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Effect of nitrogen and phosphorus levels on growth and yield of safflower (*Carthamus tinctorius* L.)

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Abstract
A field research trial was conducted to study “Effect of Nitrogen and Phosphorus levels on growth and yield of Safflower (*Carthamus tinctorius* L.)” at Crop Research Farm, Naini Agriculture Institute, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during the period of *Rabi* season of 2020-21. The experiment was carried out in a randomized block design comprising of nine treatments of three levels of Nitrogen (30, 40 and 50 kg N/ha) and Phosphorus (40, 50 and 60 kg P kg/ha) which were replicated three times. The result revealed that growth and yield attributes of safflower ware increased through successive increases in nitrogen and phosphorus levels. The application of 50 kg nitrogen/ha + 60 phosphorus kg/ha reported significantly maximum plant height (102.93 cm), dry matter accumulations (41.17 g), seeds per capitulum (29.53), capitulum per plant (24.50), seed yield (1.57 t/ha), and stover yield (4.19 t/ha) was found in treatment T_9.

Keywords: Safflower, nitrogen, phosphorus growth, and yield

Introduction
India is the largest producer of oilseeds in the world and the oilseed sector occupies an important position in the country’s economy. The country accounts for 12-15 per cent of global oilseeds area, 6-7 per cent of vegetable oils production, and 9-10 per cent of the total edible oil consumption. In terms of acreage, production and economic value, oilseeds are second only to food grains. Safflower is an important oilseed crop of the world. In India, it is grown in winter season and accounts for about 8.0% of the value of total oilseeds produce.

Safflower (*Carthamus tinctorius* L.) an oilseed crop is a member of the family Compositae or Asteraceae. Presently, in India it is most commonly known as Kardai in Marathi and Kusum in Hindi. It is an important *rabi* oil seed crop, There are approximately 25 valid species in the genus, of which only *C. tinctorius* is the cultivated type, having 2n = 24 chromosomes. India ranks first in area (51%) and production (37%) in the world. The safflower area in the country during 2017- 18 was 0.81 lakh ha area as compared to the year 2016-17 (1.05 lakh ha). India is the largest producer of safflower (43.67 000’ MT) in the world with highest acreage (4.3 lakh hectares) but with an average productivity of only 843 kg/ha. Safflower oil preferred for its higher poly unsaturated fatty acid (78% linoleic acid) which reduces blood cholesterol level (Belgin *et al.*, 2007) [1]. Safflower seed contains 28- 34% of oil, and nutritionally similar to sunflower oil, which is very useful for reducing blood cholesterol content (Kadu and Ismail, 2008) [4].

Nitrogen fertilizers are one of the important inputs in dry rainfed agricultural systems. In order to obtain optimum yield and quality product in these regions, sufficient amount of nitrogen in suitable time and form should be given to the plant. Nitrogen compounds are important in plant chemical compounds such as protein, nucleic acid, chlorophyll and enzymes structure, and has an important role in the tissues structure of plants and nitrogen deficiency reduces plant amino acid content as the basic element for the construction of amino acids and proteins. It has an important role in the tissues structure of plants. Nitrogen is essential in plant processes such as photosynthesis. Thus, plants with sufficient nitrogen will experience high rates of photosynthesis and typically exhibit vigorous plant growth and development. N availability is an important factor in determining crop productivity, managing fertilizer rate can be a suitable strategy to improve crop growth and yield when crops need to enhance nutrient uptake Nitrogen was effective on the vegetative and reproductive stages of safflower (Bitarafan *et al.*, 2011) [2]. Phosphorus (P) is vital to plant growth and is found in every living plant cell.

It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next (Sultenfuss and Doyle, 1999) [12]. Phosphorus plays an important role in the growth and development, as well as maturity of all crops. An adequate supply of P in the early stages helps in initiating its reproductive parts. The P requirement of oilseeds and pulses is relatively high as it plays an important role in plant metabolism.

Materials and Methods

The experiment was conducted during the *Rabi* season of 2020-21 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj. The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitudes and at an altitude of 98 m above mean sea level. This area is situated on the proper side of the river Yamuna and by the other side of Prayagraj. All the facilities required for crop cultivation were available. Just before the layout preparation and sowing, 5 samples of soil from the various spot of the allotted research plot was collected randomly from a depth of 0 to 15 cm for analysing the soil sample. The soil texture of the experimental site was sandy loam having available N (110.8 kg/ha) P (6.9 kg/ha), potassium (119.2kg/ha) and organic carbon of soil was of 0.34% with 6.8 available pH of soil. the experimental plot was a randomized block design with having nine treatments which replicated three times with a suitable plot size was of 3m×3m.There were nine treatments combination used for this experiment which are T_1 : 30 kg/ha Nitrogen + 40 kg/ha Phosphorus, T2: 30 kg/ha Nitrogen + 50 kg/ha Phosphorus, T3: 30 kg/ha Nitrogen + 60 kg/ha Phosphorus, T4: 40 kg/ha Nitrogen + 40 kg/ha Phosphorus, T5: 40 kg/ha Nitrogen + 50 kg/ha Phosphorus, T6: 40 kg/ha Nitrogen + 60 kg/ha Phosphorus, T7: 50 kg/ha Nitrogen + 40 kg/ha Phosphorus, T8: 50 kg/ha Nitrogen + 50 kg/ha Phosphorus, T9: 50 kg/ha Nitrogen + 60 kg/ha Phosphorus. The Recommended dose of fertilizer is 40:40:20 kg/ha NPK. Fertilizer was applied at the time of sowing in the form of urea, SSP and MOP. The growth parameters were recorded at periodic intervals 20,40,60,80,100 DAS and at harvest from randomly tagged plants from each treatment.

Results and Discussion

The results of the present investigation revealed that 50 kg/ha Nitrogen + 60 kg/ha Phosphorus significantly increased the plant height (102.93 cm) at harvest stage as compared to all treatments. However, (102.63 cm) was recorded in T8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus), (102.30 cm) was recorded in T6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus) and (101.97 cm) T3 (30 kg/ha Nitrogen + 60 kg/ha Phosphorus) which were statistically at par with T9 (50 kg/ha Nitrogen + 60 kg/ha Phosphorus). The increase in plant height with higher levels of nitrogen was probably due to its beneficial effect on cell elongation which might have resulted in internodal elongation. The nitrogen was an integral part of protein, the blocks of the plant and it also helps in maintaining higher auxin level which might have resulted in better plant height, Phosphorus plays a major role in several physiological processes like photo-synthesis, respiration, energy storage and transfer, cell division, cell enlargement and development of meristematic tissues which helps in increase growth attributes of plant These results were similar with Nathan *et al* (2017) [7], Singh and Singh (2013) [10], Sofy *et al* (2020) [11].

At harvest the maximum dry weight was observed in T9 (50 kg/ha Nitrogen + 60 kg/ha Phosphorus) (41.17g). However, 40.65 g was recorded in T8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus), 40.21 g was recorded in T6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus), 39.66 g T3 (30 kg/ha Nitrogen + 60 kg/ha Phosphorus) and 39.29 g T7 (50 kg/ha Nitrogen + 40 kg/ha Phosphorus) which were statistically at par with T9 (50 kg/ha Nitrogen + 60 kg/ha Phosphorus). Dry matter production related to grain productivity contributes an important factor in source-link relationship. The increase in dry matter due to increase in N levels could be attributed to enhanced plant height, photosynthates accumulation Increased content of dry matter due to increased nitrogen and phosphorus has been reported by Naik *et al*. (2012) Nathan *et al.* (2018) [8] and Vishwanath *et al* (2000) Bhaskar *et al* (2020).

Maximum number of capsules/plant was found in the treatment combination of T9 (Nitrogen 50 kg/ha + 60 kg/ha Phosphorus) (24.50) was significantly higher among the all treatments. However, (24.07) was recorded in T8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus), 23.57 was recorded in T6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus) and (23.30) was recorded in T3 (30 kg/ha Nitrogen + 60 kg/ha Phosphorus) which were statistically at par with T9 (50 kg/ha Nitrogen + 60 kg/ha Phosphorus).

The maximum number of seeds per capitulum was observed in T9 (Nitrogen 50 kg/ha + 60 kg/ha Phosphorus) (29.53). However, 29.10 was recorded in T8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus), 28.87 was recorded in T6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus) and 28.27 was recorded in T3 (30 kg/ha Nitrogen + 60 kg/ha Phosphorus), which were statistically at par with T9 50 kg/ha Nitrogen + 60 kg/ha Phosphorus). This might be because of better growth of plant due to availability of nitrogen leading to increase number of capsules/plant as seed yield is directly related to the growth and yield attributes. Number of seeds/capitulum differed significantly among different levels of nitrogen. Application of adequate nitrogen produced large number of seeds/ capitulum with improved plant vigour coupled with increased production and translocation of photosynthesis have accommodated more number of seeds/capitulum. Similar findings were reported by Nathan *et al* (2017) [7] Sandhya Rani *et al* (2014) [9]. Reddi Ramu and Maheswara Reddy (2003) [6].

Maximum seed yield was recorded in the treatment in the combination of T9 Nitrogen 50 kg/ha + phosphorus 60 kg/ha was (1.57 t/ha). However, 1.46 t/ha was recorded in T8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus), 1.43 t/ha was recorded in T6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus) and 1.35 t/ha was recorded in T3 (30 kg/ha Nitrogen + 60 kg/ha Phosphorus), which were statistically at par with T9 (Nitrogen 50 kg/ha + phosphorus 60 kg/ha).

Higher number of capitulum/plant and increase in test weight of seed due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in well fertilized plots, which finally resulted in to higher yields. This was due to adequate application of nitrogen and phosphorus which were directly involved in cell multiplication and vigorous root system development for effective absorption of applied nutrients, where sulphur resembles nitrogen in being able to improve cell division cell elongation as well as having a favourable effect in chorophyll synthesis The results corroborates with the findings of Singh *et al* (2013) [10], Sandhya Rani *et al* (2014) [9].

The maximum stover yield was observed in T_9 (Nitrogen 50 kg/ha + phosphorus 60 kg/ha) (4.19 t/ha). However, (3.95 t/ha) was recorded in T_8 (50 kg/ha Nitrogen + 50 kg/ha Phosphorus) and (3.90 t/ha) Was recorded in T_6 (40 kg/ha Nitrogen + 60 kg/ha Phosphorus) which were statistically at par with T9 (Nitrogen 50 kg/ha + phosphorus 60 kg/ha).

Increase in stover yield was due to increase in plant height, branches plant resulting from the application of higher doses of nitrogen. Nathan *et al* (2017) [7] Nitrogen and phosphorus application brought about significant improvement in stover yield also been reported by Singh and Singh (2013) [10].

Table 1: Effect of Nitrogen and Phosphorus Levels on Yield attributes of Safflower (*Carthamus tinctorius* L.)

Treatments	Plant height (CMS) at harvest	Dry weight (g/plant) at harvest	No. of capsules/plant	No. of seeds/ capsules	Seed yield (t/ha)	Stover yield (t/ha)
30 Kg/ha Nitrogen +40 Kg/ha Phosphorus	96.23	37.42	18.67	24.90	0.96	2.98
30 Kg/ha Nitrogen + 50 Kg/ha Phosphorus	97.63	38.55	20.17	26.23	0.98	3.27
30 Kg/ha Nitrogen + 60 Kg/ha Phosphorus	101.97	39.66	23.30	28.27	1.35	3.77
40 Kg/ha Nitrogen + 40 Kg/ha Phosphorus	98.46	38.24	19.27	25.20	1.09	3.13
40 Kg/ha Nitrogen + 50 Kg/ha Phosphorus	98.86	38.93	20.70	26.73	1.18	3.42
40 Kg/ha Nitrogen + 60 Kg/ha Phosphorus	102.30	40.21	23.57	28.87	1.43	3.90
50 Kg/ha Nitrogen + 40 Kg/ha Phosphorus	99.90	39.29	22.37	27.30	1.26	3.53
50 Kg/ha Nitrogen + 50 Kg/ha Phosphorus	102.63	40.65	24.07	29.10	1.46	3.95
50 Kg/ha Nitrogen + 60 Kg/ha Phosphorus	102.93	41.17	24.50	29.53	1.57	4.19
S.Em(+)	0.34	0.75	0.68	0.61	0.08	0.10
CD (5%)	1.03	2.23	2.05	1.82	0.23	0.31

Conclusion

From the above result it can be concluded that among all the treatment combination, the treatment with Nitrogen 50 kg/ha + Phosphorus 60 kg/ha was considered to be the best treatment combination for achieving maximum seed yield (1.57 t/ha), and highest benefit cost ratio (2.29) in safflower plant with variety (PBNS-12).

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