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Impact of Nitrogen and Phosphorus on Yield and Yield Attributes of Safflower (*Carthemus tinctorius* L.)

SRIVATSA KHARAD, NIKITA NEHAL[1]*, DASHRATH BHATI, DINESH BABOO TYAGI[1], LUXMI KANT TRIPATHI[2] AND SHAILESH KUMAR SINGH[3]

Department of Horticulture, School of Agriculture, ITM (Institute of Technology and Management) University, Gwalior-474 001 (M. P.), India
**(e-mail: nikitanehal1989@gmail.com; Mobile: 7651831931)*

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ABSTRACT

A field experiment was conducted at Crop Research Centre, near polyhouse, ITM University, Gwalior (M. P.) during **rabi** season of 2021-22. The experiment was laid out in factorial randomized block design with nine treatment combinations, which included three nitrogen levels (viz., N_1–30 kg N/ha, N_2–60 kg N/ha and N_3–90 kg N/ha), three phosphorus levels (viz., P_1–20 kg P_2O_5/ha, P_2–40 kg P_2O_5/ha and P_3–60 kg P_2O_5/ha) and one control (N_0–0 kg N/ha + P_0–0 kg P_2O_5/ha). Each treatment was replicated thrice. The results of the experiment revealed that increase in the application of nitrogen and phosphorus significantly increased the yield of safflower viz., number of capitula per plant, number of seeds per capitula, test weight (100-seed weight), straw yield (kg/ha), biological yield (kg/ha) and harvest index (%) in safflower. The application of 90 kg N/ha and 60 kg P_2O_5/ha were significantly superior over the application of 30 kg N/ha and 20 kg P_2O_5/ha.

Key words: Safflower, nitrogen, phosphorus, yield parameters, harvest index

INTRODUCTION

Safflower (*Carthemus tinctorius* L.) is an important oilseed crop which belongs to family Asteraceae. Safflower (also called downy safflower, woolly distaff thistle or saffron thistle) is an erect spiny biennial plant native of the Mediterranean region. Downy safflower is reported to be sudorific (sweat inducing), fever reducing and anthelmintic (Ditomaso *et al*., 2017; Elgazzar *et al*., 2019). Previous study revealed its importance due to different components of diverse chemical nature such as flavonoids, sesquiterpenes glycosides, lipids, aromatic acids, sterols, triterpenes, volatiles alkaloids, tannins and saponins (Abu *et al*., 2020).

Nitrogen and phosphorus are major elements which increase the crop production. Among all the primary nutrients, nitrogen plays a pivotal role in quantitative as well as qualitative improvement in the productivity of the crop. Nitrogen is an important constituent of protein and chlorophyll (Khinchi *et al.,* 2017). Phosphorus is the second most important plant nutrient for the production of crops. Phosphorus has been called the "bottleneck of global hunger" (Gautam *et al.,* 2019). Phosphorus plays an important role in plant growth and development. It is a component of nucleic acids and plays a vital role in cell respiration and metabolism. Phosphorus plays a role in many enzyme reactions, sugar metabolism and energy storage and transport. Phosphorus is component of cell membranes, chloroplast and mitochondria. The importance of phosphorus as yield limiting factor in many soils is well established. Phosphorus plays an important role in the production of seed and fruit, the growth of roots and the maturing of crops. It helps the fruit ripen faster, reducing the effects of too much nitrogen in the soil. Phosphorus strengthens the plant's skeletal structure, reducing the risk of lodging (Meseret, 2018). Several studies have indicated that adding phosphorus to the soil

[1]Faculty of Agriculture Science, Mandsaur University, Mandsaur-458 001 (M. P.), India.
[2]Faculty of College of Agriculture Sciences, Teerthankar Mahaveer University, Moradabad-244 001 (U. P.), India.
[3]Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara-144 411 (Punjab), India.

improves plant growth and has a positive impact. Phosphorus increase from 50 to 60 kg P/ha increased plant height from 96.23 to 101.97 cm (Sreekanth *et al*., 2021).

MATERIALS AND METHODS

The experiment was conducted during the **rabi** season of 2021-22 at Crop Research Centre near polyhouse, ITM University, Gwalior. The soil was sandy loamy. Annigeri-1 (A-1) variety of safflower [developed by AICRP (Safflower) centre, Agricultural Research Station, Annigeri, University of Agricultural Sciences, Dharwad, Karnataka] was taken for this study. This variety was moderately tolerant to wilt and aphids. It required 125-130 days for maturity, the average yield was 1200 kg/ha and the oil content was 28%.

The experiment was laid out in factorial randomized block design with nine treatment combinations, which included three nitrogen levels (viz., N_1–30 kg N/ha, N_2–60 kg N/ha and N_3–90 kg N/ha), three phosphorus levels (viz., P_1–20 kg P_2O_5/ha, P_2–40 kg P_2O_5/ha and P_3–60 kg P_2O_5/ha) and one control (N_0–0 kg N/ha + P_0–0 kg P_2O_5/ha). Each treatment was replicated thrice. Yield data were collected at the harvesting stage of the crop from four tagged plants. Seeds were randomly selected from each net plot and one hundred seeds were counted and their weight in gram was recorded. The total weight of the plants obtained from each net plot was recorded in kg and then converted into kg/ha. After harvesting and threshing, the grain yield of each net plot was weighed and recorded in kg and afterwards it was converted to kg/ha. Straw yield was obtained by subtracting the total weight of seed yield from the total weight of biological yield from each net plot. Harvest index was calculated by dividing the grain yield to the biological yield and was represented in percentage. The seeds were collected from each net plot and the oil content in seed was evaluated by Nuclear Magnetic Resource (NMR) technique and represented on a percentage basis. The oil yield was determined by multiplying the seed yield by the respective oil percentage. It was represented in kg/ha. The total cost of cultivation and the variable cost for each treatment during the period of experiment was calculated to get gross returns and net returns. The B-C ratio was calculated and represented in percentage.

RESULTS AND DISCUSSION

Nitrogen and phosphorus application induced significant increase in yield attributes, viz. number of capitula per plant, number of seeds per capitula and test weight (g) of safflower (Table 1). Nitrogen application up to 90 kg/ha and phosphorus application up to 60 kg/ha recorded significant increase in number of capitula per plant, number of seeds per capitula and test weight (g) over the control. With increase in nitrogen supply, the process of tissue differentiative from somatic to reproductive meristemic activity and development of floral primordial might have increased which resulted in longer earheads. Present finding further confirmed the earlier reports of Barad *et al.* (2017), Chaudhary *et al*. (2018) and Thakor *et al*. (2018). The increase in the test weight by the phosphorus application can be ascribed as a vital role of phosphorus in energy transformation making ADP and ATP molecules through various metabolic processes and thus, probably resulting in more synthesis and translocation of photosynthates of better filling and development of more as well as bold grains. These findings are in close conformity with those of Bhuva *et al*. (2018) and Singh *et al.* (2019) in pearl millet and Choudhary *et al.* (2017) in maize.

Table 1. Effect of nitrogen and phosphorus levels on number of capitula/plant, number of seeds/capitula and test weight (g) in safflower

Treatment	No. of capitula/plant	No. of seeds/capitula	Test weight (g)
Nitrogen			
N_1–30 kg N/ha	27.50	14.13	5.83
N_2–60 kg N/ha	30.25	15.80	5.86
N_3–90 kg N/ha	32.17	16.07	5.87
S. Em±	0.19	0.43	0.23
C. D. (P=0.05)	2.70	1.28	NS
Phosphorus			
P_1–20 kg P/ha	27.85	14.31	5.42
P_2–40 kg P/ha	30.58	15.60	5.85
P_3–60 kg P/ha	31.48	16.10	6.29
S.Em±	0.19	0.43	0.23
C. D. (P=0.05)	2.70	1.28	NS
Control			
N_0P_0–0 kg N/ha+0 kg P/ha	23.34	9.55	5.30
Interaction			
S. Em±	1.57	0.75	0.40
C. D. (P=0.05)	NS	NS	NS

NS–Not Significant.

Nitrogen and phosphorus application brought about significant improvement in grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha) and harvest index (%) of safflower (Table 2). The amount of nitrogen applied had a significant influence on yield (kg/ha); application of 90 kg N/ha was significantly superior over 30 kg N/ha and 60 kg N/ha was at par with this treatment, but the application of 30 kg P/ha had significant differences with 60 kg P_20_5/ha. Different phosphorus levels had a significant influence on the biological yield (kg/ha). 60 kg P_20_5/ha was significantly superior to other treatments in terms of biological yield (kg/ha). The application of 40 kg P_20_5/ha was at par with this treatment, but the application of 20 kg P/ha had significant differences with 40 kg P_20_5/ha. There was no significant difference in the interaction effects of nitrogen and phosphorus. It was observed that the applications of various levels of nitrogen and phosphorus levels had no significant influence on harvest index. The better effect of nitrogen levels might be attributed to rapid expansion of dark green foliage, which could intercept and utilize incident light energy in the production of carbohydrate through the process of photosynthesis. Earlier workers have also reported such positive response on straw yield due to nitrogen application to summer pearl millet. These results are also in agreement with the findings of Barad *et al.* (2017), Daroga *et al*. (2017), Chaudhary *et al*. (2018), Reddy *et al*. (2018) and Thakor *et al*. (2018) in maize crop. The result is also in line with the findings of Bhuva *et al*. (2018) and Singh *et al.* (2019) in pearl millet; Amanullah *et al*. (2025) and Awuni *et al*. (2024) in soybean.

The application of various levels of nitrogen and phosphorus levels had no significant influence on oil content (%). Oil content decreased with increase in nitrogen level from 0 to 90 kg N/ha (Table 3). The amount of nitrogen applied had a significant influence on oil yield (kg/ha); application of 90 kg N/ha was significantly superior over 30 kg N/ha and 60 kg N/ha was at par with this treatment, but the application of 30 kg P/ha had significant differences with 60 kg P_2O_5/ha. Higher oil yield with increasing nitrogen was probably due to favourable effect of nitrogen on seed yield. Different phosphorus levels had a significant influence on the oil yield (kg/ha). 60 kg P_2O_5/ha showed significant superiority to other treatments in terms of oil yield (kg/ha). The application of 40 kg P_2O_5/ha was at par with this treatment, but the application of 20 kg P/ha had significant differences with 40 kg P_2O_5/ha. There was no significant difference in the interaction effects of nitrogen and phosphorus. Said-Al Ahl *et al.* (2016) and Ahmed (2018) reported that phosphorus significantly increased oil content in rapeseed. Wang *et al.* (2024) also reported it in flax oil seed.

Table 2. Effect of nitrogen and phosphorus levels on grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha) and harvest index (%) in safflower

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Nitrogen				
N_1–30 kg N/ha	2051.30	4271.13	6322.43	32.39
N_2–60 kg N/ha	2244.13	4696.36	6940.49	32.45
N_3–90 kg N/ha	2301.53	4704.51	7006.04	32.81
S. Em±	59.78	117.81	131.81	-
C. D. (P=0.05)	177.62	350.03	391.63	-
Phosphorus				
P_1–20 kg P/ha	2003.31	4270.15	6273.46	31.91
P_2–40 kg P/ha	2277.61	4681.95	6959.56	32.79
P_3–60 kg P/ha	2316.03	4719.90	7035.93	32.95
S. Em±	59.78	117.81	131.81	-
C. D. (P=0.05)	1273.95	350.03	391.63	-
Control				
N_0P_0–0 kg N/ha+0 kg P/ha	1473.95	3163.15	4437.10	28.79
Interaction				
S. Em±	103.55	204.05	228.30	-
C. D. (P=0.05)	NS	NS	NS	-

NS–Not Significant.

Table 3. Effect of nitrogen and phosphorus levels on oil content (%) and oil yield (kg/ha) in safflower

Treatment	Oil content (%)	Oil yield (kg/ha)
Nitrogen		
N_1–30 kg N/ha	27.37	561.77
N_2–60 kg N/ha	27.56	618.80
N_3–90 kg N/ha	27.82	640.32
S. Em±	0.79	18.38
C. D. (P=0.05)	NS	54.61
Phosphorus		
P_1–20 kg P/ha	27.37	548.66
P_2–40 kg P/ha	27.57	628.06
P_3–60 kg P/ha	27.81	644.16
S. Em±	0.79	18.11
C. D. (P = 0.05)	NS	54.61
Control		
$N_0P_{0–}0$ kg N/ha+0 kg P/ha	27.08	344.99
Interaction		
S. Em±	1.36	31.83
C. D. (P=0.05)	NS	NS

NS–Not Significant.

The cost of cultivation varied according to different doses of nitrogen and phosphorus. Maximum gross returns, net returns and the benefit: cost ratios were obtained with 60 kg N/ha and 40 kg P_2O_5/ha (Table 4). This behaviour of gross returns, net returns, and benefit: cost ratio, crop productivity and profitability may be attributed to yield trend due to N and P application and relative cost of inputs in relation to output. Awuni *et al*. (2024) asserted that resource-limited farmers, basically smallholder farmers, would invest in the lowest opportunity cost that enhances crop growth and provides the best returns on investment. Similar results were found by Vilvert *et al*. (2023) in sunflower.

Table 4. Effect of nitrogen and phosphorus levels on economics of safflower

Treatment	Gross returns (Rs./ha)	Net returns (Rs./ha)	B-C ratio
0 kg N/ha+0 kg P/ha	63654.05	31797.05	0.99
30 kg N/ha+20 kg P/ha	87850.18	54058.18	1.59
30 kg N/ha+40 kg P/ha	105678.39	70386.39	1.99
30 kg N/ha+60 kg P/ha	109023.70	72231.70	1.96
60 kg N/ha+20 kg P/ha	100587.44	66360.44	1.93
60 kg N/ha+40 kg P/ha	114752.20	79025.20	2.21
60 kg N/ha+60 kg P/ha	115795.74	78568.74	2.11
90 kg N/ha+20 kg P/ha	107630.30	72968.30	2.10
90 kg N/ha+40 kg P/ha	115138.85	78976.85	2.18
90 kg N/ha+60 kg P/ha	116164.45	78502.45	2.08

CONCLUSION

This study presents new insights into how nitrogen (N) and phosphorus (P) application rates influence the yield and yield components in safflower (*Carthamus tinctorius* L.). When applied both fertilizers, the highest rate of one was preferred alongside the highest rate of the other, indicating a synergistic effect on plant performance. The application of 90 kg/ha of nitrogen and 60 kg/ha of phosphorus significantly outperformed other treatments.

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