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Influence of Nitrogen and Sulphur on Yield and Quality Parameters of Spineless Safflower under Irrigated Conditions

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A B S T R A C T

A field experiment was conducted during Rabi, 2014 at college farm, college of agriculture, Rajendranagar, Hyderabad to realize the optimal dose of nitrogen and sulphur in safflower and to evaluate the effect of levels of nitrogen and sulphur on yield and quality parameters of safflower. The experiment was carried out with three nitrogen levels 0, 40 and 60 kg N ha^{-1} and three sulphur levels 0, 25 and 45 kg S ha^{-1} were laid out in randomized block design with factorial concept and replicated thrice. With respect to nitrogen levels, *Viz.* number of capitula plant^{-1} (26.7), number of seeds capitulum^{-1} (24.0), weight of capitulum plant^{-1} (37.5 g), 100 seed weight (4.4 g), oil content (29.3 %) oil yield (427 kg ha^{-1}) and protein content (16.0 %) were recorded highest with 60 kg N ha^{-1} and it was significantly superior than 40 kg N ha^{-1} and 0 kg N ha^{-1}. Among sulphur levels, significantly highest yield parameters *viz.* number of capitula plant^{-1} (25.7), number of seeds capitulum^{-1} (22.6), weight of capitulum (35.1 g plant^{-1}), 100 seed weight (4.1 g), oil content (31.1 %) oil yield (448 kg ha^{-1}) and protein content (15.0 %) were recorded with 45 kg S ha^{-1} over 25kg S ha^{-1} and 0 kg S ha^{-1}.

Introduction

Safflower (*Carthamus tinctorius* L.) is an important annual industrial crop. The stem, leaves, seeds and flowers are used as vegetable and industrial oil, bird feed, forage plant, medicinal purpose and for its colourful petals used as food colouring, flavouring agent and preparing textile dyes (Dordas and Sioulos, 2008). Safflower oil preferred for its higher poly unsaturated fatty acid (78% linoleic acid) which reduces blood cholesterol level (Belgin *et al.,* 2007) also contains tocopherols, known to have antioxidant effect and high vitamin E content. For this reason, safflower oil is used in the diets of patients with cardiovascular disease, and bears great importance for its anti-cholesterol effect (Pongracz *et al.*, 1995; Arslan *et al.*, 2003). India is a major safflower growing country and contributes 60 per cent of the total world production. India ranks first in area and production of safflower grown across the world. In India, safflower is grown in an area of 1, 78, 400 ha with a production of 1.453 lakh tonnes and productivity of 498 kg ha^{-1} (Indiastat, 2012). But, the productivity of safflower is very low as the crop is cultivated under nutrient stress environment conditions. This necessitates rational application of these elements as they have become limiting factor for obtaining higher yields in safflower.

Higher yields and quality of safflower oil can be realized only when all three major nutrients (N, P and K) and secondary nutrient (S) is supplied in sufficient quantity and in a balanced way. Apart from determining the response, identification of right dose is also very important to optimize production.

Materials and Methods

The field experiment was conducted at College farm, Professor Jyashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *Rabi* season 2014-15. The experimental soil was sandy loam in texture, slightly alkaline in reaction (p^H 7.3). The fertility status of the experimental soil was low in organic carbon (0.41%) and available nitrogen (217.63 kg ha^{-1}), medium in available phosphorous (40.93 kg P_2O_5 ha^{-1}) and high in available potassium 370.7 kg K_2O ha^{-1}) and low in available sulphur (15.7 kg S ha^{-1}). The experiment was laid out in a factorial randomized block design with three replications having nine treatments combinations of three levels of nitrogen 0 kg N ha^{-1},: 40 kg N $ha^{-1}$and 60 kg N ha^{-1} and three sulphur levels 0 kg S ha^{-1}, 25 kg S ha^{-1}, 45 kg S ha^{-1}).

Results and Discussion

Number of capitula plant^{-1}

The number of capitula plant^{-1} increased with increment of nitrogen dose because the application of N fertilizer. Application of 60 kg N ha^{-1} recorded significantly more number of capitula plant^{-1} (26.7) over 40 kg N ha^{-1} and 0 kg N ha^{-1}. Other investigation also reported the positive effects on number of capitula plant^{-1} Singh and Singh (2013).

The highest number of capitula plant^{-1} (25.7) was recorded in the treatment receiving 45 kg S ha^{-1} and it was significantly superior over 25 kg S ha^{-1} (24.4), and control (23.2). This might be because of better growth of plant due to availability of sulphur leading to increased number of capsules plant^{-1} as seed yield is directly related to the growth and yield attributes (Patil *et al.*, 2014).

Number of seeds capitulum^{-1}

Number of seeds capitulum^{-1} differed significantly among different levels of nitrogen. Application of adequate nitrogen produced large number of seeds capitulum^{-1} with improved plant vigour coupled with increased production and translocation of photosynthates have accommodated more number of seeds capitulum^{-1}.

Application of 60 kg N ha^{-1} recorded statistically higher number of seeds capitulum^{-1} (24.0) over 40 kg N ha^{-1} and control. Lowest number seeds capitulum^{-1} (19.6) was observed in control (0 kg N ha^{-1}).These results are in line with Reddi Ramu and Maheswara Reddy (2003), Sharma and Gupta, (1992).

Among the sulphur levels, application of 45 kg S ha^{-1} (22.6) registered the highest number of seeds capitulum^{-1}. It was significantly superior over 25 kg S ha^{-1} (21.9) and control (21.1). Application of sulphur increased the plant growth by increasing the assimilating surface area. The higher photosynthates assimilation helped in net export of carbon to sink and thus increased the number of seeds capitulum^{-1} (Kapila Shekhawat and Shivay, 2008).

Weight of capitulum (g plant^{-1})

Weight of capitulum plant^{-1} was significantly influenced when the safflower crop was fertilized with 60 kg N ha^{-1} compared to other levels of nitrogen. The weight of capitulum plant^{-1} was significantly higher (37.5g) with

60 kg N ha^{-1} compared to 40 kg N ha^{-1} (33.6 g) and control (28.3 g). The highest weight of capitulum plant^{-1} (35.1 g) was recorded in the treatment receiving 45 kg S ha^{-1} and it was significantly superior over 25 kg S ha^{-1} and 0 kg S ha^{-1}.

Higher weight of capitulum plant^{-1} might be due to higher yield components that are directly responsible for higher seed yield determined by physiological characters both during vegetative and reproductive phase of the crop (Ravi *et al.*, 2010).

100 seed weight

100-seed weight differed significantly among different levels of nitrogen and sulphur. Application of 60 kg N ha^{-1} recorded significantly highest 100-seed weight (4.4g) over 40 kg N ha^{-1} (4.1g) and 0 kg N ha^{-1} (3.3g). Test weight among different sulphur levels maximum was obtained (4.1 g) with highest sulphur level (45 kg S ha^{-1}) and it reduced with decrease in the sulphur levels and it was significantly superior over 25 kg S ha^{-1} (3.9 g) and the lowest test weight was recorded in control (3.7 g) (Table 1).

The increase in 100 seed weight with higher sulphur level may be due to the balanced system of nutrition and consequently producing healthy seeds (Mishra and Agrawal, 1994). These results are in conformity with the results of Ravi *et al.*, (2010), Singh and Singh (2013), Dashora and Sharma (2006).

Oil content (%)

Oil content differed non-significantly among different levels of nitrogen. But, among different levels of nitrogen, control (0 kg N ha^{-1}) recorded higher oil content (30.2 %) over 60 and 40 kg N ha^{-1}. Lowest oil content was observed in 60 kg N ha^{-1} (29.3 %).

Table.1 Yield attributes of safflower as influenced by nitrogen and sulphur levels

Treatments	No. of Capitula plant^{-1}	No. of Seeds capitulam^{-1}	Weight of Capitula plant $^{-1}$ (g)	100 seed Weight (g)
Nitrogen levels				
N_0-0 kg ha^{-1}	22.1	19.6	28.3	3.3
N_1-40 kg ha^{-1}	24.5	21.9	33.6	4.1
N_2-60 kg ha^{-1}	26.7	24.0	37.5	4.4
SEm ±	0.38	0.21	0.59	0.05
CD ($P \leq 0.05$)	1.15	0.64	1.78	0.15
Sulphur levels				
S_0-0 kg ha^{-1}	23.2	21.1	31.2	3.7
S_1-25 kg ha^{-1}	24.4	21.9	33.0	3.9
S_2-45 kg ha^{-1}	25.7	22.6	35.1	4.1
SEm ±	0.38	0.21	0.59	0.05
CD ($P \leq 0.05$)	1.15	0.64	1.78	0.15
Interaction (N x S)				
SEm ±	0.66	0.37	1.03	0.09
CD ($P \leq 0.05$)	NS	NS	NS	NS

Table.2 Oil content, oil yield and protein content of safflower as Influenced by nitrogen and sulphur levels

Treatments	Oil content (%)	Oil yield (kg ha^{-1})	Protein Content (%)
Nitrogen levels			
N_0-0 kg ha^{-1}	30.2	348	11.5
N_1-40 kg ha^{-1}	29.4	391	13.9
N_2-60 kg ha^{-1}	29.3	427	16.0
SEm ±	0.26	10.06	0.36
CD ($P \leq 0.05$)	NS	30.15	1.06
Sulphur levels			
S_0-0 kg ha^{-1}	28.1	306	12.6
S_1-25 kg ha^{-1}	29.8	389	13.8
S_2-45 kg ha^{-1}	31.1	448	15.0
SEm ±	0.26	10.06	0.36
CD ($P \leq 0.05$)	0.74	30.15	1.06
Interaction (N x S)			
SEm ±	0.45	17.42	0.62
CD ($P \leq 0.05$)	NS	NS	NS

Oil content decreased with increase in nitrogen level from 0 to 60 kg N ha^{-1}. Reduction in oil content in seed by higher N application might be due to higher degradation of carbohydrates in tricarboxylic acid (TCA) cycle to acetyl Co A. By reductive amination and transamination process more amino acids are formed rather than fatty acids. Crop fertilized with 60 kg N ha^{-1} resulted in comparatively greater accumulation of protein in seed, there by hindering a satisfactory availability of carbohydrates for polymerization into fatty acids and thus leading to lower content of oil in the seed (Zaman, 1988).

The treatment receiving 45 kg S ha^{-1} resulted in the maximum oil content (31.1 %). This was significantly superior over 25 kg S ha^{-1} (29.8 %) and 0 kg S ha^{-1} (28.1 %). The increase in oil content with increase in sulphur might be due to the involvement of sulphur in electron- transport chain. The acetic thiolinase, a sulphur based enzyme in the presence of sulphur converts acetyl Co A to melonyl Co A rapidly resulting in higher oil content (Krishnamurthi and Mathan, 1996 and Nagavani *et al.*, 2001).

Oil yield (kg ha^{-1})

Oil yield differed significantly among different levels of nitrogen. Application of 60 kg N ha^{-1} recorded maximum oil yield (427 kg ha^{-1}) over lower levels of 40 kg N ha^{-1} and 0 kg N ha^{-1}. Lowest oil yield was obtained in control (348 kg ha^{-1}).

Higher oil yield with increasing nitrogen was probably due to favourable effect of nitrogen on seed yield. Thus crop receiving adequate nitrogen recorded higher oil yield despite of lower seed oil content (Reddy *et al.*, 1994).

Oil yield of safflower increased steeply with increasing application rates of sulphur and attained maximum oil yield at higher doses of sulphur. Oil yield was maximum with sulphur application upto 45 kg S ha^{-1} and decreased with lower levels. Oil yield of safflower ranged from 306 kg ha^{-1} in control to 448 kg ha^{-1} at 45 kg S ha^{-1}.

Oil yield is a function of oil content and seed yield, both the attributes increased with increasing levels of sulphur resulting in a significant increase in oil yield (Santosh Kumar *et al.,* 2009). Higher oil yield with higher dose of sulphur fertilization was due to higher seed yield.

Further, application of sulphur to plant enhanced the formation of acetyl co enzyme A, a precursor compound for the synthesis of long chain fatty acid resulting in increase in oil content which ultimately led to greater oil yield (Panda *et al.*, 2000).

Protein content (%)

Protein content differed significantly among the different levels of nitrogen. Application of 60 kg N ha^{-1} recorded significantly higher protein content (16.0 %) over lower levels of 40 kg N ha^{-1} and 0 kg N ha^{-1}. Control (0 kg N ha^{-1}) recorded significantly lower protein content (11.5 %). Nitrogen is the main nutrient involved in amino acid structure, therefore application of nitrogen can increase the value of seed protein. Zohra *et al.,* (1985) reported that nitrogen had positive effects on seed protein content of safflower (Table).

Application of sulphur significantly increased the protein content in seeds. There was differential increase in protein content due to the application of higher levels of sulphur than lower levels. The treatment receiving 45 kg S ha^{-1} resulted in the highest protein content (15.0 %) and it was significantly superior over 25 kg S ha^{-1} (13.8 %) and 0 kg S ha^{-1} (12.6 %). Sulphur is a constituent of essential amino acids methionine, cystein and cystine. Sulphur also helps in conversion of these amino acids into high quality protein. Appropriate structure is essential for protein formation and sulphur provides di-sulphide (S-S) bonds for cross linkage of two polypeptide chains and thus helps in formation of proteins (Allaway and Thompson, 1966).

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