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EFFECT OF DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS ON GROWTH, YIELD AND FRUIT QUALITY OF SPONGE GOURD (*LUFFA CYLINDRICA. L*)

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ABSTRACT

The present study pertains to the effect of different levels of nitrogen and phosphorus on growth, yield and fruit quality of sponge gourd (*Luffa cylindrica. L*) was undertaken at the Instructional Farm, Department of Vegetable Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during the *summer* season of the year 2022-23, with a view to find out the optimum dose of chemical fertilizers for sponge gourd under Akola conditions. For the experiment Factorial Randomized Block Design (FRBD) was used with two factors. Factor 'A' constitutes three levels of nitrogen (0, 100, 150 kg N per hectare) and factor 'B' constitutes three levels of phosphorus (0, 50 and 75 kg P₂O₅ per hectare) with nine treatment combinations replicated thrice. In the treatment combination (T₉) i.e 150 kg nitrogen ha⁻¹ (N₂) and 75 kg phosphorus ha⁻¹ (P₂) recorded maximum values of growth, yield and fruit quality parameter viz., vine length, number of branches per plant, average leaf area, days to 1st female flower appearance, node at which 1st female flower appeared, number of fruits per vine, yield per vine, yield per plot, yield per ha, length of fruit, diameter of fruit, weight of fruit and number of fruits per vine. The plant nutrient status in respect of nitrogen and phosphorus was increased with application of respective element but not in proportion. As regards to the B:C ratio, it was found the maximum (3.12) from the application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus ha⁻¹. From the study, it was observed that the sponge gourd Cv. Phule Komal showed a better response to increasing concentration of nitrogen and phosphorus fertilizers under existing soil and climatic conditions of Akola.

Key words: Sponge Gourd, Nitrogen, Phosphorus, Growth, Yield, Fruit Quality.

Introduction

Sponge gourd (*Luffa cylindrica L.*) is also known as luffa, bath sponge, vegetable sponge belonging to Cucurbitaceae family it has originated from America but the main commercial production countries China, Korea, India, Japan, Central America. In India the crop widely grown in Uttar Pradesh, Bihar, West Bengal, Orissa, Assam, Andhra Pradesh and Kerala. India is the world's second-largest producer of vegetables and melons behind China. Sponge gourd cultivation area in India is 7.21 lakh ha with production of 12.87 lakh tonnes. The productivity of this crop is 10.52 tonnes per hectare (Anon., 2022). The fruit contains proteins (0.5%), carbohydrates (3%), vitamin C and (18 mg per 100 g) edible portion (Zohura *et al.*, 2013). Samples of *L. cylindrica* were analyzed

for proximate composition and mineral contents (Mg, Ca, K, Fe, Cu, Zn and Mn), Tannin, oxalate, phytin, phosphorus and phytic acid. It play important role in medicine to cure fever, enteritis and swell. Sponge gourd is one of the important cucurbitaceous crop being grown on large scale area and has got commercial importance in vegetable production still there is no recommended dose of chemical fertilizers. In view of this to obtain optimum dose of chemical fertilizers the said experiment on effect of different levels of nitrogen and phosphorus on growth, yield and fruit quality of sponge gourd (*Luffa cylindrica. L*) was undertaken. Macro nutrients such as Nitrogen, Phosphorus and Potassium play a significant role in plant growth and development. Nitrogen support the vegetative parts of the plant and phosphorus have

significant role in the development of the root and also producing the energy by forming ATP and potassium encourage metabolism, enzyme establishment and osmotic regulation (Saheen *et al.*, 2007).

Material and Methods

The present investigation was conducted at field of Instructional Farm, Department of Vegetable Science, Dr. PDKV Akola, during the summer season of the year 2022-2023. The seed material used for Sponge Gourd Cv. Phule Komal was used for said experiment and was sown at spacing of 1.50×1.00 m with vertical training system. The statistical design adopted for the experiment was factorial randomized block design (FRBD) with nine treatment combinations and replicated three times. The first factor was levels of Nitrogen (N_0) - Control, (N_1) - 100 kg per ha, (N_2) - 150 kg per ha and second factor was levels of Phosphorus (P_0) - Control, (P_1) - 50 kg per ha, (P_2) - 75 Kg per ha. There were nine treatment combination *viz.*, T_1 - N_0P_0 (Absolute control), T_2 - N_0P_1 (No application N + Application of 50 kg P_2O_5), T_3 - N_0P_2 (No application of N + Application of 75 kg P_2O_5), T_4 - N_1P_0 (Application 100 kg N/ha + No application P_2O_5), T_5 - N_1P_1 (Application of 100 kg N/ha + 50 kg P_2O_5 /ha), T_6 - N_1P_2 (Application of 100 kg N/ha + 75 kg P_2O_5 /ha), T_7 - N_2P_0 (Application of 150 kg N/ha + No application P_2O_5), T_8 - N_2P_1 (Application of 150 kg N/ha + 50 kg P_2O_5 /ha), T_9 - N_2P_2 (Application of 150 kg N/ha + 75 kg P_2O_5 /ha) and doses of potassium are kept common for all treatments *i.e.* 50 kg per ha. A balanced dose of nitrogen was supplied in the form of urea in three split doses, half at the time of planting, remaining half dose of nitrogen was applied in two equal splits at 30 DAS and 60 DAS. At the time of planting, phosphorus and potassium were applied in the form of single superphosphate (SSP) and muriate of potash (MOP) respectively. The fertilizers were placed in rings at the planting site and well mixed in the soil with the assistance of a khurpi. Observations were recorded for growth, yield and fruit quality parameter by selecting five plants at random from each treatment plot. The following observations were recorded,

Growth parameter:

Length of vine (m) - In each observational plot length of vine was measured from base to the top portion of the vine at 30, 60 & 90 DAS.

Number of branches - On each vine were mean number of branches per vine counted at 30, 60 & 90 DAS.

Average leaf area (cm^2) - It was measured at 30, 60 & 90 DAS with the help of automatic leaf area meter.

Days to appearance of 1st male and female flower – It were noted each observational vine and mean period in days was calculated.

Node at which 1st male and female flower appeared – It were counted for each observational vine and mean number was calculated.

Fruit parameters:

Length of fruit (cm) - At the first and last pickings, the length of five fruits observed on the vine were measured in centimeter from stalk end to styler end.

Diameter of fruit (cm) and weight of fruits (g) - The five fruits from observational vines at first and last pickings was recorded.

Yield parameter:

Number of fruits per vine is calculated at each picking and harvesting, yield of fruits per vine recorded in kg, fruits are gathered from all vines from the net plot at each picking collected together for weighing in kg and total yield per ha in kg has been converted on arithmetically on ha basis and recorded accordingly on quintal per ha.

The parameters included were length of vine (m), number of branches, average leaf area (cm^2), days to first male and female flower appearance, node at which first male and female flower appeared, sex ratio, length of fruit (cm), diameter of fruit (cm), weight of fruit (g), number of fruit per vine, yield of fruit per vine (kg), total yield per plot (kg), total yield per ha (q). The soil nutrients status and BC ratio were recorded.

Results and Discussion

Effect of different levels of nitrogen and phosphorus on growth parameter of sponge gourd

- **Length of vine (m)**-The data presented in Table 1 indicated that, the interaction effects of nitrogen and phosphorus on vine length were found significant at 90 DAS. The maximum vine length (4.69m) was obtained in treatment combination N_2P_2 (150 kg nitrogen ha^{-1} and 75 kg phosphorus ha^{-1}). However, the minimum vine length (3.44 m) was recorded in treatment combination N_0P_0 . The portable reason responsible for better vine length may be due to supply of nutrients in balanced amount and available form. Application of nitrogen in addition to other nutrients like phosphorus in adequate quantity stimulates the heavy vegetative growth. These findings are in close conformity with the findings of Jilani *et al.*, (2009) in cucumber, Niharika *et al.*, (2023) in sponge gourd.

- **Number of branches per vine**-The data presented in Table 1 noticed that, the interaction effects

Table 1: Effect of different levels of nitrogen and phosphorus on length of vine (m), number of branches per vine, average leaf area (cm²), days to appearance of 1st female flower, node at which 1st female flower appeared of sponge gourd.

Treatments	Length of vine (m)	Number of branches per vine	Average leaf area (cm ²)	Days to Appearance of 1 st female flower	Node at which 1 st female flower appeared
Nitrogen levels					
N ₀ (0 kg ha ⁻¹)	3.52	6.55	106.43	46.68	11.16
N ₁ (100 kg ha ⁻¹)	3.61	6.81	129.63	45.57	9.88
N ₂ (150 kg ha ⁻¹)	4.56	7.71	130.80	45.12	8.16
'F' test	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.01	0.03	0.58	0.12	0.04
CD. at 5%	0.05	0.09	1.74	0.34	0.12
Phosphorus levels					
P ₀ (0 kg ha ⁻¹)	3.81	6.77	119.43	45.22	10.14
P ₁ (50 kg ha ⁻¹)	3.85	7.03	122.38	44.58	9.67
P ₂ (75 kg ha ⁻¹)	4.02	7.28	125.05	43.26	9.42
'F' test	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.01	0.03	0.58	0.12	0.04
CD. at 5%	0.05	0.09	1.74	0.34	0.12
Interaction (AXB)					
N ₀ P ₀	3.44	6.52	102.88	40.27	11.70
N ₀ P ₁	3.49	5.56	104.52	40.23	11.08
N ₀ P ₂	3.52	6.59	111.90	39.92	10.72
N ₁ P ₀	3.56	6.63	127.89	38.45	10.28
N ₁ P ₁	3.64	6.79	130.56	37.12	9.79
N ₁ P ₂	3.84	7.03	130.46	36.09	9.59
N ₂ P ₀	4.46	7.14	127.53	36.99	8.45
N ₂ P ₁	4.53	7.80	132.07	36.48	8.17
N ₂ P ₂	4.69	8.23	132.80	35.84	7.98
'F' test	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.02	0.05	1.00	0.23	0.06
CD. at 5%	0.08	0.15	2.98	0.68	0.18

of different levels of nitrogen and phosphorus on number of branches per vine were found significant at 90 DAS. The maximum number of branches per vine (8.23) were recorded in treatment combination N₂P₂ *i.e.* application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus ha⁻¹. The minimum number of branches per vine (6.52) were recorded in treatment combination N₀P₀. Application of nitrogen along with phosphorus have a beneficial effects on growth parameters like number of branches per vine in sponge gourd crop. These results are in agreement with the findings of Prasanna *et al.*, (2004) in ridge gourd, Jilani *et al.*, (2009) in cucumber.

• **Average leaf area (cm²)** -The data presented in Table 1 revealed that, the interaction effect due to different levels of nitrogen and phosphorus were found statistically significant at 90 DAS. However, average leaf area was found to be decreased as compared to 30 and 60 DAS. Significantly the maximum leaf area (132.80 cm²) with application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus ha⁻¹ in treatment combination (N₂P₂).

However, the N₀P₀ recorded minimum leaf area (102.88 cm²). This might be due to the long duration of sponge gourd crop *i.e.* upto 120 days from sowing leads to increase its vegetative growth upto 60 to 80 days, thereafter the energy might be diverted to fruit setting and development of quality fruits. These findings are in line with the results of Prasanna *et al.*, (2004) in ridge gourd, Jilani *et al.*, (2009) in cucumber.

• **Days to appearance of 1st male and female flower**- The data presented in Table 1 indicated that, the interaction effects of nitrogen and phosphorus on days required for appearance of 1st male flower were found non significant but the appearance of 1st female flower were found statistically significant. The minimum days required for appearance of 1st female flower (35.84) were obtained in treatment combination with the application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus ha⁻¹. However, the maximum days required for appearance of 1st female flower (40.27) was obtained in control treatment N₀P₀. The optimum dose of nitrogen might be the right solution

Table 2: Effect of different levels of nitrogen and phosphorus on yield per vine (kg), yield per plot (kg), yield per ha (q), length of fruit (cm), average fruit weight (g), number of fruits per vine of sponge gourd.

Treatments	Yield per vine (kg)	Yield per plot (kg)	Yield per ha (q)	Length of fruit (cm)	Average fruit weight (g)	Number of fruits per vine
Nitrogen levels						
N ₀ (0 kg ha ⁻¹)	2.16	31.13	145.68	19.62	111.42	10.63
N ₁ (100 kg ha ⁻¹)	3.35	38.03	164.01	20.94	120.90	11.09
N ₂ (150 kg ha ⁻¹)	4.28	47.07	176.91	22.49	122.35	13.06
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.07	0.44	0.96	0.16	0.60	0.12
CD. at 5%	0.24	1.32	2.86	0.46	1.79	0.36
Phosphorus levels						
P ₀ (0 kg ha ⁻¹)	2.85	35.73	159.42	20.16	116.30	11.03
P ₁ (50 kg ha ⁻¹)	3.30	39.40	162.49	21.26	117.97	11.37
P ₂ (75 kg ha ⁻¹)	3.64	41.09	164.68	21.63	120.40	12.38
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.07	0.44	0.96	0.16	0.60	0.12
CD. at 5%	0.24	1.32	2.86	0.46	1.79	0.36
Interaction (AXB)						
N ₀ P ₀	1.89	30.94	140.68	18.73	108.01	9.90
N ₀ P ₁	1.93	31.09	147.66	19.73	110.50	10.86
N ₀ P ₂	2.67	31.35	148.68	20.20	115.75	11.15
N ₁ P ₀	2.83	34.23	158.54	19.78	120.14	10.92
N ₁ P ₁	3.54	38.96	167.64	20.98	120.66	11.18
N ₁ P ₂	3.70	40.88	165.86	22.15	121.92	11.19
N ₂ P ₀	3.82	42.02	172.07	21.99	120.76	12.09
N ₂ P ₁	4.48	48.16	179.14	22.54	122.76	12.29
N ₂ P ₂	4.57	51.03	179.52	22.94	123.54	14.83
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.13	0.76	1.65	0.27	1.03	0.20
CD. at 5%	0.40	2.28	4.50	0.79	3.09	0.62

to earliness in female flowering. The availability of phosphorus takes place at very slow after application, hence it might showed non-significant effect on days to appearance of 1st male flower. This is in conformity with the results found by Anjanappa *et al.* (2012) in cucumber, Ashraf *et al.*, (2019) in bitter gourd, Niharika *et al.*, (2023) in sponge gourd.

• **Node at which 1st female flower appeared-** The data presented in Table 1 noticed that the interaction effect of different levels of nitrogen and phosphorus on node at which 1st female flower appeared was found statistically significant. Application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus per ha in treatment combination (N₂P₂) recorded earlier node at which 1st female flower node (7.98). However, late appearance of flower on later node (11.70) at which 1st female flower appeared was recorded in N₀P₀. The variation in number node at which first female flowers appeared at the lowest nodes with the least amount of nitrogen and phosphorus than at the highest nodes with the optimum levels of them. Similar

results have also been reported by Jilani *et al.*, (2009) in cucumber, Niharika *et al.*, (2023) in sponge gourd.

Effect of different levels of nitrogen and phosphorus on yield parameter of sponge gourd

The data presented in Table 2 observed that, the interaction effect between different levels of nitrogen and phosphorus were found statistically significant in fruit yield per vine (kg), yield per plot (kg) and yield per ha (q). The maximum fruit yield per vine (4.57 kg), yield per plot (51.03 kg) and yield per ha (179.52 q) were recorded in treatment combination N₂P₂ with application of 150 kg nitrogen ha⁻¹ and 75 kg phosphorus ha⁻¹. The minimum yield per vine (1.89 kg), yield per plot (30.94 kg) and yield per ha (140.68 q) was recorded in control treatment combination (N₀P₀). This variation might be due to the appearance of maximum fruit set percentage, fruit length, number of fruits per vine and average fruit weight in the present study as well as genetic makeup, environmental factors and vigour of the crop which were directly associated with nitrogen and phosphorus application.

Table 3: Effect of different levels of nitrogen and phosphorus on available nitrogen, phosphorus, potassium and total uptake of nitrogen, phosphorus and potassium by sponge gourd vine kg ha⁻¹.

Treatments	Available nitrogen (kg ha ⁻¹)	Available phosphorus (kg ha ⁻¹)	Available potassium (kg ha ⁻¹)	Total nitrogen uptake (kg ha ⁻¹)	Total phosphorus uptake (kg ha ⁻¹)	Total potassium uptake (kg ha ⁻¹)
Nitrogen levels						
N ₀ (0 kg ha ⁻¹)	2.16	31.13	145.68	19.62	111.42	10.63
N ₁ (100 kg ha ⁻¹)	3.35	38.03	164.01	20.94	120.90	11.09
N ₂ (150 kg ha ⁻¹)	4.28	47.07	176.91	22.49	122.35	13.06
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.07	0.44	0.96	0.16	0.60	0.12
CD. at 5%	0.24	1.32	2.86	0.46	1.79	0.36
Phosphorus levels						
P ₀ (0 kg ha ⁻¹)	2.85	35.73	159.42	20.16	116.30	11.03
P ₁ (50 kg ha ⁻¹)	3.30	39.40	162.49	21.26	117.97	11.37
P ₂ (75 kg ha ⁻¹)	3.64	41.09	164.68	21.63	120.40	12.38
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.07	0.44	0.96	0.16	0.60	0.12
CD. at 5%	0.24	1.32	2.86	0.46	1.79	0.36
Interaction (AXB)						
N ₀ P ₀	1.89	30.94	140.68	18.73	108.01	9.90
N ₀ P ₁	1.93	31.09	147.66	19.73	110.50	10.86
N ₀ P ₂	2.67	31.35	148.68	20.20	115.75	11.15
N ₁ P ₀	2.83	34.23	158.54	19.78	120.14	10.92
N ₁ P ₁	3.54	38.96	167.64	20.98	120.66	11.18
N ₁ P ₂	3.70	40.88	165.86	22.15	121.92	11.19
N ₂ P ₀	3.82	42.02	172.07	21.99	120.76	12.09
N ₂ P ₁	4.48	48.16	179.14	22.54	122.76	12.29
N ₂ P ₂	4.57	51.03	179.52	22.94	123.54	14.83
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.13	0.76	1.65	0.27	1.03	0.20
CD. at 5%	0.40	2.28	4.50	0.79	3.09	0.62

Increased fertilizer treatments produced highest fruit yield per vine, yield per plot and yield per ha, which was due to the production of highest fruit length, highest fruit weight and highest number of fruits per vine. These results are in line with the findings of Narayanamma *et al.*, (2010) in cucumber, Niharika *et al.*, (2023) in sponge gourd.

Effect of different levels of nitrogen and phosphorus on fruit quality parameter of sponge gourd

• **Fruit length (cm)**- The data presented in Table 2 revealed that, the interaction effects of different levels of nitrogen and phosphorus on fruit length was found statistically significant. Maximum fruit length was (22.94 cm) in treatment combination N₂P₂ *i.e.* application of 150 kg nitrogen ha⁻¹ along with 75 kg phosphorus ha⁻¹. However, minimum fruit length (18.73 cm) was recorded in control treatment. This might be due to the fact that, the variation in fruit length at different fertilizer levels under study could be attributed to the hybrid vigour and environmental factors. The results of present investigation

are in agreement with the finding of Jilani *et al.*, (2009) in cucumber, Niharika *et al.*, (2023) in sponge gourd.

• **Average fruit weight (g)** -The data presented in Table 2 observed that, the interaction effects of different levels of nitrogen and phosphorus were found statistically significant. Significantly maximum fruit weight (123.54 g) was found in treatment combination N₂P₂ with application of 150 kg nitrogen ha⁻¹ along with 75 kg phosphorus ha⁻¹ followed by N₂P₁ While, minimum fruit weight (108.01 g) were recorded in control treatment. The results of present investigation are in agreement with the finding of Jilani *et al.*, (2009) in cucumber.

• **Number of fruit per vine** - The data presented in Table 2 noticed that, the interaction effect of different levels of nitrogen and phosphorus were found statistically significant. Significantly the maximum number of fruits per vine (14.83) were obtained in treatment combination N₂P₂ with application of 150 kg nitrogen ha⁻¹ along with 75 kg phosphorus ha⁻¹. However, minimum number of

fruits per vine (9.90) were recorded in treatment combination (N_0P_0) with increasing the levels of nitrogen and phosphorus the fruit weight also started increasing gradually. It might be due to increase in nitrogen dose to sponge gourd vine all the vegetative characters respond positively. Similar trends were reported by Ahmed *et al.*, (2007) in cucumber, Niharika *et al.*, (2023) in sponge gourd.

Effect of different levels of nitrogen and phosphorus on status of available nitrogen, phosphorus and potassium in soil

The data presented in Table 3 indicated that, the interaction effect of nitrogen and phosphorus on available soil nutrient status shows significant effect. Significantly the maximum available nitrogen (231.42 kg ha⁻¹) phosphorus (18.37 kg ha⁻¹) and potassium (264.73 kg ha⁻¹) were found with application of 150 kg and 75 kg phosphorus ha⁻¹ in treatment combinations N_2P_2 . While, minimum available nitrogen (182.56 kg ha⁻¹), phosphorus (14.75 kg ha⁻¹) and potassium (255.51 kg ha⁻¹) was found in control treatment (N_0P_0). This might be due to fact that, increased dose of nitrogen and phosphorus enhanced availability of these nutrients ultimately resulted higher nutrient uptake. These results are in conformity with the findings of Meenakshi *et al.*, (2008) in bitter gourd.

Effect of different levels of nitrogen and phosphorus on uptake of nitrogen, phosphorus and potassium by sponge gourd vine (kg ha⁻¹)

The data presented in Table 3 indicated that, the interaction effects of nitrogen and phosphorus on uptake of nutrients was found significant. The maximum uptake (152.24 kg ha⁻¹, 16.94 kg ha⁻¹ and 192.53 kg ha⁻¹ of nitrogen, phosphorus and potassium, respectively) was recorded with application of 150 kg nitrogen and 75 kg phosphorus ha⁻¹ (N_2P_2) was applied. It was followed by in treatment combination N_2P_1 . However, minimum (99.28, 14.03 and 166.35 kg ha⁻¹ nitrogen, phosphorus and potassium were noticed in control treatment (N_0P_0). In respect to nutrient uptake by sponge gourd vines, uptake of nitrogen was noticed significantly superior. This could be due to production of higher dry matter production and higher sponge gourd fruit yield by these vines which might be due to soil application of inorganic fertilizers showed highest nutrient content and uptake of nutrient. These results are in conformity with findings of Suojala *et al.*, (2005) in cucumber, Meenakshi *et al.*, (2008) in bitter gourd.

Effect of different levels of nitrogen and phosphorus on gross monetary returns, net monetary returns and benefit cost ratio

The benefit cost ratio was maximum (3.12) recorded with application of 150 kg nitrogen ha⁻¹ (N_2) and 75 kg phosphorus ha⁻¹ (P_2) whereas, the minimum benefit cost ratio (1.96) was recorded in control treatment. The maximum gross and net monetary return (Rs. 170183, Rs. 115872, respectively) were recorded with application of 150 kg nitrogen and 75 kg phosphorus ha⁻¹ in treatment combination (N_2P_2). However, the treatment in which there is no application of nitrogen and phosphorus *i.e.* control treatment (N_0P_0) recorded minimum values of NMR and GMR (Rs. 98476, and Rs. 48076.33, respectively). These results are in conformity with findings of Janapriya *et al.*, (2010) in cucumber, Meena *et al.*, (2017) in bottle gourd.

Conclusion

Based on the findings of the present investigation, it can be concluded that the different levels of nitrogen and phosphorus has significant influence on growth, yield and fruit quality of sponge gourd. Among the various treatment combination, the application of 150 kg nitrogen per ha and 75 kg phosphorus per ha shows the notable advantages, resulting in enhanced growth, increased vine length, yield and improved fruit quality.

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