*Original Research Article*

Soil Nutrient Status of Okra as Affected by Plant Spacing and Fertilizer Levels

.

ABSTRACT

|  |
| --- |
| The present experiment was carried out to find out the influence of various levels of spacing and fertilizer on soil nutrient statusof okra at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, India during the *kharif* seasons of 2023 and 2024. The trial was laid out in Randomized Block Design with factorial concept having sixteen treatments and three replications comprising of two factors *i.e.* factor-I spacing (S) *viz*. 60 cm **×**15 cm (S1), 60 cm **×** 20 cm (S2), 60 cm **×** 25 cm (S3) and 60 cm **×** 30 cm (S4) and factor-II fertilizer (F) *viz*. 160 % RDF (F1), 140 % RDF (F2), 120 % RDF (F3) and 100 % RDF (F4). The results obtained from the study of two consecutive years revealed that the spacingcould notaffect available N, P and K content of soil after harvestof okra while, amid various fertilizer levels, higher fertilizer dose of 160 % RDF (F1) significantly enhanced available N (308.15, 287.07 and 297.61kg ha-1), P (92.92, 83.96 and 88.44 kg ha-1) and K (471.40, 460.71 and 466.05 kg ha-1) of soil after okra harvest in 2023, 2024 and in pooled analysis, respectively. Increased fertilizer application could result in enhanced nutrient levels in the soil. |

*Keywords: Available N, P & K, Fertilizer, Nutrient, Okra, Soil, Spacing.*

1. INTRODUCTION

Okra is also known as lady's finger, *bhendi* or *bhindi* [*Abelmoschus esculentus* (L.) Moench] which belongs to the Malvaceae family and is originated in tropical Africa. It is widely grown in tropical and subtropical regions across the globe for its tender pods in *kharif* and summer seasons (Ghosh and Jana, 2022) [1]. Okra is a versatile, adaptable crop grown for its nutritious pods, and valued for its various uses. It is a rich source of minerals, offering relief from diseases like hemorrhoids, ulcers and goiter, while also supporting cardiac health. Beyond its edible pods, okra seeds can substitute coffee, and its roots, stems and fibers have industrial applications such as cleaning sugarcane juice, oil extraction and paper production. Additionally, okra is used in limited forms like canned or frozen products (Bishnoi *et al*., 2019) [2]. India is the leading producer and cultivator of okra in the world. In India, okra farmers often overlook specialized techniques for cultivating high-quality crop. To achieve optimal growth, yield and quality with soil nutrient status, it is essential to employ best practices, particularly maintaining ideal plant spacing and applying the optimum amount of fertilizer. Optimal plant density and spacing are vital for maximizing okra yields, as they impact plant growth and resource allocation. Inadequate spacing can lead to reduced soil nutrients due to competition among the plants. Soils with poor fertility necessitate additional nutrient supplementation and deficiencies in critical nutrients like nitrogen, phosphorus and potassium can substantially compromise yield and quality. As the world's largest okra producer, India must prioritize understanding the interaction between spacing and fertilizer application to optimize okra cultivation.Improving soil nutrient status is vital for sustainable agriculture, ensuring healthy plant growth, higher crop yields and productivity. Healthy soil benefits the farmers and consumers and supports vital plant processes and leads to improved quality also. Additionally, soil with good nutrient status promotes soil health and resilience, supports biodiversity and provides ecosystem services. Overall, maintaining healthy soil nutrient status is crucial for long term productivity, human nutrition and environmental protection (Bake *et al*., 2017 [3] and Danmaigoro *et al*., 2022 [4]).

2. material and methods

The present investigation was conducted during *kharif*-2023 and *kharif*-2024 at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat (India) in Block ‘E’, plot 7. The experiment was laid out in Randomized Block Design with Factorial concept with total sixteen treatment combinations comprising of two factors *viz*., Spacing (S) *viz*., S1 (60 cm × 15 cm), S2 (60 cm × 20 cm), S3 (60 cm × 25 cm) and S4 (60 cm × 30 cm) and Fertilizer (F) *viz*., F1 (160 % RDF), F2 (140 % RDF), F3 (120 % RDF) and F4 (100 % RDF). The variety used for the research study was GNO 1 (Purna Rakshak) which yields about 12.72 t ha-1 in *kharif* season and shows moderate resistant against YVMV, powdery mildew, ELCV disease as well as fruit and shoot borer, jassid and whitefly. The variety was planted in plots measuring 4.8 m × 3.0 m.

For both the seasons of study, well decomposed FYM (10 t ha-1) on dry weight basis required for gross plot area was calculated, weighed and incorporated in the experimental field at the time of land preparation as per the recommended dose. As per the treatments, calculation was made for urea, single super phosphate and muriate of potash to apply nitrogen, phosphorus and potassium, respectively in each plot. The 25 % of N with full dose of phosphorus and potassium was applied as a basal dose in the form of urea, single super phosphate and muriate of potash, respectively as per the treatments. The remaining dose of nitrogen was applied in three equal split doses at 30, 45 and 60 days after sowing as top dressing.The data collected for soil parameters involved under study were subjected to the statistical analysis which was followed as described by Panse and Sukhatme (1985) [5].

Topography of the site of experiment was fairly uniform and leveled. The soil of Navsari Agricultural University campus is considered as ‘black cotton soil’. According to the soil taxonomy, experimental soil belonged to the order *Inceptisol*, sub-order *Ochrepts*, sub-soil group *VerticUstochrepts* a group of *Ustochrepts* under the soil series of Jalalpore South Gujarat as classified by Soil Survey Officer, Department of Agriculture, Gujarat State (Desai and Patel, 1970) [6].The experimental soil was deep black having well drainage as well as good water holding capacity, which was reasonably suitable for okra growing. The chemical properties of soil before experiment in both the seasonsof research are tabulated in (Table 1) and procedure followed is described in 2.1.1 section.

**Table 1 Initial chemical properties of experimental soil (0-30 cm depth)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Particulars** | **Values(kg ha-1)** | | **Method used for analysis** | **Reference** |
| **2023** | **2024** |
| Available nitrogencontent | 206.87 | 218.60 | Modified Kjeldahl | Jackson (1973) [7] |
| Available phosphorus content | 51.09 | 68.06 | Spectrophotometry | Olsen *et al*., 1967 [8] |
| Available potassium content | 398.47 | 409.07 | Flame photometry | Jackson (1973) [7] |

**2.1 Collection of soil samples**

The soil samples were collected from 0-30 cmdepth at random sites covering the entire experimental field before starting the experiment during both the seasons of study. Moreover, after the completion of investigation in both years, soil samples were collected treatment wise. Soil samples were air dried in shade and ground with wooden pestle and mortar and passed through 2 mm sieve. The processed samples were stored in bags with suitable labels for further laboratory analysis at the Department of Natural Resources Management, ASPEE College of Horticulture, Navsari Agricultural University, Navsari.

**2.1.1 Procedure followed to estimate available nitrogen, phosphorus and potassium content of soil**

***2.1.1.1Available nitrogen content (kg ha-1)***

Available nitrogen content in soil was estimatedby using modified Kjeldahl method suggested by Jackson (1973) [6]. The soil sample (20 g) was transferred in 80 ml distillation flask and 100 ml of KMnO4 was added to it. Then, few glass beads and 2 ml paraffin liquid was added in same. A 250 ml beaker was placed for receiver tube in Kjeldahl distillation unit, after transferring 25 ml 4 % boric acid and mixed indicator. Collected distillate was titrated with standard 0.1 N H2SO4 up to pink coloured end point. Blank was run without soil for blank reading (B).

(S – B) × 0.014 × N of H2SO4 × 2240000

Sample weight

**Calculation:** Available N (kg ha-1) =

***2.1.1.2Available phosphorus content (kg ha-1)***

The determination of available phosphorus content was carried out by using spectrophotometry method as described by Olsen *et al*. (1967) [7]. Soil sample (5 g) was transferred in 250 ml titration flask and a teaspoon of activated charcoal and 100 ml 0.5 M NaHCO3 was added. It was kept on a mechanical shaker for 30 min and then suspension was filtered using Whatman filter paper. It was followed by taking out 5 ml aliquot in a 25 ml volumetric flask and addition of 5 ml ammonium molybdate and distilled water. After shaking the flask well, 1 ml of working SnCl2 wasadded and final volume was made up to 25 ml. The transmittance was measured at 660 nm in spectrophotometer (B). Blank reading was also run for the spectrophotometer (B).

**Calculation:** P (mg kg-1 or ppm) =

(S – B) × GF × Extractant used × Final volume made

Soil weight × Filtrate taken

P2O5 (mg kg-1 or ppm)= P (mg kg-1 or ppm) × 2.29

Available P2O5 in soil (kg ha-1) = P2O5 (mg kg-1 or ppm)× 2.24

***2.1.1.3Available potassium content (kg ha-1)***

According to the procedure stated by Jackson (1973) [6] using flame photometry, available potassium content was determined.The soil sample (5 g) was transferred in 250 ml conical flask and neutral N ammonium acetate (25 ml) was added. It was kept on a mechanical shaker for 30 min and then suspension was filtered using Whatman filter paper. Filtrate was fed in flame photometer and reading (R) was noted.

**Calculation:**

K2O(mg kg-1 or ppm)= K (mg kg-1 or ppm) × 1.20

Available K2Oin soil (kg ha-1) = K2O(mg kg-1 or ppm)× 2.24

R × GF × Volume of ammonium acetate (ml)

Soil weight (g)

K (mg kg-1 or ppm) =

3. results and discussion

**3.1 Effect of spacing, fertilizer and their interaction on available nitrogen, phosphorus and potassium content (kg ha-1) of soil after harvest in okra**

A perusal of data presented in (Table 2 to 4) and (Fig. 1 to 3) revealed the effect of spacing, fertilizer and their interactions for the available N, P and K content of soil after harvest in okra during both years (2023 and 2024) and pooled analysis.

**3.1.1 Effect of spacing**

Non significant variation was noticed for available N, P and K content of soil after harvest due to different spacing treatments during relevant years and pooled analysis.

However, higher N (287.85, 266.17 and 277.01 kg ha-1), P (82.39, 75.17 and 78.78 kg ha-1) and K (427.94, 413.67and 420.80 kg ha-1) content of soil after harvest was determined with wider spacing of 60 cm × 30 cm (S4) and lower N (269.70, 247.28 and 258.49 kg ha-1), P (75.72, 68.96 and 72.34 kg ha-1) and K (396.01, 380.20 and 388.10 kg ha-1) content of soil after harvest was noted with closer spacing *i.e.* 60 cm × 15 cm (S1) in 2023, 2024 and in pooled analysis, respectively.

In wider plant spacing *i.e.* 60 cm × 30 cm (S4), there were fewer plants per unit area, so total nutrient demand and soil uptake was lower as compared to the narrow planted plots. As a result, more of the applied N, P and K remained unused in the soil, leading to higher residual soil NPK levels.

**3.1.2 Effect of fertilizer**

Various fertilizers had produced significant difference for available N, P and K content of soil after harvest in okra for both the years of investigation (2023 and 2024) and in pooled analysis.

Higher fertilizer *i.e.* 160 % (F1) was able to obtain higher N (308.15, 287.07 and 297.61 kg ha-1), P (92.92, 83.96 and 88.44 kg ha-1) and K (471.40, 460.71 and 466.05 kg ha-1) and lower N (243.13, 218.81 and 230.97 kg ha-1), P (61.50, 57.28 and 59.39 kg ha-1) and K (335.27, 319.59 and 327.43 kg ha-1) in the year 2023, 2024 in pooled analysis, respectively. In addition to that, the at par values for available N (292.57, 272.87 and 282.72 kg ha-1) was reported with 140 % RDF (F2) in both years as well as in pooled analysis; for available P (77.94 kg ha-1) and K (427.11 kg ha-1) in the year 2024.

The improvement of available nitrogen, phosphorus and potassium content of soil after the harvest of okra crop might be due to the more nutrients were made available in the soil for plant absorption by adding of higher amount of fertilizers *i.e.* 160 % RDF (F1) which improved availability of the nutrient from native as well as applied fertilizer. Similar results were also reported by Wagh *et al*. (2014) [9] in okra, Patel *et al*. (2020) in cow pea [10], Kimi *et al.* (2021) in cluster bean [11] and Patel (2024) in cow pea [12].

**3.1.3 Interaction effect of spacing and fertilizer**

All the interactions (S × F, Y × S, Y × F and Y × S × F) were failed to show any significant variation on available N, P and K content of soil after harvest in okra any of years of research trial and in pooled analysis.

However, higher N (317.24, 297.60 and 307.23 kg ha-1), P (96.71, 87.34 and 92.02 kg ha-1) and K (488.49, 477.99 and 483.24 kg ha-1) content of soil after harvest was determined with wider spacing of 60 cm × 30 cm (S4) and lower N (231.05, 205.98 and 218.52 kg ha-1), P (56.41, 52.86 and 54.63 kg ha-1) and K (313.77, 296.90 and 305.34 kg ha-1) content of soil after harvest was noted with closer spacing *i.e.* 60 cm × 15 cm (S1) in 2023, 2024 and in pooled analysis, respectively.

**Table 2: Effect of spacing, fertilizer and their interaction on available nitrogen content (kg ha-1) of soil after harvest in okra**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Available nitrogen content (kg ha-1) of soil** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | **2023** | | | | | | | | **2024** | | | | | | | **Pooled** | | | | | | |
| **F1** | | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** |
| **S1** | 301.37 | | 284.03 | | 262.35 | 231.05 | | **269.70** | 280.72 | 264.08 | | 238.33 | 205.98 | | **247.28** | 291.04 | 274.05 | | 250.34 | 218.52 | | **258.49** |
| **S2** | 304.34 | | 290.76 | | 267.55 | 241.87 | | **276.13** | 283.59 | 271.63 | | 244.94 | 217.54 | | **254.43** | 293.97 | 281.19 | | 256.25 | 229.71 | | **265.28** |
| **S3** | 309.67 | | 297.21 | | 274.97 | 245.07 | | **281.73** | 286.76 | 276.18 | | 252.42 | 220.72 | | **259.02** | 298.21 | 286.70 | | 263.69 | 232.89 | | **270.37** |
| **S4** | 317.24 | | 298.28 | | 281.36 | 254.54 | | **287.85** | 297.21 | 279.60 | | 256.88 | 230.99 | | **266.17** | 307.23 | 288.94 | | 269.12 | 242.76 | | **277.01** |
| **Mean** | **308.15** | | **292.57** | | **271.55** | **243.13** | |  | **287.07** | **272.87** | | **248.14** | **218.81** | |  | **297.61** | **282.72** | | **259.85** | **230.97** | |  |
| **Source** | **S** | | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | |
| **S.Em.±** | 6.049 | | | 6.049 | | | 12.099 | | 8.728 | | 8.728 | | | 17.456 | | 5.416 | | 5.416 | | | 10.832 | |
| **C.D.**  **(5 %)** | NS | | | 17.47 | | | NS | | NS | | 25.21 | | | NS | | NS | | 15.32 | | | NS | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | | 7.660 | | | | | | | 7.660 | | | | | | | 15.319 | | | | | | |
| **C.D. (5 %)** | | NS | | | | | | | NS | | | | | | | NS | | | | | | |
| **CV %** | | 7.52 | | | | | | | 11.78 | | | | | | | 9.91 | | | | | | |

**Table 3: Effect of spacing, fertilizer and their interaction on available phosphorus content (kg ha-1) of soil after harvest in okra**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Available phosphorus content (kg ha-1) of soil** | | | | | | | | | | | | | | | | | | | | | |
| **Source** | **2023** | | | | | | | **2024** | | | | | | | **Pooled** | | | | | | |
| **F1** | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** |
| **S1** | 90.60 | 84.52 | | 71.38 | 56.41 | | **75.72** | 82.41 | 75.00 | | 65.56 | 52.86 | | **68.96** | 86.51 | 79.76 | | 68.47 | 54.63 | | **72.34** |
| **S2** | 92.12 | 84.27 | | 74.37 | 61.09 | | **77.97** | 83.00 | 77.23 | | 67.81 | 56.82 | | **71.22** | 87.56 | 80.75 | | 71.09 | 58.95 | | **74.59** |
| **S3** | 92.26 | 86.27 | | 77.15 | 62.42 | | **79.52** | 83.08 | 79.48 | | 70.15 | 57.75 | | **72.62** | 87.67 | 82.87 | | 73.65 | 60.09 | | **76.07** |
| **S4** | 96.71 | 87.07 | | 79.70 | 66.08 | | **82.39** | 87.34 | 80.04 | | 71.59 | 61.71 | | **75.17** | 92.02 | 83.56 | | 75.65 | 63.89 | | **78.78** |
| **Mean** | **92.92** | **85.53** | | **75.65** | **61.50** | |  | **83.96** | **77.94** | | **68.78** | **57.28** | |  | **88.44** | **81.74** | | **72.21** | **59.39** | |  |
| **Source** | **S** | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | |
| **S.Em. ±** | 2.151 | | 2.151 | | | 4.302 | | 2.420 | | 2.420 | | | 4.839 | | 1.631 | | 1.631 | | | 3.263 | |
| **C.D. (5 %)** | NS | | 6.21 | | | NS | | NS | | 6.99 | | | NS | | NS | | 4.61 | | | NS | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | |
| **Source** | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | 2.307 | | | | | | | 2.307 | | | | | | | 4.614 | | | | | | |
| **C.D. (5 %)** | NS | | | | | | | NS | | | | | | | NS | | | | | | |
| **CV %** | 9.44 | | | | | | | 11.64 | | | | | | | 10.59 | | | | | | |

**Table 4: Effect of spacing, fertilizer and their interaction on available potassium content (kg ha-1) of soil after harvest in okra**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Available potassium content (kg ha-1) of soil** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | **2023** | | | | | | | | **2024** | | | | | | | **Pooled** | | | | | | |
| **F1** | | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** | **F1** | **F2** | | **F3** | **F4** | | **Mean** |
| **S1** | 465.01 | | 429.10 | | 376.15 | 313.77 | | **396.01** | 447.19 | 410.59 | | 366.11 | 296.90 | | **380.20** | 456.10 | 419.84 | | 371.13 | 305.34 | | **388.10** |
| **S2** | 466.67 | | 439.56 | | 391.28 | 333.15 | | **407.67** | 456.55 | 429.32 | | 374.99 | 317.21 | | **394.52** | 461.61 | 434.44 | | 383.14 | 325.18 | | **401.09** |
| **S3** | 465.44 | | 446.12 | | 402.15 | 338.72 | | **413.11** | 461.09 | 430.95 | | 386.70 | 323.24 | | **400.49** | 463.26 | 438.54 | | 394.42 | 330.98 | | **406.80** |
| **S4** | 488.49 | | 447.61 | | 420.26 | 355.41 | | **427.94** | 477.99 | 437.55 | | 398.12 | 341.01 | | **413.67** | 483.24 | 442.58 | | 409.19 | 348.21 | | **420.80** |
| **Mean** | **471.40** | | **440.60** | | **397.46** | **335.27** | |  | **460.71** | **427.11** | | **381.48** | **319.59** | |  | **466.05** | **433.85** | | **389.47** | **327.43** | |  |
| **Source** | **S** | | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | | **S** | | **F** | | | **S × F** | |
| **S.Em.±** | 10.154 | | | 10.154 | | | 20.307 | | 12.168 | | 12.168 | | | 24.336 | | 8.175 | | 8.175 | | | 16.349 | |
| **C.D.**  **(5 %)** | NS | | | 29.32 | | | NS | | NS | | 35.14 | | | NS | | NS | | 23.12 | | | NS | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | | 11.560 | | | | | | | 11.560 | | | | | | | 23.121 | | | | | | |
| **C.D. (5 %)** | | NS | | | | | | | NS | | | | | | | NS | | | | | | |
| **CV %** | | 8.55 | | | | | | | 10.61 | | | | | | | 9.91 | | | | | | |

**Fig. 1: Effect of fertilizer on available nitrogen content of soil (kg ha-1) after harvest in okra**

**Fig. 2: Effect of fertilizer on available phosphorus content of soil (kg ha-1) after harvest in okra**

**Fig. 3: Effect of fertilizer on available potassium content of soil (kg ha-1) after harvest in okra**

4. Conclusion

From the study of two consecutive years, it can be concluded that okra sown at wider spacing (60 cm × 30 cm) and fertilized with higher dose of fertilizer [160 % RDF (where, 100 % RDF = 100:50:50 NPK kg ha-1)] improved the soil nutrient status (available N, P & K).

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

References

1. Ghosh K,Jana J. Growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench] F1 hybrids as influenced by planting time and spacing under Teraiagro-climatic zone of West Bengal. Journal of Crop and Weed. 2022;18(2):94-103.
2. Bishnoi RK, Tinna D, Gandhi N. Effect of different spacing on growth and fruit quality of okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of Pharmacognosy and  Phytochemistry*. 2019;8(1S):209-211.
3. Bake ID, Singh BK, Singh AK,Moharana DP, Maurya AK. Impact of planting distances and sowing dates on yield attributing traits of okra [*Abelmoschus esculentus*(L.) Moench] cv. Kashi Pragati. International Journal of Current Microbiology and Applied Sciences.2017;6(7): 4112-4125.
4. Danmaigoro O,Bilyaminu AS, Abduljalal T, Umar MM. Effects of NPK fertilizer and spacing on the growth parameters of okra [*Abelmoschus esculentus* (L.) Moench]. FUDMA Journal of Sciences. 2022;6(2);200-202.
5. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. India: Indian Council of Agricultural Research; 1985.
6. Desai RG, Patel MD. Report on soil survey Navsari Taluka. Dept. of Agri., Gujarat, Bulletin No. 1970;41(4).
7. Jackson ML. (1973). Soil Chemical Analysis. New Delhi: Prentice Hall of India Pvt. Ltd.
8. Olsen SR, Cole CV, Watanable BS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S. Department of Agriculture Circular. 1967;939:1-19.
9. Wagh SS, Laharia GS, IratkarAG, Gajare AS. Effect of INM on nutrient uptake, yield and quality of okra [Abelmoschus esculents (L.) Moench]. Asian Journal of Soil Science.2014;9(1): 21-24.
10. Patel K, Pankhaniya RM, Parmar SK. Influence of integrated nutrient management on quality, nutrient uptake and soil status in fodder cowpea. Journal of Pharmacognosy and Phytochemistry. 2020;9(4):478-480.
11. Kimi ZS, David AA, Thomas T, Swaroop N, Amreen H. Response of integrated nutrient management on soil health, yield attributes and yield of pea (Pisum sativum L.). [The Pharma Innovation Journal](https://www.thepharmajournal.com/). 2021;10(10):1815-1818.
12. Patel PM. Effect of fertilizer levels and foliar application of nutrients on cowpea [*Vigna unguiculata* (L.) Walp.]. M.Sc. Thesis (Horti.). Navsari Agricultural University, Navsari, Gujarat, India. 2024;34-67 p.