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Effect of Chemical Fertilizers on *Abelmoschus Esculentus L.*

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ABSTRACT

In developing countries such as India, agriculture remains the most critical factor influencing national economic development. With the constant increase in population, the demand for agricultural products and the need for adequate food availability have also risen significantly. To address food scarcity, farmers often apply large quantities of chemical fertilizers to agricultural soils, frequently exceeding the recommended doses. Such practices can lead to the accumulation of heavy metals and other adverse effects on soil and crop health. In the present study, okra (Abelmoschus esculentus L.) has been selected as the test crop to evaluate the impacts of chemical fertilizers on different varieties cultivated in the Kota region. The experimental design will involve the application of nitrogen (N), phosphorus (P), and potassium (K) fertilizers, both individually and in various combinations, at higher-than-recommended levels. Prior to sowing, soil samples will be analyzed to determine pH, electrical conductivity (EC), cation exchange capacity (CEC), and nutrient levels (NPK). Water samples will also be tested for pH and EC. After sowing different okra varieties, specific fertilizer doses will be administered, and their influence on crop yield and vegetative growth parameters will be assessed. The primary aim of this study is to investigate how varying proportions of NPK fertilizers affect "Vegetative and yield characteristics of okra plants." Furthermore, the study seeks to identify potential risks associated with the overuse of chemical fertilizers, including the accumulation of toxic substances in vegetables, which may ultimately pose health hazards to both humans and animals consuming them.

***Keywords**: Chemical Fertilizers, EC and CEC, Heavy Metal, Soil Quality, Physical and Biochemical Properties, Toxic Substance.*

Introduction

Indian agriculture has witnessed significant progress, especially with the extensive adoption of high-yielding crop varieties during the Green Revolution. Despite these achievements, a decline in productivity-related inputs has become evident in recent years. This reduction is mainly associated with centuries of continuous cultivation, indiscriminate adoption of modern agricultural practices, uneven use of chemical fertilizers, and insufficient awareness regarding their appropriate application (Kumar Bhatt et al., 2019).

When fertilizers are introduced into the soil, crops absorb only a limited proportion of the nutrients, while a large amount remains unused. Traditionally, India relied on organic farming practices for thousands of years, which helped maintain soil fertility naturally. However, the growing dependence on chemical fertilizers has considerably deteriorated soil health and fertility levels (Irfan et al., 2021).

Certain soils, including black cotton soil with high plasticity and poor bearing strength, require regular supplementation of nutrients from external sources each year. Over time, repeated fertilizer applications reduce the efficiency of the recommended dosages. Continuous use of chemical fertilizers can make the soil rigid, decrease its permeability, and gradually reduce its fertility (L et al., 2016).

In addition, soil functions as a living ecosystem that supports numerous organisms involved in nutrient recycling and fertility maintenance. Excessive application of chemical fertilizers may cause soil acidification, which lowers the amount of organic matter, humus, and beneficial microbial populations. As a consequence, plant growth becomes restricted and crusts may develop on the soil surface. Changes in soil pH due to acidification, combined with fertilizer use without proper soil testing, contribute to soil degradation, nutrient imbalance, deterioration of soil structure, and increased bulk density (Chandini et al., 2019).

The use of fertilizers, particularly nitrogen (N) and phosphorus (P), has created both beneficial and adverse environmental impacts. However, the excessive and unscientific application of these fertilizers in cropping systems has resulted in several environmental concerns. One of the most serious issues associated with the overuse of nitrogen and phosphorus fertilizers is eutrophication, which leads to excessive growth of aquatic plants and algae in water bodies (Randive et al., 2021). In addition, the release of nitrous oxide into the atmosphere contributes to the greenhouse effect and increases air pollution. Nitrogen leaching into the soil also causes contamination of water resources (Randive et al., 2021).

After plant uptake, surplus nitrates often leach into groundwater. Elevated nitrate concentrations are commonly detected in leafy vegetables. Consumption of nitrate-contaminated groundwater or vegetables containing excessive nitrate levels can create severe health risks for humans (Ahmed, Rauf and Saeed, 2017).

The present study focuses on evaluating the effects of chemical fertilizers on plants, specifically the okra crop.

Okra, scientifically known as *Abelmoschus esculentus* (L.) Moench, belongs to the family Malvaceae and is an important vegetable crop originating from the tropical regions of Africa. Among the 2,283 recorded accessions, nearly 1,769 were collected from West Africa, while 2,029 originated from the African continent, indicating that West Africa contributes significantly to the crop's diversity and production. Okra is an annual crop with a growth duration ranging from one to five months depending on the variety.

The seeds are generally medium-sized, spherical in shape, grey in colour, and measure approximately 1.5–3 mm in diameter. Okra is widely valued for its taste and mucilaginous texture, which improves the digestibility of staple foods such as mashed yam and cassava paste. The crop is also recognized for its rich nutritional content, including vitamins A, B, and C. Its leaves contain comparatively higher amounts of protein (2.7–3.0%), riboflavin, and folic acid than the pods.

Due to its multiple uses and increasing demand, there is a growing need for practical methods to enhance okra production without relying heavily on labour-intensive farming practices. Consequently, emphasis has been placed on plant breeding and selection to improve the genetic quality of the crop. Okra is believed to have originated in Ethiopia and Sudan in northeastern Africa, and it has become one of the most widely consumed vegetable crops in India.

Although okra is considered an oligopurpose crop, its tender green fruits can be prepared in several ways as a vegetable. The fruits are rich in vitamins, calcium, potassium, and other essential minerals. Mature okra seeds possess high nutritional value because of their elevated protein and oil content. Okra seed oil contains a high proportion of unsaturated fatty acids, particularly linoleic acid, which is important for human nutrition. Additionally, the mature fruits and stems contain crude fibre that is useful in the paper industry (Singh et al., 2015).

The chemical composition of okra indicates the presence of 67.5% cellulose, 15.4% hemicellulose, 7.1% lignin, 3.4% pectic substances, 3.9% fatty and waxy matter, and 2.7% aqueous extract. Among these components, cellulose, hemicellulose, and lignin are the major constituents.

The unique fibre content of okra plays an important role in regulating blood sugar levels and maintaining intestinal health. The mucilage present in okra assists in eliminating toxins and harmful cholesterol from the liver. Its natural laxative properties support colon cleansing and help maintain proper moisture balance in fecal matter, thereby reducing constipation and discomfort. Unlike wheat bran, which may sometimes cause stomach irritation, okra provides a gentler and safer alternative. Furthermore, the mucilage exerts a soothing effect on the intestines and promotes bile secretion, which helps remove toxins and excess cholesterol from the body. Since elevated cholesterol and toxins are associated with various health disorders, regular consumption of okra may contribute positively to overall health.

Furthermore, okra helps protect the mucous membranes of the digestive tract from inflammation and is considered beneficial in the treatment of sore throat, stomach irritation, and lung inflammation (Yadav et al., 2018). Studies conducted in India have suggested that okra may serve as an effective substitute for human blood plasma. To preserve its valuable nutrients, okra should preferably be cooked quickly using steam or low heat.

During crop production, plants utilize sunlight, air, water, and nutrients present in the soil to synthesize essential compounds required for growth. Continuous cultivation without proper nutrient management can gradually exhaust soil nutrient reserves. Depletion of these reserves negatively affects crop growth, productivity, soil fertility, and overall agricultural sustainability. Long-term nutrient loss may also contribute to soil degradation and reduced crop yields. The application of both organic and inorganic fertilizers helps restore and maintain soil fertility by replenishing nutrients removed during harvesting. Fertilizers therefore enable farmers to manage crop nutrition efficiently and achieve optimum production.

Among the essential nutrients required by plants, nitrogen (N), phosphorus (P), and potassium (K) are considered primary macronutrients because they are needed in large quantities for proper growth and development. Nitrogen is an important constituent of amino acids, proteins, enzymes, vitamins, and plant hormones. Adequate nitrogen supply promotes vigorous vegetative growth, dark green foliage, improved flowering, and better fruit setting. However, excessive nitrogen application may delay crop maturity and reduce fruit size. Nitrogen also influences the utilization of phosphorus, potassium, and several other nutrients within the plant system.

Nitrogen is one of the most abundant mineral nutrients in plants and constitutes nearly 2–4% of the dry matter content. Although atmospheric air contains about 79% nitrogen, plants primarily absorb it in the form of nitrate (NO_3^-) and ammonium (NH_4^+). Nitrogen is a major component of proteins and enzymes and also participates in various metabolic processes related to energy transformation (Lal et al., 2014). Since nitrogen plays a fundamental role in agricultural productivity, maintaining an adequate supply is essential for healthy plant growth.

According to Rajgopal and Rao (1974), nitrogen deficiency reduces exogenous auxin levels and gibberellin activity in plants. Adequate nitrogen application can reduce the severity of root rot diseases, although excessive nitrogen may increase blossom-end rot incidence. Proper nitrogen nutrition also improves fruit quality, size, colour, flavour, and acidity (Sharma, 1971).

Atmospheric nitrogen can be converted into plant-available compounds by *Rhizobium* bacteria associated with the roots of leguminous plants. Nitrogen is therefore regarded as one of the most essential nutrients required by plants, as it forms part of chlorophyll, proteins, nucleic acids, and protoplasm. It encourages vegetative growth, imparts a dark green color to plants, and is necessary for starch formation and amino acid synthesis.

In addition to nitrogen, phosphorus acts as another major limiting nutrient for crop production. It promotes rapid root development, facilitates the translocation of carbohydrates from leaves to roots, and supports flowering and fruit formation, thereby increasing overall yield. Phosphorus deficiency adversely affects cambial activity, delays starch formation, reduces succulence in plant tissues, disrupts nitrogen and carbohydrate metabolism, and ultimately slows plant growth and maturity.

Phosphorus is a vital macronutrient involved in several physiological and biochemical processes in plants. It is an essential component of proteins, phospholipids, nucleic acids, enzymes, sugar phosphates, and energy-rich phosphate compounds. Phosphorus plays a significant role in photosynthesis, energy transfer, synthesis of sugars, oils, and starches, and the conversion of solar energy into chemical energy. It also improves stress tolerance, enhances water-use efficiency, promotes early maturity, and increases resistance to adverse winter conditions. Moreover, phosphorus is important for cell division, seed and fruit development, root establishment, leaf expansion, tillering, flowering, and grain production. Deep root development encouraged by phosphorus enables plants to absorb moisture and nutrients efficiently while improving anchorage and reducing lodging (Oladipo et al., 2015).

Potassium (K) is another essential macronutrient required for agricultural productivity, although its economic importance is often underestimated. Many farmers tend to neglect potassium fertilization because they assume it contributes less to yield improvement compared to nitrogen and phosphorus fertilizers. However, potassium performs numerous physiological functions essential for plant growth, nutrient transport, and water regulation, especially under stressful environmental conditions. Consequently, potassium significantly influences both crop yield and quality.

Potassium improves crop productivity and enhances the quality of agricultural produce. It is closely associated with healthy plant growth, stress tolerance, disease resistance, seed quality, and overall crop performance (Roy et al., 2013). Adequate potassium nutrition increases the protein and oil content of grains, thereby improving their nutritional value. In cereal crops, potassium promotes the development of strong stalks and well-filled grains. It also increases resistance to damage during transportation and storage, ultimately extending shelf life (Agbede, 2019).

Phosphorus, when applied along with nitrogen and potassium, improves fruit colour, taste, firmness, and vitamin C content, while also promoting early crop maturity (Su, 1974).

Foliar application of micronutrients plays an important role in modern crop production. Along with the use of major nutrient fertilizers, foliar spraying of micronutrients has shown significant positive responses in agricultural crops. In this method, nutrient solutions are directly sprayed onto plant foliage rather than applied through the soil, where complex chemical interactions may reduce nutrient availability and uptake. The use of micronutrients has been reported to improve the quality of vegetable crops in many regions of the world.

The ability of plants to absorb and efficiently utilize micronutrients from the soil is greatly influenced by several soil and plant-related factors. The concentration of micronutrients within plant tissues also affects the plant's resistance or tolerance to pests and diseases. Furthermore, genetic differences among crop varieties influence nutrient uptake efficiency and micronutrient accumulation in vegetable crops. Therefore, detailed investigations are necessary to identify efficient genotypes and improve nutrient management practices.

Considering the above facts, the present investigation entitled *"Effect of Chemical Fertilizers on* Okra *(Abelmoschus esculentus L.)"* was conducted during the summer seasons of 2022–2023 and 2023–2024.

Statement of the Problem

"Effect of chemical fertilizers on *Abelmoschus esculentus L.* ".

Method and Materials

To investigate the **effects of chemical fertilizers in varying quantities on the vegetative properties of okra (*Abelmoschus esculentus* L.)** an experiment will be conducted.

- **Study area**: Kota is a city located in the southeastern part of Rajasthan, India. The region is characterized by a **semi-arid climate**, with persistently high temperatures throughout the year. During the summer months of May and June, average temperatures range between **40–48 °C**, while the district receives an **average annual rainfall of 660.6 mm**. The mean elevation of the region is approximately **271 m (889 ft)** above sea level. The dominant soil type of Kota is **black soil**, which is known for its distinctive physical and chemical properties.
- **Experimental design**: At the onset of the experiment, soil and water samples from the experimental site was analyzed for basic physico-chemical characteristics. Specifically:
  - **Soil electrical conductivity (EC)** and **water EC** was measured by using electrodes.
  - **Soil pH** and **water pH** was determined with a digital electronic pH meter.
  - Prior to the application of fertilizers, **soil samples collected randomly up to a depth of 15 cm** from the experimental plots. These samples analyzed to determine baseline concentrations of **nitrogen (N), phosphorus (P), and potassium (K)**.

Subsequent treatments with different fertilizer quantities then applied and their impact on **okra growth parameters** were systematically assessed.

Experiment Design

In this experiment, **NPK fertilizers applied both individually (N, P, and K) and in different combinations** at recommended and above-recommended rates. The treatments arranged in separate beds to allow for comparative assessment.

In some beds, fertilizer treatments were follow specific formulations, such as **NPK at 20:10:10 kg/ha**, while in others, different application levels were tested. The experimental setup included the following fertilizer application rates:

- **Control** (no fertilizer application)
- **150 kg/ha**
- **200 kg/ha**
- **300 kg/ha**
- **350 kg/ha**
- **> 350 kg/ha** (above recommended dose)

Treatments Details

Treatments	Symbols Prabani Kranti	Symbols, Arka,	Symbols Anamika
Control	Pk_1	Ar1	An1
Organic	Pk_2	Ar2	An2
100 mg N	Pk_3	Ar3	An3
200 mg N	Pk_4	Ar4	An4
400 mg N	Pk_5	Ar5	An5
100mg P	Pk_6	Ar6	An6
200mg P	Pk_7	Ar7	An7
400mg P	Pk_8	Ar8	An8
100 mg K	Pk_9	Ar9	An9
200 mg K	Pk_{10}	Ar10	An10
400 mg K	Pk_{11}	Ar11	An11
20 N + 10 P + 10 K	Pk_{12}	Ar12	An12

Design and Layout

Number of replications	3
Treatments	11
Recommended NPK dose	20:10:10
Varieties	Prabani Kranti(Pk), Arka(Ar) and Anamika(An) This design allowed the evaluation of both the **individual and combined effects of NPK fertilizers** on the growth and yield of okra (*Abelmoschus esculentus* L.).

Result

- **Effects of Nutrient Dynamics on Growth Parameter**

Vegetative growth parameters are important indicators of plant vigour and are essential for obtaining higher yields. In the present investigation, growth characteristics such as plant height, number of branches per plant, stem diameter, fresh weight per plant, and initiation of first flowering were studied to evaluate the response of Okra to different nutrient dynamics treatments.

The application of nitrogen and phosphorus through inorganic fertilizers, in combination with biofertilizers, significantly influenced the vegetative growth of okra at all stages of crop development. Among the various treatments, the application of NPK at 20:10:10 consistently produced the highest plant height and maximum number of branches per plant across all three varieties tested. These findings are in close agreement with the observations reported by Jayathilake et al. (2002), Sharma and Thakur (2001), Sengupta et al. (2002), and Sharma and Kumar (2004).

The improvement in plant height and branch development may be attributed to the increased availability of nitrogen and phosphorus within the rhizosphere. Similar observations were made by Kumaran et al. (1998), who reported enhanced growth following the combined application of recommended NPK doses along with vermicompost and biofertilizers. Likewise, Sharma and Thakur (2000) recorded increased plant height and branch number when biofertilizers were integrated with 50%, 75%, and 100% of the recommended nitrogen dose.

The present study further demonstrated significant variation in the number of nodes per plant and internodal length under different nutrient treatments. Application of NPK at 20:10:10 resulted in the maximum number of nodes and longest internodes throughout all stages of observation. These results are in accordance with the findings of Naidu (1999), who reported that increased doses of nitrogen and phosphorus supplied through both inorganic and organic sources enhanced node formation and internodal elongation.

In the current investigation, increasing levels of nitrogen and phosphorus significantly affected growth parameters such as stem diameter, fresh weight per plant, and initiation of first flowering. The application of NPK at 20:10:10 produced the highest stem diameter, maximum fresh weight per plant, and earliest flowering initiation during the experimental period. Significant differences were also observed among the various organic fertilizer treatments.

Enhanced vegetative growth and increased stem diameter due to NPK application may be associated with higher metabolic activity and improved photosynthetic efficiency, leading to increased production of active metabolites responsible for cell division and elongation. These findings are in conformity with the results reported by Ushakumari et al. (1999).

- **Effects of Nutrient Dynamics on Yield Attributes and Yield**

Okra is considered a heavy nutrient-feeding crop, requiring substantial nutrient availability for optimum fruit production. Yield attributes such as number of fruits per plant, average fruit weight, and dry fruit weight were significantly improved with the application of NPK at 20:10:10. The enhancement in these yield parameters may be attributed to improved plant growth and development resulting from the combined use of organic and inorganic fertilizers. Similar findings were also reported by Sharma and Sharma (2004).

According to Yawalkar et al. (1984), the combined application of inorganic fertilizers and organic manures significantly increases the number of fruits per plant and average fruit weight because these nutrient sources supply essential macro- and micronutrients required for enzymatic activities, energy transfer, carbohydrate translocation, fat metabolism, and respiration, ultimately promoting extensive cell division and plant development.

The present investigation revealed that nutrient dynamics treatments significantly affected the yield characteristics of okra fruits. Application of NPK at 20:10:10 kg/ha resulted in the maximum increase in fruit diameter and fruit length. This treatment proved superior to organic fertilizer treatments, although some treatments were found statistically at par. The increase in fruit size may be attributed to greater accumulation of photosynthates within the developing fruits.

The study also indicated that maintaining an optimum nutrient balance is essential for achieving higher yields, as either excess or deficiency of nutrients may adversely affect productivity. The results clearly demonstrated the positive role of nutrient dynamics in enhancing okra fruit yield. Among all treatments, the recommended dose of NPK at 20:10:10 kg/ha produced the highest fruit yield.

Application of nitrogen, phosphorus, and potassium at recommended levels, either alone or in combination with biofertilizers, improved plant growth and development, thereby positively influencing yield attributes and total yield. The combined application of NPK may have enhanced photosynthetic activity, promoted carbohydrate accumulation, and stimulated vegetative growth, ultimately leading to increased fruit production in okra (Sengupta, 2002).

Furthermore, the application of nitrogen at 120 kg/ha in combination with bioinoculants significantly increased plant height, number of branches, fruit diameter, number of fruits per plant, and yield per hectare.

Growth Attributes

- **Plant Height (cm)**

A detailed analysis of the data presented in **fig. 4.1** indicates that the various fertilizer treatments had a significant effect on plant height at both **30 and 60 days after sowing (DAS)**. The experiment was conducted in triplicate, and the **mean values** are presented in the table for accuracy and consistency.

According to the result (plot no. 12), the **maximum plant height** was recorded in the treatment **20N + 10P + 10K**, with values of **35.6 cm** in the variety *Arka* and **34.2 cm** in *Anamika(30DAS)* and with values of **65.4cm** in *Arka(60DAS)*. Organic fertilizer treatments also demonstrated favorable effects, showing an overall increase in plant height with rising concentrations of nitrogen, phosphorus, and potassium. These results suggest that the balanced application of N, P, and K, either individually or in combination with organic inputs, positively influences the vegetative growth of okra.

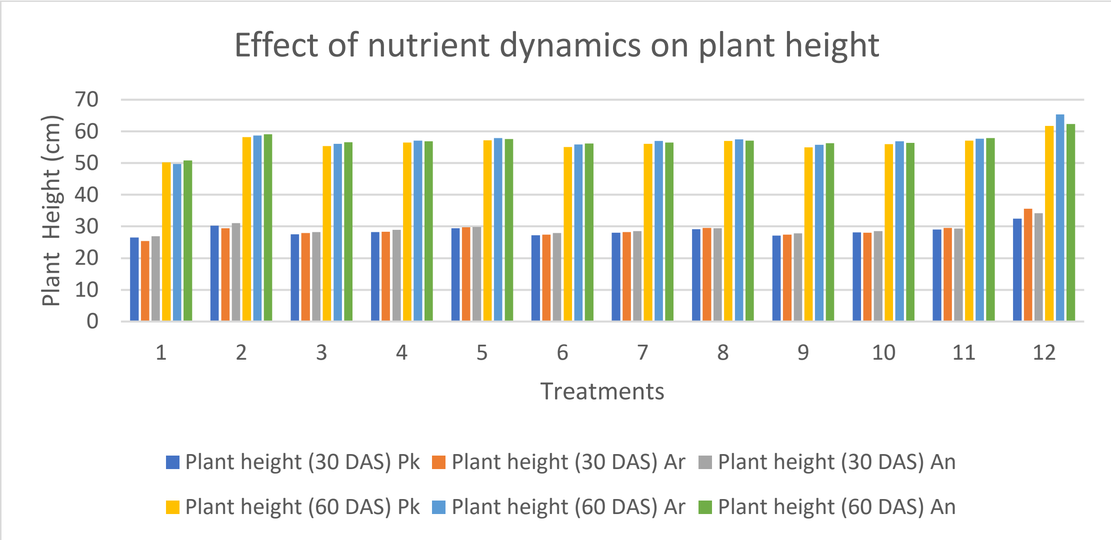


Fig. 1: Effect of nutrient dynamics on plant height (cm)

- **Number of Nodes per Plant**

The data across the experimental years demonstrated that all fertilizer treatments produced a **significantly higher number of nodes per plant** compared to the control. The **maximum number of nodes (6.1)** was recorded (plot no.12) in both varieties, *Arka* and *Anamika*, under the treatment **20N + 10P + 10K**.

Organic fertilizer treatments also exhibited positive effects, with the **number of nodes per plant increasing in proportion to the concentration of nitrogen, phosphorus, and potassium** applied. These findings highlight the role of balanced nutrient management in enhancing nodal development, which is a key determinant of plant vigor and potential yield in okra.

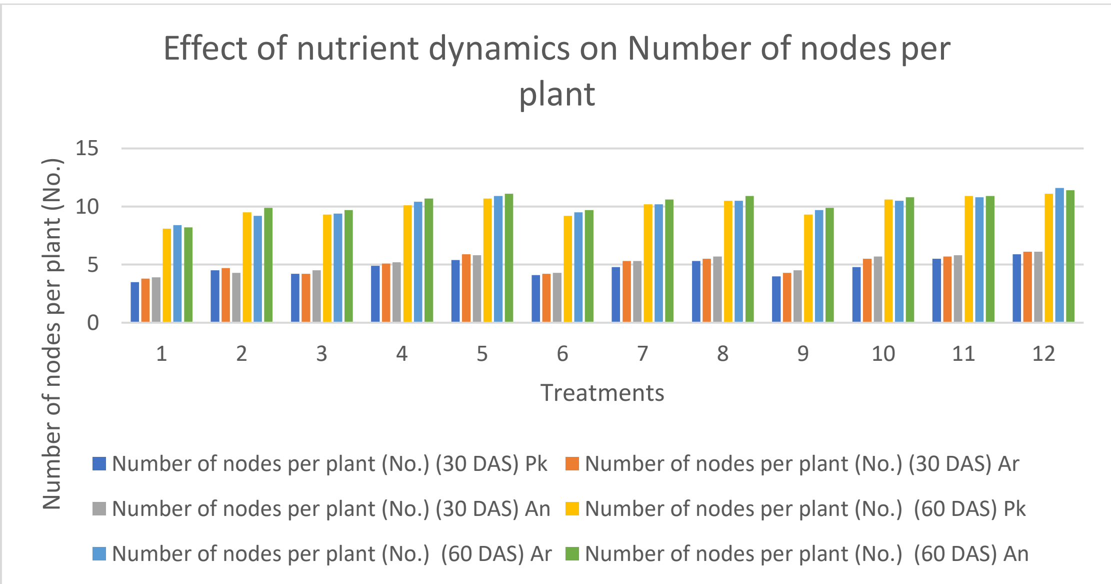


Fig. 2: Effects of nutrient dynamics on number of nodes per plant (No.)

- **Length of Internodes (cm)**

The data revealed that the application of fertilizers significantly influenced the **length of internodes per plant** compared to the control. The **maximum internode length (2.5 cm)** was observed (plot no.12) in both varieties, *Arka* and *Anamika*, under the treatment **20N + 10P + 10K**.

Organic fertilizer treatments also produced favorable results, with internode length increasing progressively as the concentrations of nitrogen, phosphorus, and potassium were raised. This indicates that balanced nutrient application enhances internodal elongation, thereby contributing to improved vegetative growth in okra.

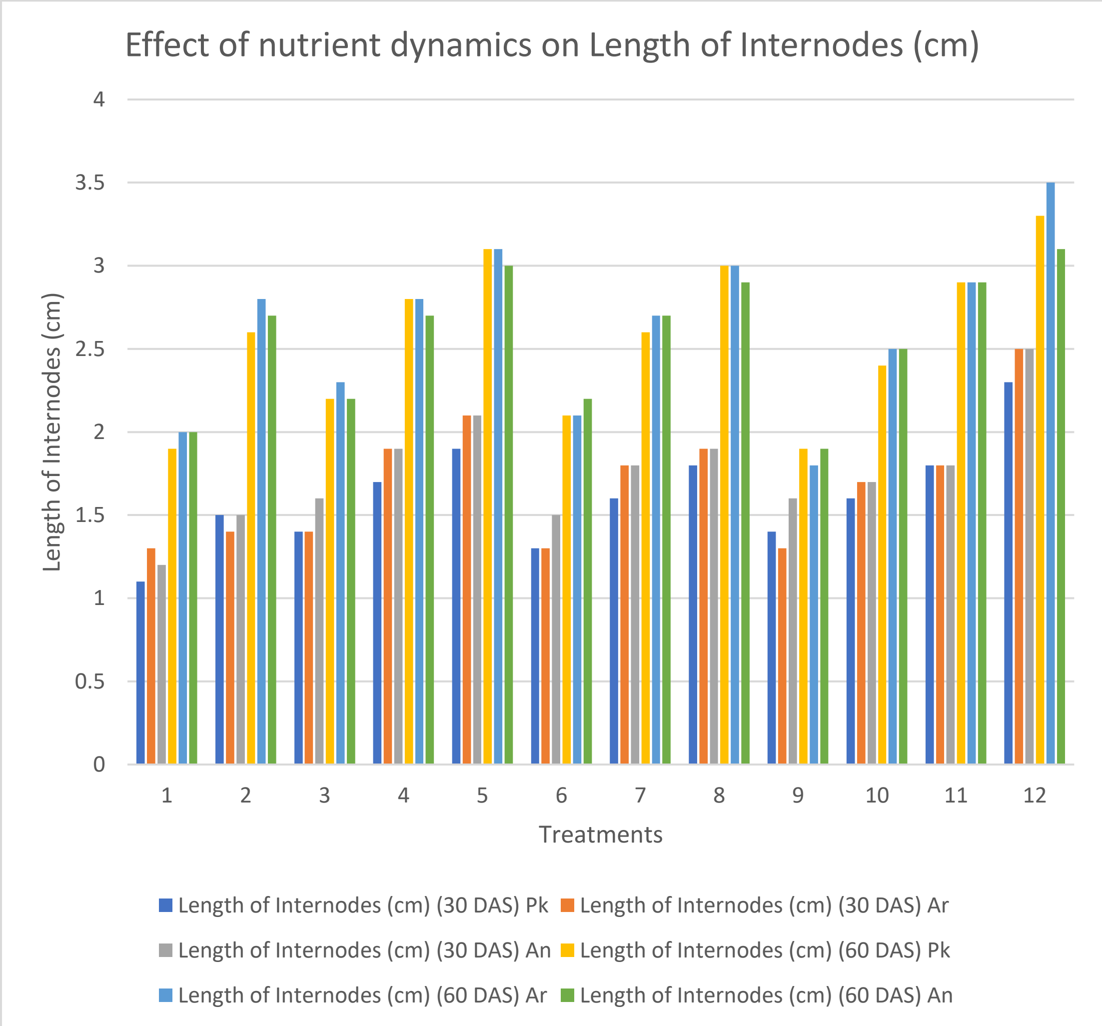


Fig. 3: Effect of nutrient dynamics on Length of Internodes (cm)

- **Number of Branches per Plant**

The results showed that fertilizer treatments had a significant effect on the **number of branches per plant** in both varieties of okra. The **highest number of branches** was recorded (plot no.12) under the treatment **20N + 10P + 10K**, with values of **6.0 branches in *Arka*** and **5.6 branches in *Anamika***.

Organic fertilizer treatments also produced encouraging results, with the number of branches per plant increasing progressively as the concentrations of nitrogen, phosphorus, and potassium were raised. This trend suggests that balanced nutrient application promotes branching, an important vegetative trait that contributes to higher productivity in okra.

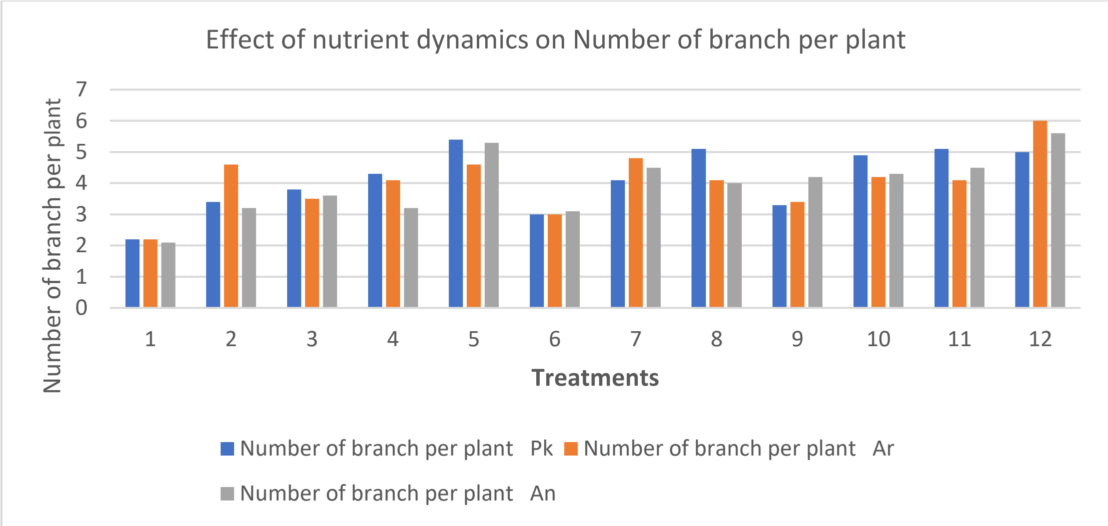


Fig 4: Effect of nutrient dynamics on Number of branches per plant

- **Stem Diameter (cm)**

Analysis of the data indicated that fertilizer treatments significantly influenced the **stem diameter** of okra plants. The **maximum stem diameter** was recorded(plot no.12) under the treatment **20N + 10P + 10K**, with values of **2.43 cm in *Arka*** and **2.39 cm in *Prabani Kranti***.

Organic fertilizer treatments also showed beneficial effects, with stem diameter increasing steadily as the concentrations of nitrogen, phosphorus, and potassium were raised. These findings suggest that balanced nutrient application contributes to enhanced stem robustness, thereby improving the structural strength and overall vigor of the okra plant.

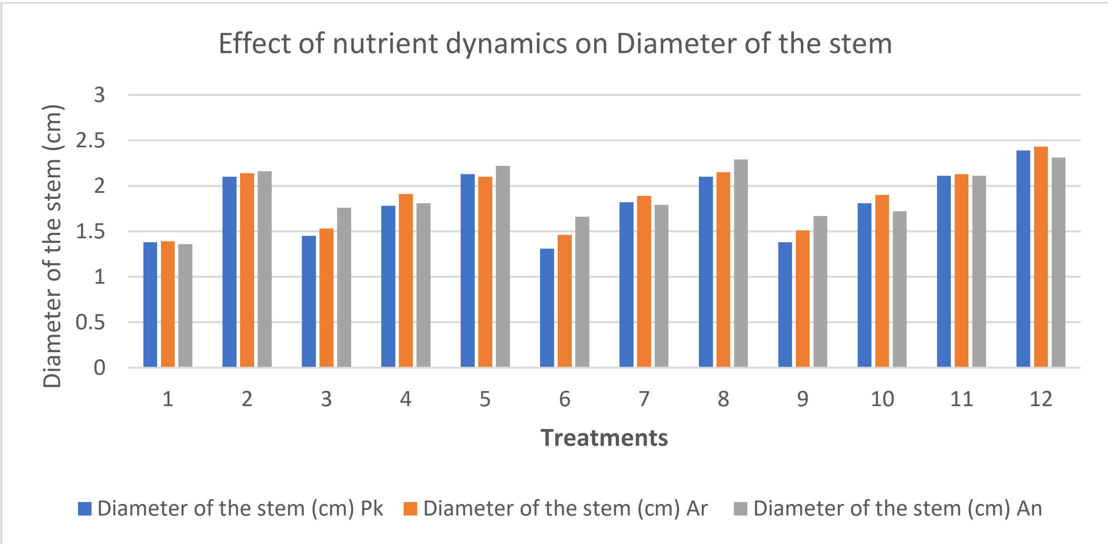


Fig. 5: Effect of nutrient dynamics on Diameter of the stem (cm)

- **Days to First Flower Initiation**

The results demonstrated that fertilizer treatments had a marked effect on the **days required for first flower initiation** in okra. The **earliest flowering** was recorded (plot no.12) under the treatment **20N + 10P + 10K**, with **29 days in *Arka*** and **30 days in *Prabani Kranti***.

Organic fertilizer treatments also performed well, with the **days to first flower initiation decreasing progressively** as the concentrations of nitrogen, phosphorus, and potassium increased. These findings indicate that balanced nutrient application accelerates the onset of reproductive growth, which is a desirable trait for enhancing yield potential in okra.

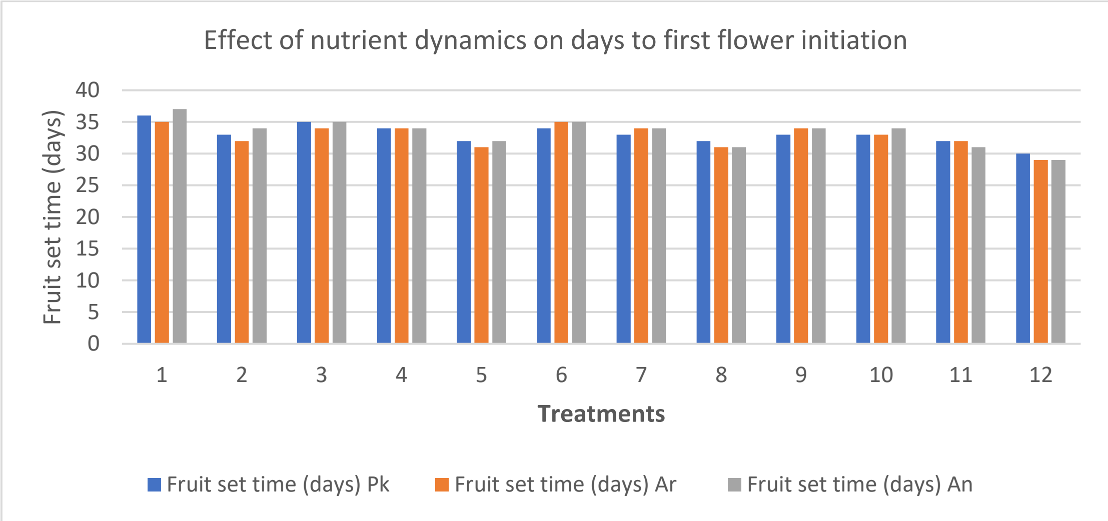


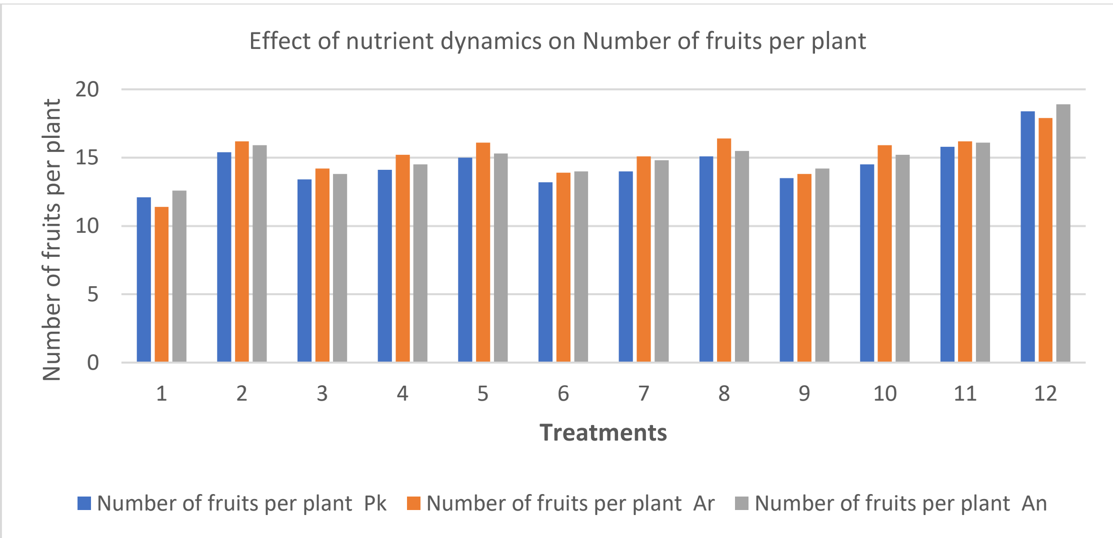
Fig. 6: Effect of nutrient dynamics on days to first flower initiation

Yield attributes parameters and yield

- **Number of Fruits per Plant**

According to the data (plot no.12), Number of fruits per plant were 18.9 and 18.4 (Anamika and Prabani Kranti 20 N + 10 P + 10 K). Organic fertilizer also show good results and Number of fruits per plant also increases when N,P and K concentration increases.

Fig. 7: Effect of nutrient dynamics on Number of fruits per plant

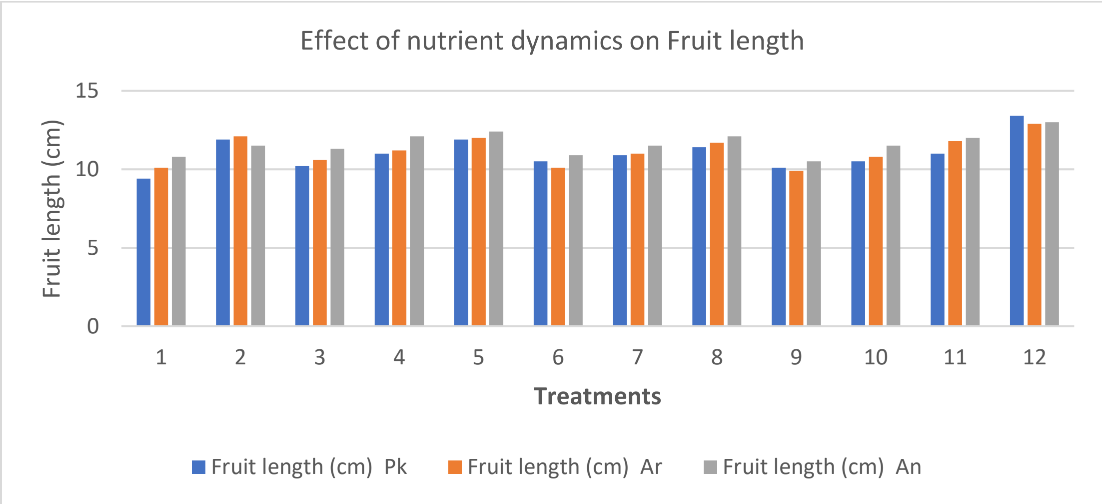


- **Fruit Length (cm)**

The results indicated that fertilizer treatments had a significant impact on the **length of fruits** in okra. The **maximum fruit length** was observed (plot no.12) under the treatment **20N + 10P + 10K**, with values of **13.4 cm in *Anamika*** and **13.0 cm in *Prabani Kranti***.

Organic fertilizer treatments also yielded positive results, with fruit length showing a steady increase as the concentrations of nitrogen, phosphorus, and potassium were raised. These findings suggest that balanced nutrient application contributes to better fruit development, thereby enhancing the marketable quality of okra.

Fig. 8: Effect of nutrient dynamics on Fruit length (cm)



- **Diameter of Fruit (cm)**

The data showed that fertilizer treatments significantly influenced the **diameter of fruits** in okra. The **maximum fruit diameter** was recorded (plot no.12) under the treatment **20N + 10P + 10K**, with values of **1.8 cm in *Anamika*** and **1.7 cm in *Arka***.

Organic fertilizer treatments also produced positive effects, with fruit diameter increasing progressively as the concentrations of nitrogen, phosphorus, and potassium were raised. These results indicate that balanced nutrient management promotes improved fruit girth, which is an important factor contributing to the overall yield and quality of okra.

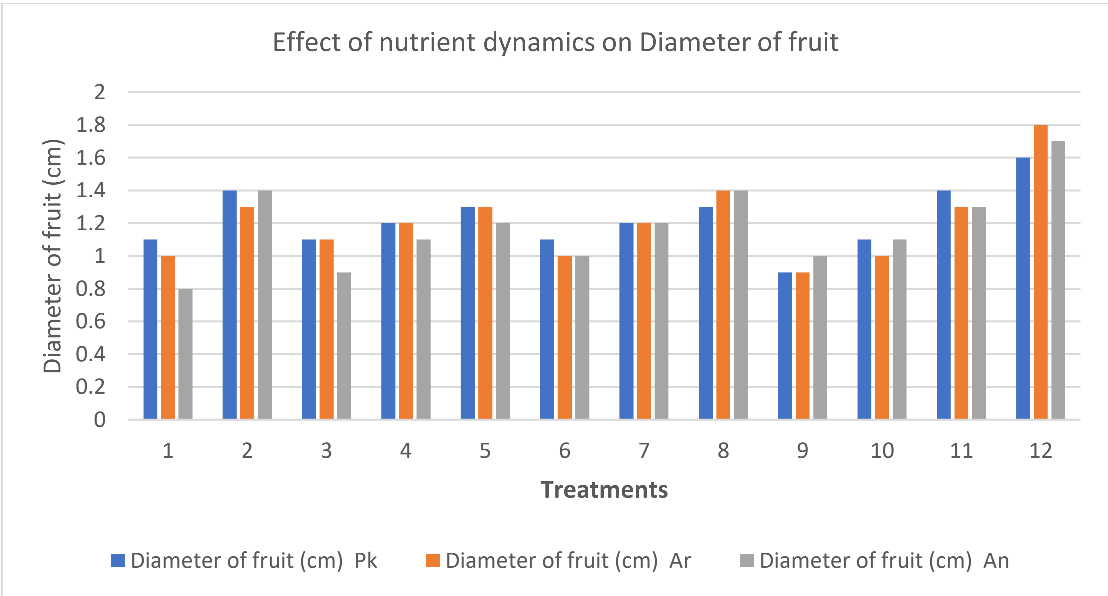


Fig. 9: Effect of nutrient dynamics on Diameter of fruit (cm)

- **Fruit's Average Weight (g)**

The results demonstrated that fertilizer treatments had a significant effect on the **average fruit weight** of okra. The **highest average fruit weight** was recorded (plot no.12) under the treatment **20N + 10P + 10K**, with values of **17.1 g in *Anamika*** and **16.8 g in *Prabani Kranti***.

Organic fertilizer treatments also showed favorable outcomes, with average fruit weight increasing steadily as the concentrations of nitrogen, phosphorus, and potassium were elevated. These findings highlight the role of balanced nutrient application in improving fruit biomass, which directly contributes to enhanced yield potential in okra.

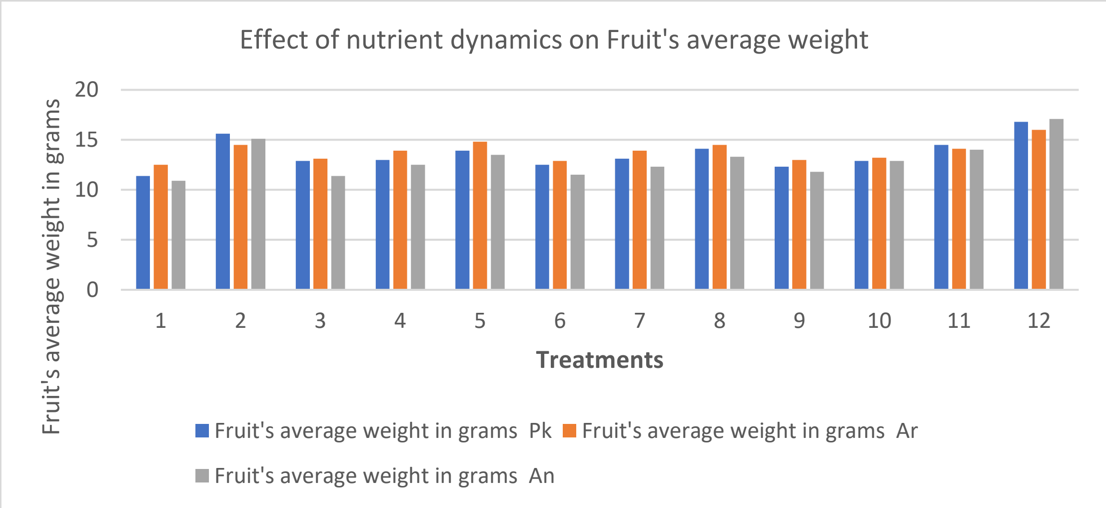


Fig. 10: Effect of nutrient dynamics on Fruit's average weight in grams

- **Fruit Production (q/ha)**

The data indicated that fertilizer treatments significantly affected the **fruit production per hectare** in okra. The **maximum fruit production** was recorded (plot no.12) under the treatment **20N + 10P + 10K**, with yields of **105.4 q/ha in *Anamika*** and **102.7 q/ha in *Arka***.

Organic fertilizer treatments also produced encouraging results, with fruit yield per hectare increasing progressively as the concentrations of nitrogen, phosphorus, and potassium were raised. These results clearly demonstrate that balanced nutrient application enhances overall productivity and yield efficiency in okra cultivation.

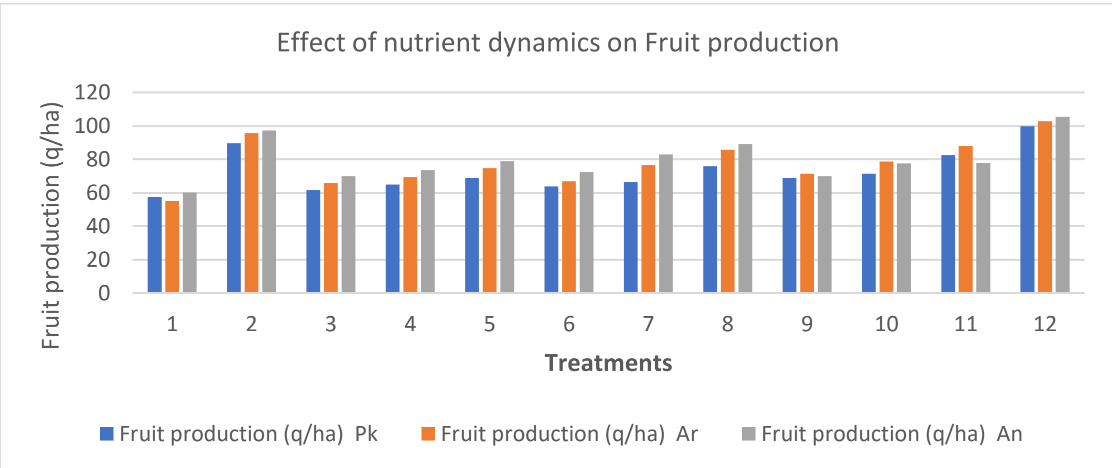


Fig. 11: Effect of nutrient dynamics on Fruit production (q/ha)

Conclusion

The present study demonstrated that the application of the recommended dose of NPK (20:10:10 kg/ha) resulted in **significantly superior performance** in terms of growth attributes, yield components, overall fruit yield, quality, and cost–benefit ratio when compared to the control. The combined use of chemical fertilizers and organic amendments further enhanced soil fertility and plant performance.

It can be concluded that under the **agro-climatic conditions of Rajasthan**, the varieties tested, particularly when treated with NPK 20:10:10 kg/ha, produced higher yields and better fruit quality. Thus, balanced fertilization with NPK, along with supplementary organic inputs, offers a sustainable strategy for maximizing okra production in this region.

Discussion

The experiment entitled *“Effect of Chemical Fertilizers on* Okra *(Abelmoschus esculentus L.)”* was carried out near Thekra Canal Road, Kota, during the summer season of 2023–24. The investigation included eleven treatments applied to three okra varieties, consisting of organic fertilizers alone as well as their combinations with the recommended doses of NPK fertilizers. The treatments were laid out in a Randomized Block Design (RBD) with three replications.

The experimental field soil was sandy loam in texture with a pH of 7.46, electrical conductivity of 0.42 S/m, organic carbon content of 0.43%, available nitrogen of 221.6 kg/ha, and available phosphorus (P_2O_5) of 15.6 kg/ha. Recommended agronomic practices were adopted throughout the experiment. The full recommended doses of phosphorus and potassium, along with half of the nitrogen dose, were applied as basal dressing at sowing, while the remaining nitrogen was top-dressed at 30 days after sowing (DAS). Vermicompost was incorporated into the ridges, and seeds inoculated with biofertilizers were sown at a spacing of 60 × 30 cm under adequate moisture conditions to ensure proper germination.

Among all treatments, the application of NPK at 20:10:10 kg/ha proved to be the most effective in improving vegetative growth, number of branches, stem girth, early flowering, and yield-related parameters. Organic fertilizer treatments also showed beneficial effects and ranked next in performance. Significant enhancement was observed in fruit length, fruit diameter, average fruit weight, and dry matter accumulation, which ultimately contributed to increased yield.

Overall, the findings of the study indicate that balanced fertilization using the recommended dose of NPK in combination with organic nutrient sources is the most suitable strategy for enhancing the growth, productivity, and quality of okra under the agro-climatic conditions of the Kota region

References

1. **Adeboye, O., Akinmoladun, F., & Okunade, S. (2020).** *Effect of combined organic and inorganic fertilizers on the growth, yield, and quality of okra (Abelmoschus esculentus) in Nigeria. International Journal of Agriculture and Soil Science*, 13(2), 135-145.
2. **Adeboye, O., Akinmoladun, F., & Okunade, S. (2020).** *Effect of combined organic and inorganic fertilizers on the growth, yield, and quality of okra (Abelmoschus esculentus) in Nigeria. International Journal of Agriculture and Soil Science*, 13(2), 135-145.
3. Adekiya, A. O., Agbede, T. M., Aboyeji, C. M., Dunsin, O. and Ugbe, J. O. (2019) Green manures and NPK fertilizer effects on soil properties, growth, yield, mineral and vitamin C composition of okra (Abelmoschus esculentus (L.) Moench). Journal of Saudi Society Agricultural Science 18, 218–223.
4. Adekiya, A. O., Agbede, T. M., Aboyeji, C. M., Dunsin, O. and Ugbe, J. O. (2019) Green manures and NPK fertilizer effects on soil properties, growth, yield, mineral and vitamin C composition of okra (Abelmoschus esculentus (L.) Moench). Journal of Saudi Society Agricultural Science 18, 218–223.
5. *Alam, M., Hossain, M., & Rahman, M. (2021)*. "Effects of nitrogen and phosphorus on the nutrient content and yield of okra (Abelmoschus esculentus L.)." *Scientia Horticulturae*, 287, 110263
6. **Alam, M., Hossain, M., & Rahman, M. (2021)**. "Effects of nitrogen and phosphorus on the nutrient content and yield of okra (Abelmoschus esculentus L.)." *Scientia Horticulturae*, 287, 110263

7. Bharad, S. G., Korde, D. S., Satpute, P. and Baviskar, M. N. (2013) Effect of organic manures and number of cuttings on growth and quality of Indian spinach. The Asian Journal of Horticulture, 8(1): 60-64.
8. Chandini, Kumar, R., Kumar, R., & Prakash, O. (2019). The impact of chemical fertilizers on **our** environment and ecosystem. *Research Trends in Environmental Sciences*, *February*, 69–86.
9. Chaudhary, H., et al. (2019). *Impact of chemical fertilizers on okra production and quality: A case study*. Journal of Soil Science, 17(3), 123-131.
10. **Chauhan, S., Sharma, P., & Yadav, S. (2022)**. "Environmental consequences of excessive fertilizer use in okra cultivation and the role of sustainable practices." *Environmental Pollution*, 276, 116600.
11. Da Costa, C. H. M., Crusciol, C.A.C. (2016) Long-term effects of lime and phosphogypsum application on tropical no-till soybean—oat—sorghum rotation and soil chemical properties. European Journal of Agronomy 74: 119-132.
12. Gowda M.C.B.; Krishnappa K.S. and Puttaraju T.B. (2001). Dry matter production and fruit size in okra varieties as influenced by varying fertilizer levels. Current Res. Uni. Agril. Sci. Bangalore. 30(9-10): 151- 153.
13. Gowda M.C.B.; Krishnappa K.S.; Gowda M.C. and Puttaraju T.B. (2002). Effect of NPK levels on dry matter, nutrient accumulation and uptake of nutrients in okra. South Indian Hort. 50(4-6): 543-549.
14. Gupta, R., Swami, I. S., Rai, I. A., Correspondence, I., & Rai, A. P. (2019). Impact of integrated application of vermicompost, farmyard manure and chemical fertilizers on okra (Abelmoschus esculentus L.) performance and soil biochemical properties. ~ 1714 ~ International Journal of Chemical Studies, 7(2), 1714–1718.
15. Irfan, BS and Kasal, Yuvraj and Chowdary, D. M. (2021). A review on effects of chemical fertilizers and organic manures on soil fertility. *The Pharma Innovation Journal*, *10*(8), 504--507.
16. **Juma, N., et al.** (2019). "Impact of Chemical Fertilizers on Soil Erosion and Productivity." *Agricultural Systems*.
17. Katiyar, D., Singh, A., Malaviya, P., Pant, D., Singh, P. and Abrahm, G. (2012) Impact of fly ash amended soil on growth and yield of crop plants. International Journal of Environment and Waste Management. 10 (2/3): 150-162l.
18. Kaur, P., Sharma, A., & Singh, H. (2019). Impact of chemical fertilizers on soil microbiota and soil health. *Soil and Fertilization Journal*, 47(3), 214-225.
19. Kaur, P., Sharma, A., & Singh, H. (2019). Impact of chemical fertilizers on soil microbiota and soil health. *Soil and Fertilization Journal*, 47(3), 214-225.
20. **Khan, M., & Akhtar, M. (2022)**. "Impact of long-term chemical fertilizer application on soil health and okra productivity." *Soil Science and Plant Nutrition*, 68(4), 450-457.
21. **Khan, M., & Akhtar, M. (2022)**. "Impact of long-term chemical fertilizer application on soil health and okra productivity." *Soil Science and Plant Nutrition*, 68(4), 450-457.
22. Kumar Bhatt, M., Labanya, R., & Joshi, H. C. (2019). Influence of Long-term Chemical fertilizers and Organic Manures on Soil Fertility - A Review. *Universal Journal of Agricultural Research*, *7*(5), 177–188. https://doi.org/10.13189/ujar.2019.070502
23. Kumar, S.; Khan, N:; Rai, B.; Yadav, G.R.; Mishra, J.R.; Mishra, G.; Yadav, A. and Parihar, N.S. (2006). Effect of NPK with FYM and Green manuring on growth and yield of tomato, in: Second National Symposium on “Recent Trends in Hi-Tech Agriculture” at Meerut. Nov. 04-05, pp. 25.
24. L, B., KUSHWAHA, P., & SRIVASTAVA, R. (2016). *Suitability of Nano Chemical Stabilizer in Black Cotton Soil*. *August 2016*, 73–76. https://doi.org/10.15224/978-1-63248-101-6-77
25. Lal, B., Nayak, V., Sharma, P. and Tedia, K. (2014) Effect of Combined Application of FYM, Fly Ash and Fertilizers on Soil Properties and Paddy Grown on Degraded Land. Journal of Current World Environment, 9(2): 531-535.
26. **Lehmann, J., et al.** (2021). "Chemical Fertilizers and Soil Microbial Diversity." *Soil Biology & Biochemistry*.Meena, V.S., Maurya, B.R., Meena, R.S., M

27. Mohan, S., Prasad, S., & Pandey, A. (2022). "Impact of chemical fertilizers on growth, yield, and nutrient content of okra in tropical soils." *International Journal of Agronomy and Agricultural Research*, 40(4), 101-110.

28. Oladipo, O. G., Olayinka, A. and Aduayi, E. A. (2015) Effects of organic amendments on 12 microbial activity, N and P mineralization in an Alfsol. Journal of Environmental Management 2: 30–40.

29. Olujide, M.G. and Oladele, O.I. (2007). Economics of Amaranthus production under different NPK fertilizer regimes. Bulgarian J. Agril. Sci. 12: 225- 229.

30. Parton, W.J., Schimel D.S., Cole C.V. and Ojima D.S. 1987. Analysis of factors controlling soil organic matter levels in Great Plains grasslands. Soil Science Society of America Journal 51: 1173-1179.

31. **Patel, S., Rathi, M., & Tiwari, S. (2023)**. "Integrated nutrient management in okra: Effect of organic and chemical fertilizers on soil health and productivity." *Agricultural Research*, 12(2), 159-167.

32. **Raghuvanshi, S., et al.** (2021). "Integrated Nutrient Management and Soil Fertility." *Field Crops Research*.

33. Rajgopal, V. and Rao, .M. (1974). Aust. J. Bot. 22: 429-435. In T.K. Bose; J. Kabir; T.K. Maity; Parthasarathy, V.A. and Som, MG (eds): Vegetable Crops, Vol. 1. Naya Prokash, 208, Bhidhan Sarani, Calcutta 700 006. pp. 1-154.

34. Randive, K., Raut, T., & Jawadand, S. (2021). An overview of the global fertilizer trends and India's position in 2020. *Mineral Economics*, *34*(3), 371–384. https://doi.org/10.1007/s13563-020-00246-z

35. Rao, P., Sharma, R., & Singh, V. (2022). Long-term effects of chemical fertilizers on soil fertility and microbial activity in okra cultivation. *Soil Science Research*, 15(1), 67-75

36. **Ravi, V., Sinha, P., & Verma, A. (2021)**. "Nutrient composition of okra pods influenced by chemical fertilizers: A study on nitrogen fertilization." *Journal of Food Quality*, 44(8), 428-436.

37. Roy, T., Singh, R. D., Biswas, D. R. and Patra, A. K. (2013) Effect of sewage sludge and inorganic fertilizers on productivity and micronutrients accumulation by Palak (Beta vulgaris) and their availability in a Typic Haplustept. Journal of the Indian Society of Soil Science, 61(3): 207-218.

38. S.K., Singh, N.P., Malik, V.K., Kumar, V. and Jat, LK. (2014) Microbial dynamics as influenced by concentrate manure and inorganic fertilizer in alluvium soil of Varanasi, India. African Journal of Microbiology Research 8(3): 257-263.

39. Sable, P.B. and Bhamare, V.K. (2007). Effect of biofertilizers (Azotobacter and Azospirillum) alone and in combination with reduced levels of nitrogen on quality of cauliflower cv. Snowball. The Asian J. Hort 2(1): 215-217.

40. Savci, S. (2012a). An Agricultural Pollutant: Chemical Fertilizer. International Journal of Environmental Science and Development, 3(1), 73–80. https://doi.org/10.7763/ijesd.2012.v3.191

41. Savci, S. (2012b). Investigation of Effect of Chemical Fertilizers on Environment. APCBEE Procedia, 1(January), 287–292. https://doi.org/10.1016/j.apcbee.2012.03.047

42. Shanmugasundaram, R. and Savithri, P. (2002). Impact of nitrogen with organics on quality attributes and yield of carrot root (Daucus carota). Adv. Plant Sci. 15(2): 637-639.

43. Sharma, A., Kumar, M., & Singh, P. (2020). Okra: A valuable vegetable for health and nutrition. *Vegetable Crop Science*, 8(3), 105-112.

44. Sharma, C.B. (1971). Indian J. Hort. 28: 228-233. In T.K. Bose; J. Kabir; T.K. Maity; Parthasarathy, V.A. and Som, M.G. (eds): Vegetable Crops, Vol. 1, Naya Prokash, 206, Bhidhan Sarani, Calcutta 700 006, pp. 1-154.

45. Sharma, R.; Prasad, V.M.; Yadav, M. and Chaudhary, R. (2004). Effect of biofertilizers on growth and yield of carrot (Daucus carota L.). In: International Seminar on "Rec. Trends in Hi-Tech Hort. and PHT at Kanpur, Feb. 4-6, pp. 195.

46. Singh, S., Singh, V., Singh, J. P., Kumar, A., and Singh, H. (2015) Effect of sewage water irrigation on accumulation of micro nutrients and heavy metals in soils and vegetable crops. Annals of Plant and Soil Research, 17: 129-132.

47. Su, N.R. (1974). Agron. Crop. Workshop Muscle School, Alabama, 68. In T.K. Bose; J. Kabir; T.K. Maity; Parthasarathy, V.A. and Som, M.G. (eds): Vegetable Crops. Vol. 1. Naya Prokash, 206, Bhidhan Sarani, Calcutta 700 006, pp. 1-154.

48. Yadav, N., Singh, S. K., Bahuguna, A., Sharma, S. and Yadav, A. (2018) Assessment of effects of sewage-sludge, zinc, boron and sulphur application onconcentration and uptake of nutrients by mustard. International Journal of Chemical Studies, 6(4): 363- 367.

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