plant systems, allowing for significant yields to be maintained. Among various organic manure, farm yard manure (FYM) is high in nutrients, with 3.2 % nitrogen, 0.05 % phosphorus, 0.25 % potassium, 1.20 % calcium, and 0.33 % magnesium. FYM improves soil production by increasing soil fertility and adding humus to the soil (Miglani *et al.,* 2017). While inorganic fertilizers hasten the development of buds, fruit ripening, root seed and flower production, and stem vegetative growth in a short period. Although inorganic fertilizers increase the crop's nutrient content, the crop's quality degrades. To increase crop quality, it is possible to supplement inorganic fertilizers with natural nutrients in the soil.

METHODS AND MATERIALS

In this study, field experiments were carried out for the production of okra (*Abelmoschus esculentus* L) in terms of growth and yield parameters against the organic, inorganic and combination of both organic and inorganic nutrients at Kalasalingam School of Agriculture and Horticulture, Kalasalingam Academy of Research and Education, Krishnankoil, Tamil Nadu, during the same season of both in 2021 and 2022. The location of the selected area of study is at the latitude of 9° 34' 51.24" N and the longitude of 77° 40' 13.44" E with an altitude of 300 m above mean sea level. The region had a tropical climate and an average annual temperature of around 30.8°C with an average yearly rainfall of 869 mm. The experimental field soil is black cotton soil. It has a high percentage of clay and is rich in magnesium, potash, and lime but poor in nitrogen and phosphorous. The pH range is from 7.2 to 8.5.

The experiments were conducted on 5 cents of land with 24 plots of 45 × 30 cm spacing. The experimental evaluation for six different treatment combinations *viz.,* T1: Control (No FYM and NPK applied), T2: Only FYM application at the rate of 20 t/ha (100 %), T3: Only NPK (Urea: TSP: MoP) application at the rate of 200 kg/ha each (100 %), T4: FYM (25 %) and NPK (75 %), T5: FYM (50 %) and NPK (50 %), and T6: FYM (75 %) and NPK (25 %) were conducted using the Random Block Design with four replications. The number of plots used for this study was 24 (6 treatments × 4 replications).

The chosen okra variety is Hybrid-Amrapali NOH 1053, tolerant to yellow vein mosaic virus and ELCV (leaf curl virus). It was collected from the Zonal Office, Department of Agriculture, Theni District, Tamil Nadu. The Plants are medium tall with more branching, good vigour, an open plant type, and deeply lobed leaves. The fruits are attractive, dark green smooth fruits that are medium long and 13 to 150 cm in size. Okra (Hybrid-Amrapali NOH 1053) variety (250 g) amount of seeds sown on ridges and furrows at 45 × 30 cm spacing. The unit plot size was 6.0 × 1.8m, and each unit plot had seven rows. The soil was compacted over the seeds to provide good contact between the seeds and soil particles and to facilitate seed germination. The seeds germinate stars from 3^{rd} day after sowing. Okra requires enough soil moisture for proper germination. The field was irrigated immediately after sowing, and subsequent irrigation was applied based on the soil moisture condition. Gap filling and thinning were after seven days after sowing, to maintain the proper plant population thing was done 7 days after sowing. Weeding was done twice at 15 days and 30 days after sowing. Harvest starts from 45 days after sowing and continues up to 1 month. The fruits were picked manually when they were green tender and marketable in size. The picked fruits were weighed and subjected to other observations immediately after each picking. 5 Plants were randomly selected from each replication and tagged permanently. The height of each tagged plant was measured 35, 50, and 65 days after sowing from the base of the plant to the tip of the main shoot by using a meter scale and tape. Branches arising from the main stem were recorded from 5 randomly selected plants at 35, 50 and 65 days after sowing, and average branches were calculated.

The fruit length (cm) of randomly selected five okra fruits from each plot was measured from the base of the fruit to the tip of the fruits with the help of a meter scale. After recording length, the same fruits were weighed with the help of electronic balance, and fruit weight kg per plant was also calculated. The fruits harvested from the whole plot's plants were weighed after each picking, and their totals were summed up at the end for this purpose. The harvested fruit from all the plants was weighed after each picking, and their totals were summed up at the end to calculate the yield q/ac.

RESULTS AND DISCUSSION

A. Effect of Nutrients on Plant Height

The effect of organic and inorganic nutrients on plant height (average of four replicates) after 35, 50, and 65 days during 2020 and 2021 is presented in Table 1. Table 1 shows that for 2020 and 2021, a highly significant difference was observed in plant height among treatments. For 35, 50, and 65 days after sowing (DAS), the maximum height of the plant was found to be 13.38, 34.65, and 68.78 cm in the year 2020 and 14.64, 38.36 and 73.87 cm in the year 2021, respectively, for the treatment T5 compared to other treatments (T1, T2, T3, T4, and T6). Further, it may be observed that the T3 also produced the maximum plant height of 67.12 cm in 2020 and 68.94 cm in 2021, which were close to the plant height observed for treatment T5 in 2020 and 2021. Compared to the control treatment in 2020, treatment T5 (a combination of FYM 50% and 50% NPK) showed the highest percentage of plant growth rate at 65 DAS, followed by treatment T3's 12.97 % growth rate. The percentage of plant height improvement for the T5 treatment was determined to be 17.40% in 2021, which aligns with the results from 2020. Even though the FYM was increased to 75% along with 25% of NPK in 2020 and 2021, the plant heights for treatment T6 were marginally higher than those for treatment T4. As a result of Table 1, it can be inferred that treatment T5 experienced the most significant plant growth in both 2020 and 2021 when compared to other treatments. However, maximum plant growth was seen in 2021 rather than 2020, leading to a rise in the soil's N, P, and K. The crop produced better growth and yield than for the identical treatment T5 in 2020 when the soil was modified with 50% NPK and 50% FYM in 2020, which could be absorbed by the crop throughout 2021. Similar results were observed in the previous studies (Abhinav *et al.,* 2017; Aboyeji, 2021).

Table 1: Effect of Different Fertilizers on Plant Height (cm).

Year	Treatment No.	Treatment	35 DAS	50 DAS	65 DAS
2020	**T1**	Control	11.34	29.12	60.88
	T2	FYM	12.18	32.79	62.09
	T3	All 19 NPK fertiliser	13.21	34.21	67.12
	T4	25 % FYM and 75 % NPK	13.06	32.87	63.45
	T5	50 % FYM and 50 % NPK	13.38	34.65	68.78
	T6	75 % FYM and 25 % NPK	13.21	33.08	63.92
2021	**T1**	Control	11.63	31.22	62.92
	T2	FYM	12.91	33.17	64.26
	T3	All 19 NPK fertilizer	14.13	36.83	68.94
	T4	25 % FYM and 75 % NPK	13.52	34.94	66.71
	T5	50 % FYM and 50 % NPK	14.64	38.36	73.87
	T6	75 % FYM and 25 % NPK	13.93	35.87	67.39

B. Effect of Nutrients on Number of Leaves

The effect of organic and inorganic nutrients on the availability of plant leaves (average of four replicates) after 35, 50, and 65 days during 2020 and 2021 is presented in Table 2. The average maximum number of leaves per plant was observed as 52.3, 58.6, 75.3, 72.1, 78.3, and 73.8, respectively, for the treatments T1, T2, T3, T4, T5, and T6 at 65 DAS in the year 2020. Similarly, the average maximum number of leaves per plant was observed as 53.4, 60.8, 78.3, 76.4, 82.7, and 77.1, respectively, for the treatments T1, T2, T3, T4, T5, and T6 at 65 DAS in the year 2021. Table 2 shows that, compared to control, the nutritional combination FYM 50% and NPK 50% (T5) produced the most leaves at 35, 50, and 65 DAS in 2020 and 2021, respectively. Treatment T3 also produced the greatest number of leaves, which was quite similar to the observation made for treatment T5 when compared to control T1 in 2020 and 2021. Other FYM: NPK combinations (25:75 (T4) and 75:25 (T6)) had no impact on plant height and were comparable to treatment T5 for the same season in 2020 and 2021. However, there were more okra leaves in 2021 than in 2020. The okra crops had more leaves in 2021 than in 2020 as a result of the year's interaction with the amendment of conjunctive usage of FYM 50% and NPK 50%, which was significant for the okra crop's growth and yield. As a result of Table 2, it can be inferred that treatment T5 had the most plant leaves relative to other treatments. Similar results were observed in previous research (Verma *et al.,* 2000; Uka *et al.,* 2021). The increased number of leaves in okra plants is due to the presence of potassium, which was supplied through both FYM and NPK. The area of leaves is also increased for treatment processes when compared to control treatment T1. The nitrogen available in the FYM is also supported to increase the number of leaves and leave areas. Similar observations were found by the previous researchers (Akande *et al.,* 2010; Salau and Makinde 2015).

Table 2: Effect of different Fertilizers on the Number of Leaves in Okra.

Year	Treatment No.	Treatment	35 DAS	50 DAS	65 DAS
2020	T1	Control	13.2	32.8	52.3
	T2	FYM	17.9	45.8	58.6
	T3	All 19 NPK fertilizer	24.6	52.3	75.3
	T4	25 % FYM and 75 % NPK	22.4	49.3	72.1
	T5	50 % FYM and 50 % NPK	26.3	58.7	78.3
	T6	75 % FYM and 25 % NPK	22.9	51.4	73.8
2021	T1	Control	13.5	33.9	53.4
	T2	FYM	18.7	47.5	60.8
	T3	All 19 NPK fertilizer	26.7	55.9	78.3
	T4	25 % FYM and 75 % NPK	24.6	53.7	76.4
	T5	50 % FYM and 50 % NPK	28.7	62.1	82.7
	T6	75 % FYM and 25 % NPK	25.1	54.8	77.1

C. Effect of Nutrients on First Flowering and First Harvesting

The days required for the first flowering and the first harvest for each of the T1, T2, T3, T4, T5, and T6 treatments for the same season in 2020 and 2021 are shown in Table 3. There was a highly significant difference in days to first blooming and first harvesting between treatments, according to the results of okra flowering and harvesting in the years 2020 and 2021. In 2020 and 2021, treatment T5 had the shortest time to the first flowering, followed by treatments T3, T6, T4, T2, and T1. The greatest number of days needed for the first flowering and first harvesting, respectively, for the treatment T5 than other treatment alternatives in the year 2020 were found to be 32.2 days (30.6 days for the year 2021) and 44.1 days (42.8 days for the year 2021). When compared to the control treatment (T1) in the year 2020, the maximum percentage improvement was found to be 11.78% and 8.51%, respectively, for the days to require first flowering and first harvesting (T5). Similarly, compared to the control treatment (T1) in 2021, the days needed for the first flowering and harvesting (T5) were 15.23% and 11.75%, respectively. However, the year 2021 witnessed the greatest percentage improvement over 2020. The number of days needed for first blooming and first harvesting was thus found for treatment T5 when compared to other treatments for the years 2020 and 2021 (Table 3).

Table 3: Effect of Nutrients on First Flowering and First Harvesting.

Treatment No.	Treatment	2020		2021	
		Days to required first flowering	Days to required first harvesting	Days to required first flowering	Days to required first harvesting
T1	Control	36.5	48.2	36.1	46.8
T2	FYM	35.3	47.2	34.7	46.2
T3	All 19 NPK fertilizer	33.9	46.2	32.2	45.1
T4	25 % FYM and 75 % NPK	32.9	45.2	31.2	43.9
T5	50 % FYM and 50 % NPK	32.2	44.1	30.6	41.3
T6	75 % FYM and 25 % NPK	33.2	45.8	31.6	43.3

D. Effect of different Fertilizers on Number of Fruits per Plant, Fruit Weight, Yield per Plot, and Yield per acre

The number of fruits per plant, fruit weight, yield per plant, and yield per acre are presented in Table 4 for the years 2020 and 2021. From Table 4, it may be observed that for the year 2020, the maximum and minimum number of fruits per plant are 18.2 and 15.1, respectively. A similar type of observation was found in the year 2020 for the fruit weight (maximum 19.1 g for the treatment T5 and minimum 14.4 g for the treatment T1), yield per plant (maximum 7.98 kg/plot for the treatment T5 and minimum 5.63 kg/plot for the treatment T1), and yield per acre (maximum 3.85 q/ac for the treatment T5 and minimum 2.71 kg/plot for the treatment T1). The percentage improvement for the treatment of T5 was found to be 20.52 %, 30.63 %, 41.71 %, and 42.01 %, respectively, for the number of fruits per plant, fruit weight, yield per plant, and yield per acre when compared to the control treatment T1 during the year 2020. Furthermore, it may be found that the maximum okra yield (3.85 q/ac and 7.98 kg/plot) was observed for the treatment T5 and the minimum yield was observed for the control treatment T1 for the year 2020. The outcomes for 2021 were similar to those for 2020. However, for the year 2021 compared to 2020, the maximum number of fruits per plant, weight per plant, yield per plot, and yield per acre were all higher. The higher yield and number of fruits per acre for 2021 were the result of the soil's nutrients, which were added by the FYM and NPK amendments made in the previous year. The findings were consistent with previous researchers, who stated that higher crop production responses to organic manure application could be related to enhanced physical and biological features of the soil, resulting in better nutrient availability to the plants (Salau and Makinde 2015; Afe and Oluleye 2017; Aboyeji, 2021).

Table 4: Effect of different fertilisers on Number of fruits/plant, Fruit weight (gms)/plant, Yield (kg)/Plot, Yield (q)/acre in Okra – Hybrid *(Abelmoschus esculentus* L.).

Year	Treatment No	Treatment	Number of fruits/plant	Fruit weight (gms)/plot	Yield (Kg)/plot	Yield (q)/acre
2020	T1	Control	15.1	14.4	5.63	2.71
	T2	FYM	15.8	14.7	5.93	2.85
	T3	All 19 NPK fertilizer	16.4	16.3	6.42	3.09
	T4	25 % FYM and 75 % NPK	17.6	18.2	7.12	3.43
	T5	50 % FYM and 50 % NPK	18.2	19.1	7.98	3.85
	T6	75 % FYM and 25 % NPK	17.3	17.8	6.78	3.27
2021	T1	Control	15.8	14.9	5.83	2.81
	T2	FYM	16.7	15.6	6.48	3.13
	T3	All 19 NPK fertilizer	18.6	17.9	8.34	4.03
	T4	25 % FYM and 75 % NPK	17.3	16.9	7.56	3.65
	T5	50 % FYM and 50 % NPK	20.3	19.5	8.93	4.31
	T6	75 % FYM and 25 % NPK	17.9	17.4	7.72	3.73

For this investigation, the maximum okra plant growth and yield were seen at FYM 50% and NPK 50% (T5) compared to other treatment techniques (T1, T2, T3, T4, and T6) for the years 2020 and 2021. The maximum growth and yield of okra were seen for poultry waste manure rather than cow FYM, according to Uka *et al.* (2021). Increased photosynthesis is also required for optimal development and yield, which is related to more leaves and a larger leaf surface area (Jaleel *et al.,* 2009; Uka *et al.,* 2021). Due to increased photosynthesis, maximum growth and yield of okra were observed for this study. In addition, the findings of this study were similar to those of Ghannad *et al.* (2014); Al-Ubaydi *et al*. (2017). However, Ghannad *et al.* (2014) discovered that maximal growth and yield were connected to fertilizer use and seeding strategies. Natural nutrients such as FYM, poultry manure, and vermicompost should be used to improve the effects of inorganic nutrients on crop growth and yield (Asif *et al*., 2011). However, in this study, the application of a combination of FYM and NPK resulted in the highest okra growth and yield during the years 2020 and 2021.

The results of this study's integrated nutrient management (combined organic and inorganic nutrients) for enhancing okra growth and production were similar to those of Akande *et al*. (2010); Oyewole *et al.* (2011). The combined management improved soil fertility, which in turn helped to boost nutrients in the okra crop's pad. Using a combination of inorganic and organic nutrients reduces the cost of procurement of nitrogenous fertilisers (Manral and Saxena 2003). Using organic nutrients instead of mineral fertilisers slows down the delivery of nutrients to the plant at different stages, enhancing crop development and output. Because nitrogen fertilizers deliver nutrients to crops immediately, nutrients may not reach the crops at different times (Adediran, *et al.,* 2015). Thus, the organic farming employed in this study and prior studies demonstrated that optimal growth was reached and that crop growth and production were improved in quality and quantity (Afe and Oluleye 2017).

As per earlier studies, among all other fertilizer sources, poultry manure produced the highest plant height (76.4 cm), fruit length (19.94 cm), fruit diameter (2.13 cm), and fruit production (14.91 t/ha) in okra. Plant height, number of leaves, stem diameter, number of branches per plant, days to first flowering, days to 50 % flowering, number of fruits per plant, fruit yield per plant (g), fruit length, fruit weight, and fruit yield were all highest when 2.5 tonnes of vermicompost and 2.5 tonnes of poultry manure were applied per ha (Ruchika *et al.,* (2019). The highest fruit yield was obtained for the nitrogen application of 175 kg/ha and produced a seed yield of 2.86 t/ha (Moniruzzaman and Quamruzzamani 2009). According to Adhikari and Piya (2020), poultry manure produces a higher yield of okra than FYM. The higher yield was due to an excellent organic nutrient in the poultry nutrition compared to FYM. The combination of 50 per cent FYM and 50 per cent NPK 19:19:19 gave the highest fruit yield in this trial due to the availability of FYM being greater than the availability of poultry manure in the research location.

The influence of FYM on okra growth, yield, and quality was studied by Premshekar and Rajashree (2009). The maximum okra yield of 10.39 t/ha was achieved using the FYM of 20 t/ha (Premshekar and Rajashree 2009). The best yield was obtained thanks to the addition of FYM to the soil, which improved the physico-chemical and biological characteristics of the soil. Additionally, the maximum plant height, number of fruits per plant, number of branches, fruit length, and yield 5.12 t/ha were all reported in FYM 20 t/ha (Abhinav *et al.,* 2017).

The use of FYM with NPK indicated that the integrated use of both improved the nutrient uptake by the okra crop for its growth and yield against the pH variation in the soil and supplied water quality. The soil water, along with a combination of supplied FYM and NPK, also increased the nutrient uptake by the okra crop (Aboyeji, 2021). In this study, the combination of FYM and NPK (T5) increased not only the soil's fertility but also its structure, water holding capacity, and microbial population around the root zone of the okra, promoting the growth and yield of the okra for both the years 2020 and 2021. The improved soil structure is due to animal excreta and agricultural waste (Marzouka and Kassem 2018). Control field trials with no application of any combination of FYM and NPK nutrients in this study and previous studies showed poorer growth and yield than those with other treatment techniques. The lower value observed in the control field experiment indicated that the soil was nutrient deficient (Petropoulos *et al.,* 2018; Marzouka and Kassem 2018; Khanal *et al.,* 2020; Aboyeji, 2021).

The improved plant population and soil fertility seen in this study were attributed to the application of integrated organic and inorganic fertilizers, which increased okra growth and yield. Previous research on the development and yield of the okra discovered similar results (Salau and Makinde 2015; Khanal *et al.,* 2020). Crop height, number of leaves, leaf area, fruit length, and fruit weight were seen in wide ranges based on the type of organic, and inorganic fertilizer used and crop growth in various types of soil, comparable to the findings of this study (Verma *et al.,* 2020). Due to inter- and intraspecific plant competition, an increase in plant population may result in lower growth and yield per plant (Regmi *et al.,* 2020). However, a larger population could compensate for lower growth and yield due to plant density.

When compared to NPK, FYM is pure organic manure, which includes more important and micronutrients for growing crops (Ngala *et al*., 2020). However, it releases the nutrients slowly, resulting in less plant development in a shorter amount of time but promoting healthy plant growth over a longer length of time. For improved growth, okra needs these nutrients at an earlier stage (Ma and Fan 2020). The impact of FYM, NPK, and biofertilizers on the blooming and fruit output of kinnow was examined by Mandeep *et al.* (2020). The findings indicated that the combination application of FYM and NPK with biofertilizers produced greater kinnow growth and yield than either method used alone. With an application rate of 100:50:50 kg/ha, Arunkumar *et al.* (2019) investigated the effects of biochar, FYM, and NPK on the growth of rice. The yield of the rice grain production increased from 6184 to 7724 kg/ha. In agreement with Arunkumar *et al.* (2019), this study shown that using FYM and NPK together resulted in greater growth, flowering, and fruit development than using NPK alone for both the years 2020 and 2021.

Dessai *et al*. (2023) studied the impact of various levels of NPK fertilizers, FYM, and vermicompost on the yield attributes of okra. The plants had the highest plant height, number of branches, number of leaves, number of fruits, and overall fruit yield when 120:60:50 Kg/ha of NPK, 25 t/ha of FYM, and 6 t/ha of vermicompost were applied. The study of Dessai *et al.* (2023) observed that no significant change was observed in yield and growth of okra under control, and the application of organic manures (NPK) as well as its mixture with full NPK considerably increased growth and total yield attributes of okra compared to the use of 100% NPK, 100% FYM, and 100% Vermicompost on okra growth. This study also demonstrated, similarly to Dessai *et al*. (2023), that the yield of okra rose when 100 kg/ha of NPK fertilizer and 10 t/ha of FYM were used together (in a 50:50 ratio), as opposed to when 200 kg/ha of NPK and 20 t/ha of FYM were used. The increased okra yield observed during the years 2020 and 2021 of this study is a result of increased growth, flowering, and fruit development in general; however, the release of the nutrient from the FYM is slow compared to the combined usage of FYM and NPK, resulting in a better yield than the yield obtained against the usage of FYM alone (Kumar and Garhwal 2022). The use of FYM also helps the okra crop's root penetration, aeration around the root, and quick uptake of nutrients.

In terms of the capacity of the soil structure to hold water, FYM is better for okra development in dry seasons than FYM and NPK together. However, combined application of FYM and NPK increased okra fruit output beyond what FYM alone did. Previous research (Bharti *et al.,* 2021; Arunkumar *et al.,* 2019) also found results that were similar. Bharti *et al*. (2021) studied the productivity of maize using NPK and the conjunctive use of NPK, FYM, lime, and fertilizer. Bharti *et al.* (2021) found that integrated FYM and lime use with the recommended dose of fertilizers produced significantly higher grain and stover yields than either FYM or lime used separately with the prescribed dose of fertilizers. The combined application of NPK, FYM, lime, and fertilizer resulted in a yield of 22.4 q/ha as opposed to 13.9 q/ha from the use of 100% NPK.

Similar to how NPK and FYM are used separately, FYM supports healthy microbes while suppressing infections (Arunkumar *et al.,* 2019). Despite the fact that FYM has greater benefits for the development of okra crops, it primarily offers organic matter and some nutrients, and it may not have a well-balanced amount of other crucial elements like nitrogen, phosphorus, and potassium (Yadav *et al*., 2019). This can result in nutrient deficiencies that limit crop growth and yield. FYM's nutrients steadily release as it breaks down over time. Reduced yields could result if this gradual release is unable to meet the growing crop's urgent nutrient needs, particularly during crucial growth phases (Katharine, 2017). When compared to synthetic fertilizers, FYM often has a lower nitrogen content, which can lead to insufficient nitrogen supplies for the best crop development. FYM may include weed seeds and disease pathogens (Litskas, 2023). Without proper composting or sterilization, using FYM could contaminate the soil with pests, illnesses, and weed seeds, which would harm the health of the crops. When only using FYM, crop output and growth may be variable since it may not always supply the proper balance of nutrients for optimum growth (Fabrizio *et al*., 2020).

It is advised to take a more holistic approach that incorporates FYM with other nitrogen sources, such as mineral fertilizers, compost, cover crops, and crop rotation, in order to reduce these downsides and assure greater crop development and production (Singh *et al.,* 2023). A balanced nutrient supply, improved soil health, and more dependable and sustainable crop output can all be achieved through this integrated strategy. According to the study's findings, the maximum yield was 3.09 q/acre when NPK was used alone, but when FYM and NPK were used together, the yield climbed to 3.27, 3.43, and 3.85 q/acre for the ratios of 75:25, 25:75, and 50:50, respectively. The combined 50:50 use of FYM and NPK above the use of NPK alone was found to increase by 19.75%.

Organic matter and slow-release nutrients are provided by FYM, which enhances the fertility and structure of the soil (Pandey and Singh 2021). It contributes to a balanced nutritional profile for the best plant growth when used with fertilizers (Ojo, 2019). The efficiency of nitrogen uptake is improved when FYM and fertilizers are used together. While FYM encourages their progressive release, fertilizers assist their quick availability of nutrients, preventing nutritional imbalances. By decreasing the need of synthetic fertilizers, FYM use in conjunction with fertilizers encourages sustainable agriculture (Rajput *et al*., 2021). This can lessen environmental problems including soil erosion and nutrient runoff. Crop production is increased as a result of the interaction between organic matter from FYM and nutrient content from fertilizers (Sharma and Chadak 2022). The mixture promotes robust plant growth, which leads to improved.

Utilising FYM and fertilizers consistently over time can improve the fertility and structure of the soil, resulting in stable crop yields and a decreased need for excessive fertilizer application (Arunkumar *et al.,* 2019). Since FYM can be generated on-site or purchased locally, integrating FYM with fertilizers can result in cost savings (Nagla *et al*., 2020). It decreases the demand for expensive, high-dosage fertilizers (Rajneesh *et al.,* 2018). Farming has a smaller overall environmental impact when organic methods are used through FYM (Dhaliwal *et al*., 2019). This includes a reduction in the emissions of greenhouse gases and the use of synthetic fertilizers. The best FYM to fertilizer ratio and the precise nutrient needs can change according on the soil type, climate, and other local circumstances, according to this study's recommendation. Finding the optimal strategy to maximise the benefits of combined FYM and fertilizer usage for okra crop development and yield may be done with the help of conducting soil tests and consulting with agricultural specialists.

CONCLUSIONS

According to the current study, the okra crop grows and develops more quickly when 50% NPK and 50% FYM are applied in the years 2020 and 2021. However, the yield and growth of the okra crop were higher in the year 2021 than they were in the preceding years. The increased development and production for the next year, 2021, will result from the higher soil nitrogen uptake brought on by the FYM and NPK applications done in 2020. The NPK fertilizers would lead to enhanced vegetative growth in terms of the number of leaves when the okra is first growing and in its intermediate stage of development. In contrast, slow-releasing nutrients from FYM would promote okra's growth during the flowering period. Thus, it can be concluded from the study that, in comparison to the single application of chemical and organic fertilizers, the optimal combination of FYM and NPK promotes greater growth and yield during the same crop length period.

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Ethical Statement. The manuscript should not be submitted to more than one publication for simultaneous consideration. The submitted work should be original and should not have been published elsewhere in any form or language, unless the new work concerns an expansion of previous work.

HIGHLIGHTS

1. It was helpful to boost okra growth and yield by combining 19:19:19 NPK with FYM.
2. The combination manures of 19:19:19 NPK and FYM have enhanced soil fertility.
3. Using mixed manure reduced the need for chemical fertilisers.
4. Besides traditional okra farming, the composite manure may also be used for a variety.

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