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EFFECT OF IRRIGATION SCHEDULING AND NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF SAFFLOWER IN VERTISOLS

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ABSTRACT

An experiment was conducted at College of Agriculture, Nagpur to study the effect of irrigation scheduling and nutrient management on growth and yield of safflower in vertisols during *rabi* season of 2015-16 in split plot design with four different irrigation levels *viz*., I_1- Irrigation applied at vegetative, elongation and flowering stages, I_2-Irrigation applied at vegetative and flowering stages, I_3- Irrigation applied at elongation and seed development stages and I_4- Irrigation applied at vegetative and seed development stages as main plot treatments and three different nutrient managements *viz*., F_1-75% RDF (30:30:00 NPK kg ha^{-1}), F_2- 100% RDF (40:40:00 NPK kg ha^{-1}) and F_3- 125% RDF (50:50:00 NPK kg ha^{-1}) as sub plot treatments, replicated thrice. The soil was clayey, low in nitrogen, medium in phosphorus and high in potassium with normal pH 7.6. Growth and yield attributing characters *viz*., Plant height, number of branches plant^{-1}, dry matter accumulation, number of capsules plant^{-1}, seed yield plant^{-1} (g), test weight (g), seed and straw yield (kg ha^{-1}), GMR and NMR were significantly higher in three irrigations applied at vegetative, elongation and flowering stages but found at par with irrigation at vegetative and seed development stage. In case of nutrient management, the growth and yield contributing characters, yield and monetary returns were significantly increased with the application of fertilizer applied at 125 % RDF (50:50:00 NPK kg ha^{-1}) which was at par with 100 % RDF (40:40:00 NPK kg ha^{-1}).

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is one of the important edible *rabi* oilseed crop in India, widely grown on large scale. It belongs to the family Asteraceae and genus Carthamus. India is the largest producer of safflower in the world with total area and production of safflower 256 thousand hectares and 101 thousand tons respectively and average productivity was 397 kg ha^{-1} during 2013-14 (Anonymous, 2014). In India it is mainly grown in Maharashtra, Karnataka and part of Andhra Pradesh, Orissa and Bihar. In Maharashtra it was cultivated over an area of 161 thousand hectares and had a production of 89.0 thousand tons with average productivity of 576 kg ha^{-1} (Anonymous, 2014). Safflower response to different irrigation regimes plays an important role in safflower seed yield. Suitable irrigation regime increases seed yield primarily through its effect on the number of heads plant^{-1} and the increase is greater in secondary branches maintaining of soil moisture at an adequate level produce more grain and oil yield in safflower (Omidi, 2010). Safflower is a dryland crop so it require less water. But the proper time of irrigation application to crop is very important. So by scheduling of irrigation at proper growth stage of crop helps to increase in the safflower yield. Similarly, to improve production potential of safflower, it is necessary to use proper dose of fertilizer to the crop. Both the irrigation and nutrient management together give best response to increase in yield. The productivity of safflower in Maharashtra is quite low, therefore, it is need to study the effect of scheduling of irrigation and nutrient management to maximize productivity without deterioration of soil.

MATERIALS AND METHODS

A field experiment was conducted at Agronomy farm, College of Agriculture, Nagpur during *rabi* season of 2015-16. The experiment was laid out in split plot design with four different irrigation levels *viz.,* (I_1) irrigation applied at vegetative, elongation and flowering stages, (I_2) irrigation at vegetative and flowering stages, (I_3) irrigation at elongation and seed development stages and (I_4) irrigation at vegetative and seed development as main plot treatments, and three nutrient management *viz.*, F_1-75% RDF (30:30:00 NPK kg ha^{-1}), F_2-100% RDF (40:40:00 NPK kg ha^{-1}) and F_3-125% RDF (50:50:00 NPK kg ha^{-1}) as sub plot treatments forming twelve treatment combinations replicated thrice. The soil of experimental plot was clayey in texture, low in available nitrogen (212 kg ha^{-1}), medium in phosphorus (15 kg ha^{-1}) and organic carbon (0.57 %) and very high in available potash (377 kg ha^{-1}) content and slightly alkaline in reaction (pH 7.8). The crop variety AKS-207 was sown. The growth attributing characters *viz.,* plant height, number of branches plant^{-1} and dry matter accumulation, yield attributing characters and yield *viz.,* number of capsules plant^{-1}, test weight, seed yield plant^{-1}, seed and straw yield (kg ha^{-1}) were studied and recorded at harvest. The gross

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monetary and net monetary return along with B:C ratio were calculated.

RESULTS AND DISCUSSION

Effect on growth characters

The data pertaining to various growth characters studied *viz.*, plant height, number of branches plant^{-1} and dry matter accumulation as influenced by various treatments are presented in table 1.

Effect of irrigation levels

Data in table 1 reveled that plant height, number of branches plant^{-1} and dry matter accumulation (g) significantly influencd due to irrigation levels. It was significantly more with irrigation applied at vegetative stage, elongation stage and flowering stages over rest of the treatment except treatment of irrigation applied at vegetative and seed development stages (I_4).

Nabipour *et al.* (2007) reported significant increase in plant height, number of plant head,1000 seed weight, number of branches plant^{-1} and total dry matter weight. These results might be due to irrigation applied at vegetative, flowering and capsule formation stages indicated adequate moisture conservation in soil, which had been benefited to the crop during growth period, resulted in optimum cell division and their elongation which enhanced plant height.

Effect of nutrient management

Data revealed that plant height of safflower was significantly influenced and higher plant height was recorded by treatment F_3- 125 % RDF (50:50:00 NPK kg ha^{-1}) which was remained at par with F_2- 100 % RDF (40:40:00 NPK kg ha^{-1}). Vishwanath *et al.* (2006) reported that, application of nitrogen was significantly influenced the plant height (81.23 cm), number of leaves plant^{-1} (159.58) number of primary branches plant^{-1} (20.61) and leaf area plant^{-1} (34.97 dm^2 plant^{-1}). Among the different nitrogen levels, 150 and 100 per cent RDN were recorded significantly higher growth attributes as compared to 50 per cent RDN and control in safflower. This might be due to role of nitrogen and phosphorus in growth and development of plant is the established fact, both these elements play vital role in growth and development.

Number of branches plant^{-1} and dry matter accumulation plant^{-1} were significantly more in treatment where 125% RDF (50:50:00 NPK kg ha^{-1}) applied but found at par with 100% RDF (40:40:00 NPK kg ha^{-1}). Rajput *et al.* (2007) reported that growth attributes viz., plant height, plant and dry matter accumulation plant^{-1} were increased significantly with the application of 50:50:00 kg ha^{-1} NPK but at par with the application of 40:40:00 kg ha^{-1} NPK in safflower. Increase in dry matter was due to more availability of nutrients which increased height, number of branches plant^{-1}, fruiting bodies and leaf area plant^{-1} resulting in higher photosynthetic activity and consequently resulting in higher dry matter production.

Effect on yield attributes

Data pertaining to various yield attributes studied are present in table 1.

Effect of irrigation levels

Different irrigation levels significantly influenced yield attributes of safflower. Significantly higher number of capsule plant^{-1}, seed yield plant^{-1},seed and straw yield ha^{-1} was recorded with irrigation applied at vegetative stage, elongation stage and flowering stages (I_1) over rest of the treatments. However, test weight remained unaffected.

Bastia *et al.* (2003) observed that application of 2 post-sowing irrigations at branching and flowering along with 1 per-sowing irrigation resulted in the maximum seed yield of 1,822 kg ha^{-1} being at par with 1 pre sowing and a post-sowing irrigation at branching in safflower grown on black soil. Suryavanshi *et al.* (2007) reported that the application of irrigation at rossete + branching + flowering + seed development stages recorded significantly higher seeds than other irrigation treatments in safflower. Significant increase in number of capsules plant^{-1} due to application of irrigation might be because of significant increase in growth parameters like plant height, number of branches plant^{-1} dry matter accumulation plant^{-1} that helps in transfer of photosynthates from source to sink.

Nabipour *et al.* (2007) studied the effect of water deficit on yield and yield components of safflower and revealed that the different irrigation regimes had a significant effects ($p<0.05$) on the seed, yields (kg ha^{-1}), seed numbers boll^{-1}, harvest index and total dry weight. The highest seed yield (2679 kg seed ha^{-1}) was obtained from the I_1 irrigation regime. I_3 gave the lowest seed yield (1499 kg seed ha^{-1}). Increase in seed yield plant^{-1} might be because of increase in moisture availability and improvement in growth and yield attributes. These results obtained are in confirmation with the findings of Bastia *et al.* (2003), who observed that 2 post-sowing irrigations at branching and flowering stage along with 1 pre-sowing irrigation resulted in the maximum seed yield of 1,822 kg ha^{-1} being at par with 1 pre-sowing and a post-sowing irrigations at branching. Suryavanshi *et al.* (2007) reported that the application of irrigation at rosset + branching + flowering + seed development stages recorded significantly higher seed yield.

Effect of nutrient management

Various nutrient managements significantly influenced yield attributes of safflower. Higher number of capsules plant^{-1} and seed yield plant^{-1} were obtained with F_3- 125 % RDF (50:50:00 NPK kg ha^{-1}) but remained at par with F_2- 100 % RDF (40:40:00 NPK kg ha^{-1}) and significantly more over F_1- 75% RDF (30:30:00 NPK kg ha^{-1}).

Rajput *et al.* (2007) found in safflower that yield components like number of capitula plant^{-1}, weight of capitula, significantly higher with nutrient levels of 50:50:00 kg NPK ha^{-1}. Similarly it recorded higher seed yield hectare^{-1} and oil yield over 20:20:00 kg ha^{-1} NPK, where as it was at par with the application of 40:40:00 kg ha^{-1} NPK. The

Table 1. Growth and yield attributes, yield and economics of safflower as influenced by different irrigation levels and nutrient management

Treatments	Growth attributes			Yield attributes		Yield			Economics		
	Plant height (cm)	No. of branches plant^{-1}	Dry matter accumulation plant^{-1} (g)	No. of capsule plant^{-1}	Test weight (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross Monetary return (Rs. ha^{-1})	Net Monetary return (Rs. ha^{-1})	B:C Ratio
Irrigation levels (L)											
I_1 – Irrigation at vegetative , elongation and flowering stage	91.29	11.89	89.30	28.89	61.7	23.02	1673.38	3916.11	51038	37138	3.67
I_2- Irrigation at vegetative and flowering stage	84.19	8.75	82.72	26.89	57.0	20.75	1450.48	3603.89	44239	30799	3.29
I_3- Irrigation at elongation and seed development stage	86.04	9.67	84.59	27.52	59.2	21.30	1457.90	3816.22	44466	30976	3.30
I_4- Irrigation at vegetative and seed development stage	90.78	10.81	88.18	28.67	60.4	22.80	1596.15	3916.22	48682	35142	3.59
SE (m)±	1.49	0.56	1.25	0.29	0.34	0.46	43.90	51.76	1339	1339	-
CD at 5%	5.18	1.95	4.35	1.01	-	1.61	151.92	179.12	4633	4633	-
Nutrient management (F)											
F_1 (30:50:00 NPK kg ha^{-1})	85.70	9.56	83.56	27.00	57.6	21.02	1475.65	3558.00	45007	29996	2.96
F_2 (40:50:00 NPK kg ha^{-1})	87.68	10.11	87.18	28.00	59.3	22.09	1533.91	3799.17	46784	31122	2.98
F_3 (50:50:00 NPK kg ha^{-1})	90.85	11.18	87.85	28.98	61.9	22.79	1623.88	3938.58	49528	33216	3.03
SE (m) ±	1.34	0.39	0.86	0.43	0.18	0.32	33.88	55.61	1033	1033	-
CD at 5%	4.04	1.19	2.59	1.29	-	0.73	101.57	166.71	3098	3098	-
Interaction (L X F)											
SE (m) ±	2.69	0.79	1.73	0.86	0.36	0.73	67.76	111.22	2066	2066	-
CD at 5%	-	-	-	-	-	-	-	-	-	-	-

entire yield attributes were increased significantly with the increased nutrient management. This might be because of good growth of plant due to easy availability of moisture and absorption of nutrients, which helped in higher metabolic activity and dry matter accumulation, which ultimately reflected yield enhancement.

Significantly higher seed yield and stover yield was obtained with 125% RDF over 75% RDF application. However, it was at par with 100% RDF.

Patil *et al.* (2009) concluded that the yield components like number of capitula plant^{-1} (16.87), weight of seed capitula^{-1} (1.29 g), seed yield plant^{-1} (26.70 g), seed yield ha^{-1} (14.09 q ha^{-1}) were significantly higher with the application of nutrients at the levels of 50:50:00 NPK kg ha^{-1} over the application of 30:30:00 NPK kg ha^{-1}, where as it was found to be at par with the application of 40:40:00 NPK kg ha^{-1} to the safflower crop. Tondare (2011) recorded that the application of 50 kg N ha^{-1} recorded significantly higher seed yield plant^{-1} (23.31 g) and seed yield ha^{-1}(1794.39 kg ha^{-1}). The increase in yield components may be due to vigorous growth, which helped the plant in absorption of higher amount of nutrients from soil. Thus, resulting in beneficial effect of nutrient management on seed yield of safflower.

Economic studies

Data on gross monetary returns, net monetary returns and B:C ratio as affected by various treatments are presented in table 1.

Effect of irrigation level

Significantly higher Gross monetary returns (Rs. 51038) and net monetary returns (Rs. 37138) were registered in the treatment of irrigation applied at vegetative, elongation and flowering stage (I_1) over irrigation at vegetative and flowering (I_2) (Rs.44239 and Rs. 30799 respectively) and irrigation at elongation and seed development stage (I_3) but remained at par with Irrigation at vegetative and seed development stage (I_4). Higher B:C ratio was obtained with irrigation applied at vegetative, elongation and flowering stage (I_1) (3.67) as compared to irrigation at vegetative and flowering (I_2) (3.29) and Irrigation at elongation and seed development stage (I_3) (3.30).

Effect of nutrient management

The gross monetary returns and net monetary returns were significantly influenced due to nutrient management. Nutrient management with 125 % RDF (50:50:00 NPK kg ha^{-1}) recorded significantly higher net monetary returns over 75% RDF (30:30:00 NPK kg ha^{-1}) but it was at par with application of 100% RDF (40:40:00 NPK kg ha^{-1}).

Interaction effect

Interaction effect between irrigation levels and nutrient management were found non-significant in case of growth and yield attributes, yield and monetary returns of safflower.

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NUTRITIONAL QUALITY AND NUTRIENT USE EFFICIENCY OF PIGEONPEA AS INFLUENCED BY POTASSIUM AND SULPHUR

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ABSTRACT

A field experiment was conducted during *kharif* season of 2014-15 to study the response of potassium and sulphur on nutritional quality and nutrient use efficiency in pigeonpea .The experiment was laid out in a factorial randomized block design replicated thrice. The treatment comprised of four levels of potassium viz., K_0-no potassium, K_{15}-15 kg ha^{-1}, K_{30}-30 kg ha^{-1} and K_{45}-45 kg ha^{-1} potassium and three levels of sulphur viz., S_{10}- 10 kg ha^{-1}, S_{20}- 20 kg ha^{-1}, and S_{30}- 30 kg ha^{-1} sulphur. The grain yield of pigeonpea 11.05 q ha^{-1} was significantly increased with the application of 30 kg K_2O ha^{-1} along with recommended dose of N_{25} and P_{50} kg ha^{-1} and significantly increased in yield of pigeonpea 10.80 q ha^{-1} under 20 kg S ha^{-1} along with recommended dose of N_{25} and P_{50} kg ha^{-1}. Maximum protein content was obtained with the application of 45 kg K_2O and 30 kg S ha^{-1} individually having 20.60 and 22.22 %, respectively. Methionine (1.163 mg 100 g^{-1}) and cysteine (1.360 mg 100 g^{-1}) content in pigeonpea increased with the combination of K_{45} S_{20} for methionine and K_{45} S_{30} for cysteine along with the application of 25 kg N and 50 kg P ha^{-1}. Nutrient use efficiency of N, P and K was observed maximum with the application at 30 kg ha^{-1}.Significantly highest grain yield of pigeonpea 11.78 q ha^{-1} was obtained with the interaction of K_{45} S_{20} and it found at par with K_{45} S_{10} , K_{30} S_{20} , K_{30} S_{30} and K_{15} S_{30}. Interaction effect between potassium and sulphur was found significant with respect to methionine, cysteine, calcium and magnesium content in pigeonpea. Maximum total uptake of N (105.67 kg ha^{-1}) in pigeonpea was obtained with combined application of 20 kg S and 45 kg K_2O ha^{-1}.

(Key words: Nutritional quality, nutrient use efficiency, potassium, sulphur, pigeonpea)

INTRODUCTION

Pigeonpea crop is generally cultivated as intercrop with cotton, soybean, sorghum and others. Farmers applied fertilizers to main crop and pigeonpea remains under fertilized. Now a days with increasing demand and prices of pigeonpea, it has been taken as a sole crop with N and P fertilization @ 25 : 50 : 00 kg ha^{-1}.Unlike these nutrients, potassium does not directly participated in formation of a bio molecule, however, it is involved in all processes needed to sustain the plant life. Potassium nutrition is associated with grain quality including the protein. Effective response to K application sets in when levels of potassium satisfies the potassium hunger in soil (Ravichandran and Sriramchandrasekharan, 2011). Inadequate sulphur content (less than 10 ppm) cannot provide sufficient sulphur to meet crop demand resulting in suboptimal yield and quality. Optimum supply of sulphur improves yield and quality of pulse grain. The sulphur use efficiency was observed higher at application 35 kg S ha^{-1} in pigeonpea- groundnut intercropping system (Jat and Ahalawat, 2010). In view of the above the present study was carried out to understand the nutrient use efficiency and quality of pigeonpea.

MATERIALS AND METHODS

Field experiment was conducted during *kharif* season of 2014-15 at Agronomy farm, College of Agriculture, Nagpur in a factorial randomized block design replicated thrice. The pigeonpea variety PKV-Tara was sown by drilling method. The treatment consisted of four levels of potassium viz., K_0- no potassium, K_{15}-15 kg ha^{-1}, K_{30}- 30 kg ha^{-1} and K_{45}- 45 kg ha^{-1} potassium, and three levels of sulphur viz., S_{10}- 10 kg ha^{-1}, S_{20}- 20 kg ha^{-1}, and S_{30}- 30 kg ha^{-1} sulphur. The recommended dose (25 : 50 kg NP hectare^{-1}) was applied to all the treatments. The rainfall distribution during the cropping season was normal and means annual precipitation was 938.4 mm within 37 rainy days. The crop was rainfed during its whole cropping period. The source of fertilizer was Muriate of potash, Bentonite sulphur, Urea and DAP. The soil of the experimental site was clayey, slightly alkaline in reaction and medium in organic carbon and low in available N and P and high in available K. The available sulphur in soil was at critical level of 10.2 mg kg^{-1}.

Treatment wise separate grain and straw samples were collected for analysis of different parameters. Nitrogen was determined using Kjeldahl's method (Piper, 1966). Phosphorus was estimated using vanodo molybdate yellow colour method (Jackson,1973). Potassium was estimated from

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