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Impact of nitrogen rates and plant population on growth and Phenological parameters of okra [*Abelmoschus esculentus* (L). Moench]

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Abstract
Okra is one of the most important crops in Madhya Pradesh States. Okra production and yield maximization has not been attained due to lack of appropriate production practices such as optimum plant spacing and fertilizer use. Therefore, the research was conducted to assess the effect of sources of nitrogen and plant population, on growth and yield components of Okra (*Abelmoschus esculentus* (L). Moench). The treatments were factorial combinations of Six sources of nitrogen (Control, 100% N through urea (150:75:75 NPK/ha), 100% N through vermicompost, 100% N through FYM, 50% N through urea + 50% N through vermicompost and 50% N through urea + 50% N through FYM) four spacings (40 x 30 cm, 50 x 30 cm, 60 × 30 cm and 80 × 30 cm). The experiment was laid out in randomized block design factorial arrangement with three replications. Results indicated that, sources of nitrogen and plant population had significance influence on growth and yield components of okra. Maximum number of branches (2.93), number of leaves (15.95) and pod length (29.01 cm) was obtained from the interaction of sources of nitrogen through 50% N through urea + 50% N through vermicompost and 40 cm × 30 cm spacing. The highest fresh pod yield (46.14 t ha^{-1}) and above ground biomass yield (119.34 t ha^{-1}) was obtained from sources of nitrogen through 50% N through urea + 50% N through vermicompost and 60 cm × 30 cm spacing.

Keywords: Sources of nitrogen, plant population and okra

Introduction
Okra (*Ablemoschus esculentus* L. Moench) commonly known as Lady's finger. It is one of the most well known and utlized species of the family Malvaceae. It is one of the essentially consumable crop of India, immature and tender pods can be consumed as the boiled and fried vegetable or could be utilized as it may be added to salads soups and stews. Nitrogen is one of the most important major nutrients. It encourage the plant foliage and boosts plant growth at every stage, because it is an integral part of the chlorophyll, all proteins, enzymes and structural materials (Tiwari *et al*. 2012) [13]. The optimum spacing between the plants is very important for higher productivity of okra per unit area (Mamta Kumari and Singh, 2006) [7]. The optimum spacing avoids the strong competition between plants for growth factors such as space, solar radiation, moisture and nutrients (Singh, 2018) [11].

Planting patterns play an important role in enhancing overall productivity of crops as it is likely to affect interception, absorption, penetration and utilization of incoming solar radiation. Plant density is another important character, which can be manipulated to attain the maximum production from per unit land area. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro climatic conditions. It is also a fact that specified varieties do not exhibit the same phenotypic characteristics in all the environmental conditions. Improved cultivar is an important tool, which have geared production in many countries of the world. In addition to many other factors, cultivars with higher yield potential and a wide range of adaptability to edaphic and climatic conditions is essential for increasing yield per unit area, ultimately boosting up total production (Kaur and Singh, 2011) [6]. Several new varieties have been developed which needs location specific evaluation with regard to agro-input management in which plant spacing is the most important factor (Sondhiya *et al*., 2019) [12]. Such information is acking under the existing agro-climatic conditions of Kymore plateau.

Maintaining optimum spacing or plant population and nitrogen fertilization dose are most important elements in improving productivity of okra. Optimum plant density is the key element for higher yield of okra, as plant growth, yield and quality are affected by inter and intra-row spacing (Amjad *et al*., 2002; Paththinige *et al*., 2008) [2, 9]. With increasing plant population, yield per unit area increases until a certain limit, beyond which yield decreases due to limitation of environmental resources required for plant growth (Amjad *et al.,* 2002) [2].

Materials and Methods

A field experiment entitled "Impact of nitrogen rates and plant population on growth and yield of okra [*Abelmoschus esculentus* (L). Moench]" The present experiment was conducted during the Rabi season of 2021-2023 at the experimental field, department of horticulture, faculty of agriculture, AKS University, Sherganj, Satna (M.P.).

The treatments were factorial combinations of Six sources of nitrogen (Control, 100% N through urea (150:75:75 NPK/ha), 100% N through vermicompost, 100% N through FYM, 50% N through urea + 50% N through vermicompost and 50% N through urea + 50% N through FYM) four spacings (40 x 30 cm, 50 x 30 cm, 60 × 30 cm and 80 × 30 cm). The experiment was laid out in randomized block design factorial arrangement with three replications

The observations were recorded *viz*., plant height (cm), number of leaves per plant, Number of branches / plants and Days to 50% flowering. The data were statistically analysed according to the method suggested by Fisher (1950) [5].

Results and Discussion

Growth Parameters

Plant height

The data in revealed that the statistical analysis, effect of nitrogen rates, plant population and their interaction was found significant. It is evident from pooled data that the maximum plant height at 90 Days (95.11 cm) was recorded with the treatment N_4S_1 (50% N through urea + 50% N through vermicompost and 60 x 30 cm 55,555 plants) followed by N_4S_2 (50% N through urea + 50% N through vermicompost and 50 x 30 cm 66,666 plants) in both year, while the minimum plant height at 90 Days both year (70.13 cm) was recorded under the treatment N_3S_4 (100% N through vermicompost and 80 x 30 cm 41,666 plants). (Table 1 and Fig 1). The favourable effect of spacing and nitrogen in promoting the growth of plant in terms of height of plant might be due to the fact that, closer plant spacing have higher plant density which creates competition among the population for light and resulted into increased in plant height (Birbal *et al*. 1975, Ambare *et al*. 2005) [4, 1].

Number of leaves per plant

The data in revealed that the statistical analysis, effect of nitrogen rates, plant population and their interaction was found significant. It is evident from pooled data that the maximum Number of leaves per plant at 90 Days (47.68) was recorded with the treatment N_4S_1 (50% N through urea + 50% N through vermicompost and 60 x 30 cm 55,555 plants) followed by N_4S_2 (50% N through urea + 50% N through vermicompost and 50 x 30 cm 66,666 plants) in both year, while the minimum Number of leaves per plant at 90 Days in both year (24.77) was recorded under the treatment N_3S_4 (100% N through vermicompost and 80 x 30 cm 41,666 plants). (Table 1 and Fig 2). Amongst the nutrients, nitrogen has the property to enhance the vegetative growth and capacity of plants to utilize the greater amount of nitrogen with increasing dose. This might be due to the higher utilization of nitrogen but in the closer spacing there is no scope for horizontal spread so it might have resulted in the increase in Number of leaves (Ashish *et al*. 2006, Pal *et al*. 2016) [3, 8].

Number of internodes per plant

The data in revealed that the statistical analysis, effect of nitrogen rates, plant population and their interaction was found significant. It is evident from pooled data that the maximum Number of internodes per plant at 90 Days (23.73) was recorded with the treatment N_4S_1 (50% N through urea + 50% N through vermicompost and 60 x 30 cm 55,555 plants) followed by N_4S_2 (50% N through urea + 50% N through vermicompost and 50 x 30 cm 66,666 plants) in both year, while the minimum Number of internodes per plant at 90 Days in both year (13.47) was recorded under the treatment N_3S_4 (100% N through vermicompost and 80 x 30 cm 41,666 plants). (Table 2 and Fig 3) [6].

Number of branches per plant

The data in revealed that the statistical analysis, effect of nitrogen rates, plant population and their interaction was found significant. It is evident from pooled data that the maximum Number of branches per plant at 90 Days (12.98) was recorded with the treatment N_4S_1 (50% N through urea + 50% N through vermicompost and 60 x 30 cm 55,555 plants) followed by N_4S_2 (50% N through urea + 50% N through vermicompost and 50 x 30 cm 66,666 plants) in both year, while the minimum Number of branches per plant at 90 Days in both year (6.07) was recorded under the treatment N_3S_4 (100% N through vermicompost and 80 x 30 cm 41,666 plants). (Table 2 and Fig 3) [3].

Days to 50% flowering

The data in revealed that the statistical analysis, effect of nitrogen rates, plant population and their interaction was found significant. It is evident from pooled data that the minimum Days to 50% flowering in both year (42.90) was recorded with the treatment N_4S_1 (50% N through urea + 50% N through vermicompost and 60 x 30 cm 55,555 plants) followed by N_4S_2 (50% N through urea + 50% N through vermicompost and 50 x 30 cm 66,666 plants) in both year, while the maximum Days to 50% flowering in both year (49.19) was recorded under the treatment N_3S_4 (100% N through vermicompost and 80 x 30 cm 41,666 plants). (Table 3 and Fig 4). Similar results were computed (Salvi *et al*. 2010) [10]

Table 1: Impact of nitrogen rates, plant population and their interaction on Plant height and Number of leaves per plant of okra

	Plant height at 90 Days			Number of leaves per plant at 90 Days		
Treatment	**2021-2022**	**2022-2023**	**Pooled**	**2021-2022**	**2022-2023**	**Pooled**
N_0S_1	75.46	72.15	73.81	33.84	31.63	32.74
N_0S_2	75.30	72.01	73.66	32.81	30.67	31.74
N_0S_3	74.79	71.52	73.16	28.69	26.81	27.75
N_0S_4	73.77	70.54	72.16	27.66	25.85	26.76
N_1S_1	92.13	88.10	90.12	45.17	42.22	43.70
N_1S_2	89.07	85.18	87.13	44.82	41.89	43.36
N_1S_3	87.54	83.71	85.63	44.14	41.26	42.70
N_1S_4	87.03	83.23	85.13	43.11	40.29	41.70
N_2S_1	79.89	76.40	78.15	39.91	37.30	38.61
N_2S_2	77.85	74.45	76.15	39.33	36.76	38.05
N_2S_3	76.83	73.47	75.15	37.96	35.48	36.72
N_2S_4	76.26	72.92	74.59	36.93	34.52	35.73
N_3S_1	75.81	72.49	74.15	35.90	33.55	34.73
N_3S_2	75.12	71.85	73.49	31.78	29.70	30.74
N_3S_3	72.75	69.57	71.16	26.63	24.89	25.76
N_3S_4	71.73	68.59	70.13	25.60	23.93	24.77
N_4S_1	97.23	92.98	95.11	49.29	46.07	47.68
N_4S_2	95.19	91.03	93.10	48.60	45.43	47.02
N_4S_3	94.68	90.54	92.61	47.23	44.15	45.69
N_4S_4	93.49	89.40	91.45	46.20	43.18	44.69
N_5S_1	86.35	82.57	84.46	42.08	39.33	40.71
N_5S_2	85.19	81.47	83.33	41.05	38.37	39.71
N_5S_3	82.95	79.32	81.14	40.70	38.04	39.37
N_5S_4	81.93	78.35	80.14	40.02	37.41	38.72
S.E.(m) ±	0.23	0.26	0.25	0.07	0.04	0.05
C.D. (5%)	0.71	0.76	0.74	0.20	0.10	0.15

Table 2: Impact of nitrogen rates, plant population and their interaction on Number of internodes per plant and Number of branches per plant of okra

	Number of internodes per plant			Number of branches per plant		
Treatment	**2021-2022**	**2022-2023**	**Pooled**	**2021-2022**	**2022-2023**	**Pooled**
N_0S_1	17.86	15.53	16.70	9.37	8.15	8.76
N_0S_2	17.52	15.23	16.38	9.11	7.92	8.52
N_0S_3	16.48	14.33	15.41	7.97	6.93	7.45
N_0S_4	15.45	13.43	14.44	7.44	6.47	6.96
N_1S_1	22.35	19.43	20.89	12.84	11.16	12.00
N_1S_2	22.01	19.14	20.58	12.49	10.86	11.68
N_1S_3	21.67	18.84	20.26	12.26	10.66	11.46
N_1S_4	21.31	18.53	19.92	12.14	10.56	11.35
N_2S_1	19.35	16.83	18.09	10.88	9.46	10.17
N_2S_2	19.24	16.73	17.99	11.20	9.74	10.47
N_2S_3	18.90	16.43	17.67	10.93	9.51	10.22
N_2S_4	18.56	16.14	17.35	10.76	9.35	10.06
N_3S_1	18.20	15.83	17.02	10.41	9.05	9.73
N_3S_2	17.17	14.93	16.05	8.33	7.25	7.79
N_3S_3	14.90	12.95	13.93	7.18	6.24	6.71
N_3S_4	14.41	12.53	13.47	6.49	5.64	6.07
N_4S_1	25.38	22.07	23.73	13.88	12.07	12.98
N_4S_2	24.78	21.55	23.17	13.53	11.77	12.65
N_4S_3	23.74	20.64	22.19	13.41	11.66	12.54
N_4S_4	22.70	19.74	21.22	13.18	11.46	12.32
N_5S_1	20.63	17.94	19.29	11.80	10.26	11.03
N_5S_2	20.28	17.63	18.96	11.55	10.05	10.80
N_5S_3	19.93	17.33	18.63	11.45	9.96	10.71
N_5S_4	19.59	17.04	18.32	11.33	9.85	10.59
S.E.(m) ±	0.23	0.20	0.22	0.27	0.24	0.26
C.D. (5%)	0.67	0.58	0.63	0.78	0.68	0.73

Table 3 Impact of nitrogen rates, plant population and their interaction on Days to 50% flowering of okra

	Days to 50% flowering		
Treatment	**2021-2022**	**2022-2023**	**Pooled**
N_0S_1	47.97	47.26	47.61
N_0S_2	48.23	47.52	47.88
N_0S_3	48.76	48.06	48.41
N_0S_4	48.92	48.22	48.57
N_1S_1	44.37	43.64	44.01
N_1S_2	44.71	43.98	44.34
N_1S_3	44.93	44.19	44.56
N_1S_4	45.29	44.56	44.93
N_2S_1	46.94	46.22	46.58
N_2S_2	47.14	46.42	46.78
N_2S_3	47.28	46.57	46.93
N_2S_4	47.65	46.94	47.29
N_3S_1	47.82	47.11	47.47
N_3S_2	48.38	47.68	48.03
N_3S_3	49.18	48.48	48.83
N_3S_4	49.54	48.84	49.19
N_4S_1	43.27	42.53	42.90
N_4S_2	43.61	42.87	43.24
N_4S_3	43.76	43.02	43.39
N_4S_4	43.96	43.22	43.59
N_5S_1	45.69	44.96	45.33
N_5S_2	45.98	45.25	45.61
N_5S_3	46.48	45.76	46.12
N_5S_4	46.82	46.11	46.46
S.E.(m) ±	0.021	0.016	0.02
C.D. (5%)	0.06	0.04	0.05

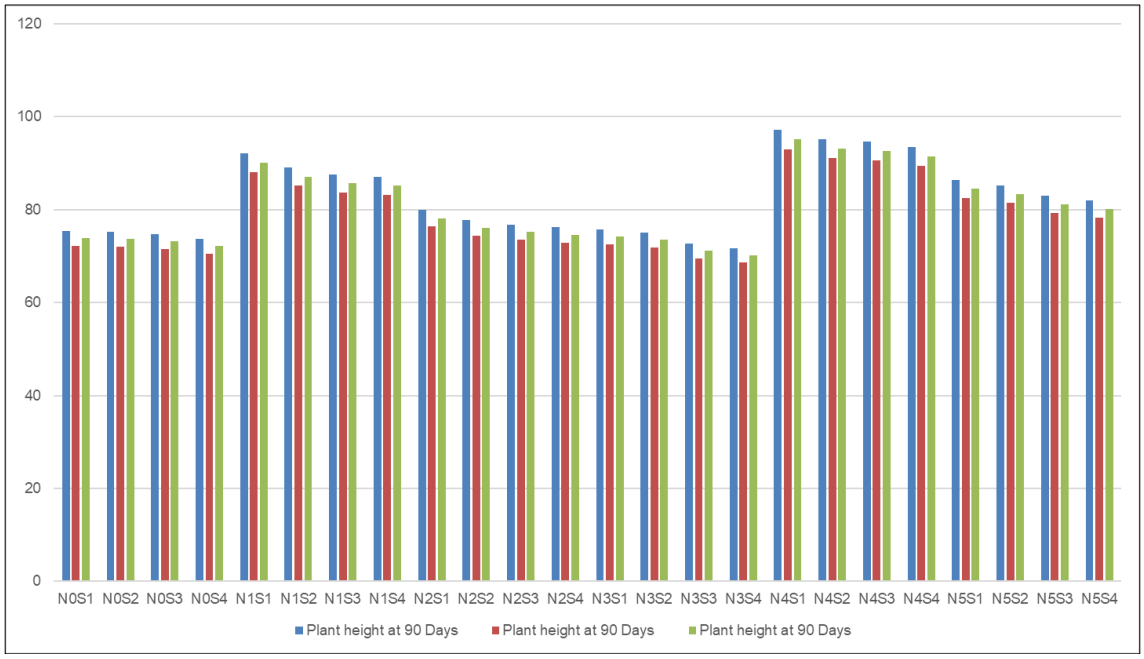

Fig. 1: Impact of nitrogen rates, plant population and their interaction on Plant height per plant of okra

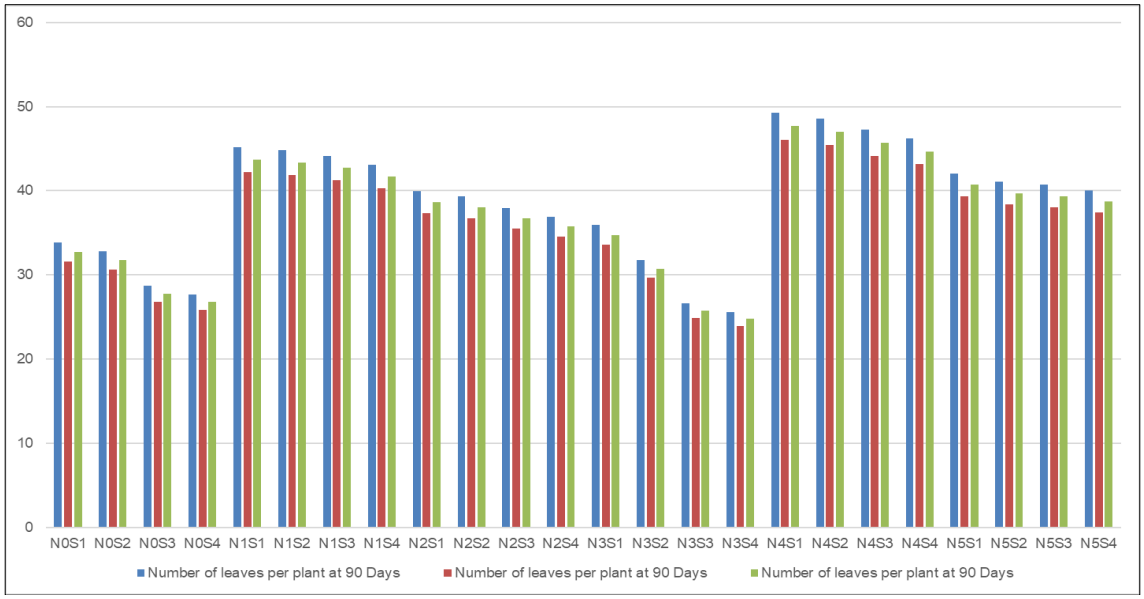

Fig. 2: Impact of nitrogen rates, plant population and their interaction on Number of leaves per plant of okra

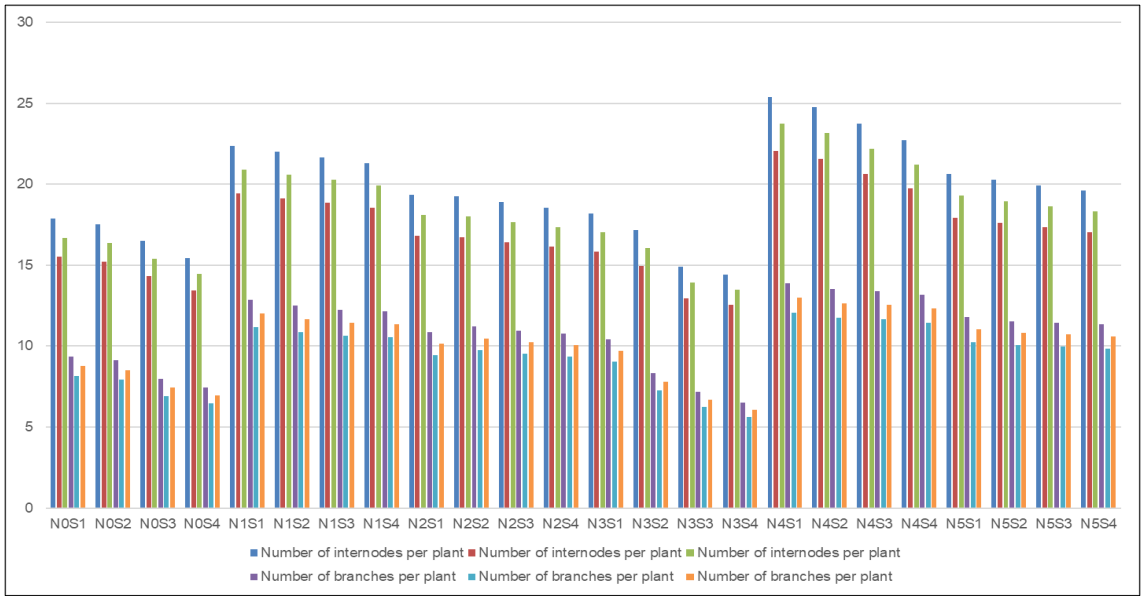

Fig. 3: Impact of nitrogen rates, plant population and their interaction on Number of internodes per plant and Number of branches per plant of okra

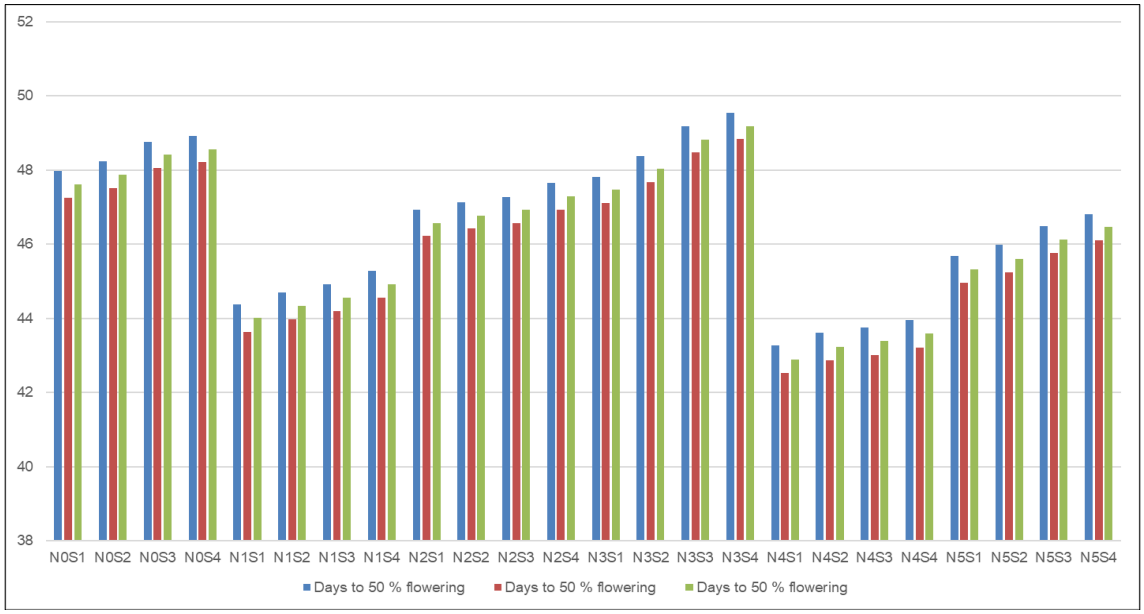

Fig. 4: Impact of nitrogen rates, plant population and their interaction on Days to 50% flowering of okra

Conclusion

In conclusion, the study demonstrated significant effects of nitrogen rates and plant population on various growth parameters of okra. Analysis revealed notable variations in plant height, number of leaves, internodes, branches, and days to 50% flowering across different treatments. Maximum values for plant height, number of leaves, internodes, and branches were observed with specific combinations of nitrogen rates and plant population, suggesting the importance of optimal nutrient management and spacing for promoting vegetative growth and development in okra plants. These findings contribute valuable insights for agricultural practices aimed at enhancing okra yield and quality. Further research could explore additional factors influencing okra growth for comprehensive agricultural recommendations.

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