RESEARCH ARTICLE Legume Research- An International Journal, Volume 47 Issue 8: 1306-1312 (August 2024)

Influence of Phosphorous and Foliar Nitrogen on the Growth, Quality and Yield of Kasuri Methi (*Trigonella corniculata* L.)

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10.18805/LR-4712

ABSTRACT

Background: Nitrogen and phosphorus are amongst fundamental macronutrients, which are crucial for the growth and development of plant. Soils of dry land of central Rajasthan are deficit in nitrogen and phosphorus content which leads to lower productivity of kasuri methi. Therefore, adequate supply of nitrogen (foliar spray) and phosphorus could enhance productivity of kasuri methi.

Methods: The experiment consisted of sixteen treatment combinations including four levels of phosphorus (control, 20, 40 and 60 kg/ha) and four levels of foliar application of nitrogen (control, 1.0, 1.5 and 2.0%). They were under taken in FRBD with three replications.

Result: Growth parameters and yield of fresh and dried leaves of the crop increased almost linearly with increasing levels of phosphorus and foliar application of nitrogen. The result indicated that application of phosphorus 60 kg/ha and foliar nitrogen @ 2.0% to the kasuri methi crop significantly increased the plant height (cm) and leaf area per plant (cm^2) at each harvest, number of nodules per plant (58.17 and 53.33, respectively) and chlorophyll content (2.32 and 2.39 mg/100 g, respectively), fresh leaves yield (139.1 and 141.66 q/ha, respectively), dry leaves yield (20.01 and 22.38 q/ha, respectively), protein content in leaves (5.28 and 5.75%, respectively) and ascorbic acid in leaves (218.15 and 222.42 mg/100 g, respectively).

Key words: Foliar nitrogen, Kasuri methi, Legume, Nodules, Phosphorus.

INTRODUCTION

Fenugreek is an important *rabi* season crop in India. There are two economically important species of the genus *Trigonella viz., Trigonella foenum-graecum* (common methi) and *Trigonella corniculata* L. (Kasuri methi). Kasuri methi is also called as “Champa methi” and “Marwari methi”. It is mainly grown as leafy vegetable and for seeds in the plains of North India. Kasuri methi (*Trigonella corniculata* L.) is a slow growing plant that remains in a rosette condition during vegetative growth. It bears bright orange-yellow flowers, which are borne on long stalks. Pods are 2-3 cm long, sickle shaped and seeds are smaller and scented. Kasuri methi is suitable for 5-8 leaf cuttings. Its seeds mature in 150-160 days after sowing. Its fresh leaves and pods are fried and consumed as vegetable.

Fenugreek occupied prime place amongst the seed spices grown in Northern India particularly in Rajasthan. Out of the total 63 spices grown in India, 20 are classified as seed spices with 36% share in area and 17% share in production of total spices (Anwer *et al.,* 2011). The crop is cultivated in the country over an area of 149.0 thousand Ha, producing 202.0 thousand tonnes with 1.4 ton/ha productivity (Anonymous, 2017). It is grown on an extensive scale in Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh, Maharashtra and Punjab. In Rajasthan, fenugreek is largely cultivated in Jaipur, Nagore, Sikar, Bharatpur, Bikaner, Sriganganagar, Jodhpur, Jalore, Kota, Udaipur and Bhilwara region.

Phosphorus plays an important role in root development and proliferation, thus it influences nutrient and water uptake by plant. It is also known to enhance the symbiotic nitrogen fixation by increasing nitrogenase activity of root nodules and plays an important role in energy transfer process in the plant body, which results in better uptake of nutrient and thus higher yields (Mehta *et al.,* 2011).

Nitrogen is vital to plants because it is a major component in chlorophyll, amino acids and also required for growth of the plants. Being a leguminous crop, kasuri methi is highly responsive to foliar application of nitrogenous fertilizer especially in early stage. Nitrogen promotes the leaf, stem and other vegetative growth. It also increases the protein content (Gendy *et al.,* 2018). The light textured soils of Rajasthan exhibited a negative balance for main nutrients due to intensive cropping and poor replenishment rate of the same (Gupta, 2001). Nitrogen application to legumes at lower doses in the initial stage is essential for vigorous start. Therefore, keeping above information in view,

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How to cite this article: Yadav, A.K., Singh, S.P., Yadav, D.K., Yadav, G.K., Singh, K. and Yadav, M. (2024). Influence of Phosphorous and Foliar Nitrogen on the Growth, Quality and Yield of Kasuri Methi (*Trigonella corniculata* L.). Legume Research. 47(8): 1306-1312. doi: 10.18805/LR-4712.

Submitted: 23-06-2021 **Accepted:** 10-11-2021 **Online:** 07-01-2022

the present study was conducted to assess the suitable dose of phosphorus and nitrogen (foliar spray) to get quality produce, higher productivity and profitability of kasuri methi.

MATERIALS AND METHODS

The field experiment was conducted at Horticulture Farm, Department of Horticulture, S.K.N. college of Agriculture, Jobner (Raj.), during *rabi* season of 2018-19. Geographically, Jobner is situated at 26°5′ North latitude and 75°28′ East longitude at an elevation of 427 meters above mean sea level in Jaipur district of Rajasthan. In Rajasthan, this region falls under agro-climatic zone IIIa (Semi-Arid Eastern Plain Zone). The soil was sandy loam in texture, alkaline in reaction (pH 8.1) with 0.34% organic carbon and 148, 13.5 and 176 kg/ha of available N, P and K, respectively. The experiment consisted of sixteen treatment combinations including four levels of phosphorus (control, 20, 40 and 60 kg/ha) and four levels of foliar application of nitrogen (control, 1.0, 1.5 and 2.0%). They were under taken in factorial randomized block design (FRBD) with three replications. Treatment was: (i) Control 0 kg/ha P_2O_5 (P_0), (ii) 20 kg/ha P_2O_5 (P_1), (iii) 40 kg/ha P_2O_5 (P_2), (iv) 60 kg/ha P_2O_5 (P_3), (i) Control (water spray) (N_0), (ii) Foliar nitrogen 1.0 % (N_1), (iii) Foliar nitrogen 1.5 % (N_2), (iv) Foliar nitrogen 2.0% (N_3).

The experiment plot was ploughed thrice by tractor drawn cultivator and leveled. The clods were crushed, weeds were removed and brought to fine tilth. The land was divided into plots of required size (2.0 m × 1.0 m). Provision was made for bunds and irrigation channels. The seeds of the variety pusa kasuri were used with seed rate of 8 kg/ha. It is an early bearing and high yielding variety. Seeds were sown with a spacing of 20 × 5 cm^2. Furrows were properly covered with a thin layer of soil and the plots were irrigated lightly. Excess seedlings were thinned out at 20 days after sowing, to maintain the 5 cm distance between the plants. The plots were kept free from weeds by hand weeding at 20 days after sowing. Irrigation was given at an interval of 10-15 days during the whole cropping period depending on the soil moisture conditions. Total of eight irrigations were given. To eliminate border effect; two rows on both sides and 0.5 m length at each end of the plot was not included in the experiment and net plot area was harvested separately from each plot. Data on growth and yield was recorded at harvest. Five plants for each treatment were taken for recording the various data. Leaf area per plant (cm^2) at harvest by leaf area meter (Licor-3100, Lincoln, NE, USA), chlorophyll content (mg/100 g) (Arnon, 1949), protein content in leaves (%), nitrogen content (%) was analyzed separately by colorimetric method (Snell and Snell, 1949) and multiplied with 6.25 factor to calculate crude protein content in leaves) and ascorbic acid in leaves (mg/100 g) (A.O.A.C., 1960), till the faint pink colour was obtained). The statistical analysis done by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Growth attributes

Plant height

The data in Table 1 show that application of P_2O_5 @ 60 kg/ha (P_3) recorded the significantly maximum plant height at cutting-I, II, III and IV (7.64, 11.98, 11.01 and 10.74 cm, respectively) as compared to control P_0 (5.82, 8.06, 7.21 and 6.86 cm, respectively) and P_1 (6.99, 10.01, 9.06 and 9.51 cm, respectively) but P_2 (7.25, 11.67, 10.69 and 10.47 cm, respectively) remains at par with P_3. Higher ratio of phosphorus application increased the plant height that may be due to favourable effect of phosphorus on nitrogen transformation leading to accumulation and metabolism of carbohydrates in plants. Similar results were reported by Kumar *et al.* (2016) and Datta *et al.* (2017). The data in Table 1 show that application of foliar nitrogen @ 2.0% (N_3) recorded the significantly maximum plant height at cutting-

Table 1: Effect of phosphorus and foliar application of nitrogen on plant height and leaf area index at each harvest of Kasuri Methi.

Treatments	Plant height (cm) at each harvest				Leaf area per plant (cm^2)			
	I cutting 40 days	II cutting 55 days	III cutting 70 days	IV cutting 85 days	I cutting 40 days	II cutting 55 days	III cutting 70 days	IV cutting 85 days
Phosphorus level (kg/ha)								
P_0	5.82	8.06	7.21	6.86	15.63	16.82	16.42	15.71
P_{20}	6.99	10.01	9.06	9.51	20.1	22.09	21.89	21.21
P_{40}	7.25	11.67	10.69	10.47	24.43	26.52	26.22	25.52
P_{60}	7.64	11.98	11.01	10.74	25.37	27.35	27.05	26.38
SEm±	0.20	0.30	0.27	0.27	0.39	0.43	0.42	0.41
CD (P=0.05)	0.56	0.86	0.78	0.77	1.12	1.23	1.22	1.19
Foliar application of nitrogen through urea (%)								
N_0	5.88	8.11	7.29	6.84	16.3	17.57	17.16	16.47
$N_{1.0}$	7.05	10.21	9.29	8.67	19.49	22.01	21.84	21.15
$N_{1.5}$	7.09	11.17	10.28	10.53	22.92	25.01	24.7	24.01
$N_{2.0}$	7.68	12.23	11.11	11.54	26.82	28.18	27.87	27.18
SEm±	0.20	0.30	0.27	0.27	0.39	0.43	0.42	0.41
CD (P=0.05)	0.56	0.86	0.78	0.77	1.12	1.23	1.22	1.19

I, II, III and IV (7.68, 12.23, 11.11 and 11.54 cm, respectively) as compared to control (N_0) (5.88, 8.11, 7.29 and 6.84 cm, respectively), foliar application of nitrogen @ 1.0% (N_1) (7.05, 10.21, 9.29 and 8.67 cm, respectively) and 1.5% (N_2) (7.09, 11.17, 10.28 and 10.53 cm, respectively). The positive influence of the nitrogen on plant height might be due to the fact that nitrogen is required for cell elongation while, the plant height was least in the control. Similar findings were reported by Muniramappa *et al.* (1997) and Patidar *et al.* (2004).

Leaf area per plant (cm^2)

The data in Table 1 show that application of P_2O_5 @ 60 kg/ha (P_3) recorded the significantly maximum leaf area at cutting-I, II, III and IV (25.37, 27.35, 27.05 and 26.38 cm^2/plant, respectively) as compared to control P_0 (15.63, 16.82, 16.42 and 15.71 cm^2/plant, respectively) and P_1 (20.10, 22.09, 21.89 and 21.21 cm^2/plant, respectively) but P_2 (24.43, 26.52, 26.22 and 25.52 cm^2/plant, respectively) remains at par with P_3. Increased leaf area per plant during periodic stages probably resulted in more interception of solar radiation and also phosphorus is noted especially for its role in capturing and converting the sun's energy into useful plant compounds leading to formation of greater amount of photosynthates. Similar findings were reported by Jat *et al.* (2013) and Dar *et al.* (2016). The data in Table 1 show that application of foliar nitrogen @ 2.0% (N_3) recorded the significantly maximum leaf area per plant at cutting-I, II, III and IV (26.82, 28.18, 27.87 and 27.18 cm^2/plant, respectively) as compared to control (N_0) (16.30, 17.57, 17.16 and 16.47 cm^2/plant, respectively), foliar application of nitrogen @ 1.0 % (N_1) (19.49, 22.01, 21.84 and 21.15 cm^2/plant, respectively) and 1.5 % (N_2) (22.92, 25.01, 24.70 and 24.01 cm^2/plant, respectively). Linear increases in leaf area per plant were observed with increase in the foliar application of nitrogen levels. This could be due to production of more number of leaves, branches and enhanced availability of nitrogen at the appropriate time, which has increased the leaf area per plant. Similar results were noticed by Mehta *et al.* (2010) and Anupama *et al.* (2017).

Number of nodules per plant

The data in Fig 1 indicated that application of 60 kg/ha dose of (P_3) fertilizer recorded the significantly maximum number of nodules per plant (58.17) as compared to P_0 (control) (46.87) and P_1 (48.13) but P_2 (56.20) remains at par with P_3. The adequate supply of phosphorus improved survival and growth of rhizobia, rate of symbiotic infection and microbial activity in plant root nodules. Valverde *et al.* (2002) and Singh *et al.* (2012) observed in their study on *Discaria trinervis* that the size of nodules and the proportion of nodule tissue were stimulated by phosphorus application. The data in Fig 1 show that foliar nitrogen @ 2% (N_3) recorded highest number of nodules/plant (53.33), which found non-significant among each other. These results were similar with the findings of Roy *et al.* (2016) and Shete *et al.* (2018).

Chlorophyll content (mg/100 g)

The data in Table 2 show that application of 60 kg/ha dose of P_2O_5 (P_3) fertilizer recorded the significantly maximum total chlorophyll content (2.32 mg/100 g) in plant leaves as compared to P_0 (control) (1.79 mg/100 g) and P_1 (2.06 mg/100g) but remains at par with P_2 (2.25 mg/100 g). Phosphorus is a necessary nutrient for the biosynthesis of chlorophyll, so higher amount of phosphorus leads to higher chlorophyll content of leaves (Ambrose and Easty, 1977). Similar results were recorded by Dar *et al.* (2015) and Gendy *et al.* (2018). Application of foliar nitrogen @ 2.0% (N_3) recorded the significantly maximum total chlorophyll content (2.39 mg/100g) as compared to control (N_0) (1.87 mg/100 g), foliar application of nitrogen @ 1.0% (N_1) (2.02 mg/100 g) and 1.5% (N_2) (2.14 mg/100 g). This might be due to increased nitrogen supply which would retard leaf

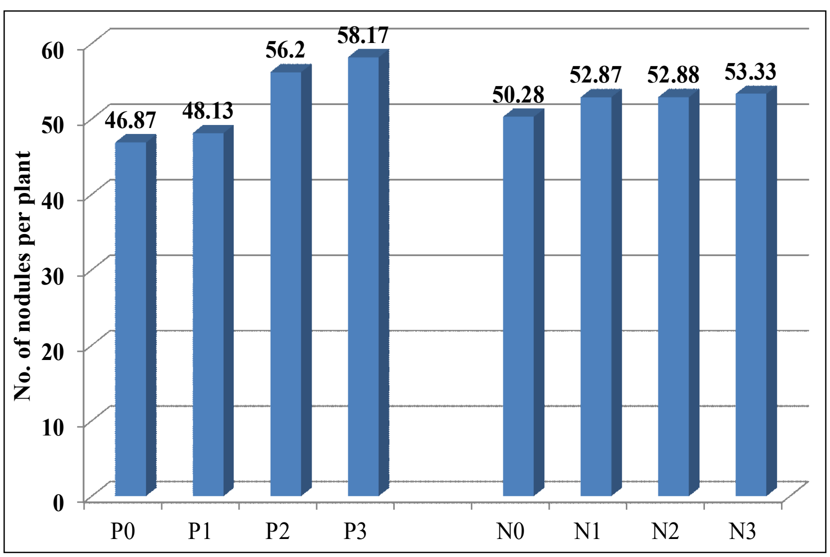

Fig 1: Effect of phosphorus and foliar application of nitrogen on no. of nodules/plant.

Table 2: Effect of phosphorus and foliar application of nitrogen on number of chlorophyll, crude protein and ascorbic acid content in leaves of Kasuri Methi.

Treatments	Chlorophyll content (mg/100 g)	Crude protein content in leaves (%)	Ascorbic acidcontent (mg/100 g)
		Phosphorus level (kg/ha)	
P_0	1.79	3.72	182.42
P_{20}	2.06	4.34	205.15
P_{40}	2.25	5.13	215.34
P_{60}	2.32	5.28	218.15
SEm±	0.02	0.06	3.68
CD (P=0.05)	0.07	0.17	10.62
		Foliar application of nitrogen through urea (%)	
N_0	1.87	3.6	188.86
$N_{1.0}$	2.02	3.98	199.74
$N_{1.5}$	2.14	5.14	210.04
$N_{2.0}$	2.39	5.75	222.42
SEm±	0.02	0.06	3.68
CD (P=0.05)	0.07	0.17	10.62

Table 3: Effect of phosphorus and foliar application of nitrogen on fresh and dry yield of Kasuri Methi.

Treatments	Fresh leaves yield		Dry leaves yield	
	(kg/plot)	(q/ha)	(kg/plot)	(q/ha)
		Phosphorus level (kg/ha)		
P_0	2.29	114.50	0.26	12.90
P_{20}	2.46	123.10	0.31	15.29
P_{40}	2.63	131.50	0.38	19.07
P_{60}	2.78	139.10	0.40	20.01
SEm±	0.07	3.61	0.01	0.33
CD (P=0.05)	0.21	10.42	0.02	0.95
		Foliar application of nitrogen through urea (%)		
N_0	2.22	111.19	0.24	11.73
$N_{1.0}$	2.49	124.48	0.29	14.87
$N_{1.5}$	2.62	130.87	0.36	18.30
$N_{2.0}$	2.83	141.66	0.44	22.38
SEm±	0.07	3.61	0.01	0.33
CD (P=0.05)	0.21	10.42	0.019	0.95

senescence and improve photosynthate and nitrogen availability for seed biomass. These results obtained are closely similar with earlier findings recorded by Mitra and Ghildiyal (1988) and Kulsum *et al.* (2007).

Fresh leaves yield

The data in Table 3 show that application of P_2O_5 @ 60 kg/ha (P_3) recorded significantly maximum total fresh leaves yield per plot (kg) and per hectare (q) (0.567 and 139.10) as compared to control (P_0) (0.447 and 114.50) and P_1 (0.499 and 123.10) but remains at par with P_2 (0.551 and 131.5). Application of phosphorus increased nutrients availability to the crop during the growing season which led to greater synthesis and utilization of assimilates into the leaves and ultimately improved the performance of various yield attributes *viz.* fresh leaves yield per plot (kg) and per hectare (q). Similar results were noticed by Sharma *et al.* (2014) and Nikfarjam and Aminpanah (2015). Application of foliar nitrogen @ 2.0% (N_3) enhanced the total fresh leaves yield per plot (kg) and per hectare (q) (0.580 and 141.66) significantly over control (N_0) (0.458 and 111.19), N_1 (0.498 and 124.48) and N_2 (0.528 and 130.87). The increased levels of foliar nitrogen enhanced the metabolic process like photosynthesis, levels of nucleic acids, soluble proteins, carbohydrates, which results in luxuriant growth of the plant and production of more fresh yield. These results similar with the findings of Meena *et al.* (2006) and Khan *et al.* (2018).

Dry leaves yield

The data in Table 3 show that application of P_2O_5 @ 60 kg/ha (P_3) recorded significantly maximum total dry leaves yield per plot (kg) and per hectare (q) (0.027 and 20.01) as compared to P_0 (control) (0.022 and 12.90) and P_1 (0.024

Table 4: Effect of phosphorus and foliar application of nitrogen on net return and B:C ratio of kasuri methi.

Treatments	Net return (Rs/ha)	B:C ratio
Phosphorus level (kg/ha)		
P_0	70161	0.93
P_{20}	95849	1.26
P_{40}	137174	1.77
P_{60}	146549	1.86
SEm±	3353	0.03
CD (P=0.05)	9685	0.09
Foliar application of nitrogen through urea (%)		
N_0	55477	0.72
$N_{1.0}$	90532	1.17
$N_{1.5}$	128982	1.67
$N_{2.0}$	174742	2.26
SEm±	3353	0.03
CD (P=0.05)	9685	0.09

and 15.29) but remains at par with P_2 (0.026 and 19.07, respectively). Adequate level of phosphorus along with increased mobility of other nutrients had a strong positive effect on photosynthesis that could enhance the plant's ability to produce more assimilates which were reflected in the higher amount of dry matter accumulation at an accelerated pace as evidenced from high leaf area per plant values resulting in higher amount of biomass. Similar results were noticed by Godara *et al.* (2013) and Singh *et al.* (2014). Application of foliar nitrogen @ 2.0% (N_3) enhanced the total dry leaves yield per plot (kg) and per hectare (q) (0.028 and 22.38) significantly over control (N_0) (0.22 and 11.73), N_1 (0.024 and 14.87) and N_2 (0.026 and 18.30). Foliar nitrogen preferentially increased the metabolic processes like photosynthesis, enhanced levels of nucleic acids, soluble proteins and carbohydrates which resulted in higher dry matter production and sink size. Similar results were observed by Godara *et al.* (2018) and Bhadru *et al.* (2019).

Quality attributes

Crude protein content in leaves (%)

The data in Table 2 show that application of P_2O_5 @ 60 kg/ha (P_3) recorded significantly maximum crude protein content (5.28%) over P_0 (control) (3.72%) and P_1 (4.34%) but remains at par with P_2 (5.13%). The increase in these parameters due to P fertilization led to an increased uptake of nutrient in the present study. Higher nitrogen in plant parts is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. These results are in close conformity with the findings of Gupta *et al.* (2009) and Dubey *et al.* (2012). Data in Table 2 show that significantly maximum crude protein content was recorded under foliar nitrogen @ 2.0% (N_3) (5.75%) over control (N_0) (3.60%), N_1 (3.98%) and N_2 (5.14). Higher nitrogen in plant parts is directly responsible for higher protein because it is a primary component of amino acids which constitute the basis of protein. Similar results were observed by Pandya and Bhatt (2007) and Naveen (2010).

Ascorbic acid content in leaves (mg/100 g)

Table 2 shows that ascorbic acid content in leaves was recorded significantly maximum with application of P_2O_5 @ 60 kg/ha (P_3) (218.15 mg/100 g) over P_0 (control) (182.42 mg/100 g) and P_1 (205.15 mg/100 g) but remains at par with P_2 (215.34 mg/100 g). Similar findings were reported by Singh *et al.* (2012) and Zikalala *et al.* (2016). Table 2 further shows that significantly maximum ascorbic acid content in leaves was recorded under foliar application of nitrogen @ 2.0% (N_3) (222.42 mg/100 g) over control (N_0) (188.86 mg/100 g), N_1 (199.74 mg/100 g) and N_2 (210.04 mg/100 g). Similar results were noticed by Moreira *et al.* (2003) and Gupta *et al.* (2009).

Economics

Table 4 shows that application of P_2O_5 @ 60 kg/ha (P_3) recorded significantly higher net return and B:C ratio (Rs. 162430 and 2.57) over control P_0 and P_1 but remains at par with P_2. Similar findings were reported by Bhunia *et al.* (2006) and Godara *et al.* (2017). Table 4 shows that application of foliar application of nitrogen @ 2.0% (N_3) recorded significantly higher net return and B:C ratio (Rs. 188536 and 2.97) over N_0 (control), N_1 and N_2. Similar results were reported by Godara *et al.* (2018) and Dhaka *et al.* (2020).

CONCLUSION

On the basis of one year experimental results, it may be concluded that application of 60 kg/ha P_2O_5 (P_3) was found significantly better in terms of growth, quality, yield and monetary value. However application of 40 kg/ha P_2O_5 (P_2) was found at par with 60 kg/ha P_2O_5 (P_3), while, Foliar application of nitrogen @ 2.0% (N_3) was found significantly better in terms of growth, quality, yield and monetary value. Thus, application of 40 kg/ha P_2O_5 (P_2) and foliar application of nitrogen @ 2.0% (N_3) may be recommended for kasuri methi crop.

Conflict of interest

All authors declared that there is no conflict of interest.

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