*Original Research Article*

Soil Nutrient Status of Okra as Affected by Spacing and Fertilizer

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ABSTRACT

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| The present experiment was carried out to find out the influence of various levels of spacing and fertilizer on soil nutrient status of 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 trail 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 spacing could not affect available N, P and K content of soil after harvest of okra while, amid various fertilizer levels, higher fertilizer dose of 160 % RDF (F1) significantly enhanced available 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) of soil after okra harvest in 2023, 2024 and in pooled analysis, respectively. |

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

1. INTRODUCTION

Okra also known as lady's finger, *bhendi* or *bhindi* [*Abelmoschus esculentus* (L.) Moench] belongs to 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]. 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[2]andDanmaigoro *et al*., 2022 [3]).

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) [4].

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 *Vertic Ustochrepts* 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) [5]. 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 seasons of 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 nitrogen content | 206.87 | 218.60 | Modified Kjeldahl | Jackson (1973) [6] |
| Available phosphorus content | 51.09 | 68.06 | Spectrophotometry | Olsen *et al*., 1967 [7] |
| Available potassium content | 398.47 | 409.07 | Flame photometry | Jackson (1973) [6] |

**2.1 Collection of soil samples**

The soil samples were collected from 0-30 cm depth 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**

***2.1.1.1******Available 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) =

***2.1.1.2******Available 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

***2.1.1.3******Available 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 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, P and K content of soil after harvest was determined with wider spacing of 60 cm × 30 cm (S4) and lower N, P and K content of soil after harvest was noted with closer spacing *i.e.* 60 cm × 15 cm (S1).

**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.

**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.

The improvement of available nitrogen, phosphorus and potassium content of soil after the harvest of okra crop might be due to the adding of higher amount of fertilizers *i.e.* 160 % RDF (F1) which improved availability of the nutrient from native and applied fertilizer also.Similar results were also reported by Wagh *et al*. (2014) [8] in okra.

**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 | |
| **CV %** | 7.52 | | | | | | | | 11.78 | | | | | | | 9.91 | | | | | | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | | 7.660 | | | | | | | 7.660 | | | | | | | 15.319 | | | | | | |
| **C.D. (5 %)** | | NS | | | | | | | NS | | | | | | | NS | | | | | | |

**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 | |
| **CV %** | 9.44 | | | | | | | 11.64 | | | | | | | 10.59 | | | | | | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | |
| **Source** | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | 2.307 | | | | | | | 2.307 | | | | | | | 4.614 | | | | | | |
| **C.D. (5 %)** | NS | | | | | | | NS | | | | | | | NS | | | | | | |

**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 | |
| **CV %** | 8.55 | | | | | | | | 10.61 | | | | | | | 9.91 | | | | | | |
| **Pooled interaction** | | | | | | | | | | | | | | | | | | | | | | |
| **Source** | | **Y × S** | | | | | | | **Y × F** | | | | | | | **Y × S × F** | | | | | | |
| **S.Em. ±** | | 11.560 | | | | | | | 11.560 | | | | | | | 23.121 | | | | | | |
| **C.D. (5 %)** | | NS | | | | | | | NS | | | | | | | NS | | | | | | |

**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.

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