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RESEARCH PAPER

Effect of irrigation and nitrogen levels on consumptive use, water use efficiency, available nutrients and uptake of summer sesame (*Sesamum indicum* L.)

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Abstract : A field experiment was conducted on summer sesame during summer season of 2012 at Agronomy Department Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to study the effect of irrigation and nitrogen levels on consumptive use, water use efficiency (WUE), available nutrients and uptake of nitrogen in summer sesame. Experimental results revealed that moisture studies, available nutrients like nitrogen, phosphorus and potassium and nitrogen uptake (by grain, stalk and total N uptake) were significantly higher with irrigation scheduling at 1.0 IW/CPE (Irrigation water amount/cumulative pan evaporation) and nitrogen application at 90 kg N ha^{-1}, over rest of the treatments. The nitrogen content in grain, stalk and total were significantly higher with irrigation scheduling at 0.4 IW/CPE which was superior over 0.6 IW/CPE, 0.8 IW/CPE and 1.0 IW/CPE and nitrogen application at 90 kg N ha^{-1} recorded highest nitrogen content in grain, stalk, total and WUE followed by 60 kg N ha^{-1} and 30 kg N ha^{-1}.

Key Words : Irrigation, Sesame, IW/CPE, Available nutrients, N uptake, WUE

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INTRODUCTION

Now-a-days, the need for healthy high-energy nutrition sources is a main concern throughout the world, while the direct share of grains in human food regime has decreased and the share of oil and protein crops as an invaluable substitute has been increased. Therefore, the cultivated area of the latter has been extended, so that the cultivated area of grains has been decreased by 29 million hectares and that of oil seeds has been increased by 75 million hectares (Mirmohan and Ghareh Yazi, 2002). Sesame is an important oil and food seed in traditional agriculture in hot and semi-hot regions. India ranks first in its area and production in world. In India sesame is cultivated on 1.86 million ha area with annual production of 0.81 million ton. Its average productivity (437 kg ha^{-1}) is below than that of the world (489 kg ha^{-1}) (Anonymous, 2010). During the year 2010, Maharashtra produced 0.775 metric tons sesame from an area of 3.79 thousand hectare with the average productivity of 205 kg ha^{-1} (Anonymous, 2010). In

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Maharashtra, sesame is grown as semi-*Rabi* crop in Gadchiroli, Chandrapur, Nagpur, Wardha and Nanded districts. Vidarbha region comprising Nagpur and Amaravati revenue divisions are the most important sesame growing area.

Sesame is probably the second most important oilseed crop next to groundnut. Sesame seeds are rich source of food nutrition, edible oil (48-52%), protein (18-20%). Among agronomic inputs, irrigation and nitrogen are the most important input for boosting the yield and quality of summer sesame. Irrigation scheduling plays an important role in the higher production of summer sesame. Nitrogen is a structural constituent of plant cell and constitutes amino acids, proteins, nucleic acids, etc. It plays important role in plant metabolism and judicious use of limited water for economical crop production with the objective of effective wetting of root zone (Wu *et al*., 2009). Keeping in view the above facts, a study was undertaken to find out the effect of irrigation and nitrogen levels on consumptive use, water use efficiency, available nutrients and uptake of nitrogen.

MATERIAL AND METHODS

A field experiment was conducted on AKT 101 sesame at Department of Agronomy Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during summer season of 2012. Experimental soil was clay lome in texture and slightly alkaline in reaction (pH 7.96). Soil was low in available nitrogen (221.47 kg ha^{-1}), medium in available phosphorus (16.86 kg ha^{-1}), high in available potassium (387.25 kg ha^{-1}) and medium in organic carbon (0.43 %).

The experiment was laid out in Split Plot Design with three replications. Main plot treatments consisted of four levels of irrigation (Irrigation at 0.4 (I_1), 0.6 (I_2), 0.8 (I_3) and 1.0 (I_4) IW/CPE ratios (Irrigation water amount/cumulative pan evaporation), while three levels of nitrogen *viz.*, 30 kg (N_1), 60 kg (N_2) and 90 kg (N_3) N ha^{-1} were taken as sub plot treatments. The crop was subjected to recommended package of agronomic practices to obtain a healthy crop. To study physico-chemical properties of soil, soil samples (0-30 cm depth) from experimental area were collected and composite soil sample was prepared by air drying in shade, powdered and analyzed for determination of physico-chemical properties of soil. The soil samples (0-30 cm depth) from each net experimental plot were collected after harvest of crop. The samples were air dried, powdered and analyzed for estimation of available nitrogen, phosphorus and potassium content.

The available nitrogen from soil was estimated by alkaline permanganate method by Subbaiah and Asija (1956). Easily oxidizable organic nitrogen present in soil was oxidized by potassium permanganate in presence of sodium hydroxide. The ammonia released during oxidation was absorbed in boric acid to convert ammonia to ammonium borate which was then titrated with standard sulphuric acid. From the volume of standard sulphuric acid required for reaction with ammonium borate, the nitrogen was calculated.

The available phosphorus from soil was estimated by Olsen's method (Olsen *et al.*, 1954). Olsen reagent (0.5 M sodium bicarbonate adjusted to pH 8.5) extracts phosphorus from calcium phosphates by lowering the calcium concentration by causing precipitation of calcium as calcium carbonate and thereby increasing the phosphorus concentration in solution. In the filtered extract phosphorus was complexes by adding ammonium molybdate and thereafter reducing the phosphor-molybdate complex in acidic medium. The intensity of the blue colour on reduction provides a measure for the concentration of phosphorus in the extract was read on colorimeter using 660 nm red filters.

The available potassium from soil was determined by neutral normal ammonium acetate extract using Flame Photometer. The available potassium *i.e.* both exchangeable and water soluble potassium in soil was determined in neutral normal ammonium acetate extract of soil. The NH_4 ions provided rapid separation from exchange complex. Shaking followed by filtration carried out the extraction and the concentration of potassium in extract was read on flame photometer.

The moisture percentage was calculated by using following formula :

$$Pw = \frac{WS_1 - WS_2}{WS_2} x100$$

where,

P_W - Moisture per cent of soil sample,

WS_1 - Weight of wet soil sample,

WS_2 - Weight of dry soil sample.

Consumptive use of water under each irrigation treatment was calculated by using following formula :

$$Cu = \sum_{i=1}^{n} \frac{(Mai - Mbi)}{100} xA_i xD_i$$

where,

Cu = Consumptive use of water in mm, for the period between two consecutive irrigations,

Mai = Soil moisture (%) after irrigation,

Mbi = Soil moisture (%) just before irrigation,

n = Number of soil layer,

A_i = Apparent specific gravity of i^{th} layer of soil,

D_i = Soil depth of the i^{th} layer of two consecutive sampling periods.

Water use efficiency for various treatments was calculated by following formula:

$$WUE = \frac{Y}{ET}$$

where,

WUE = Water use efficiency (kg ha^{-1})

Y = Economic yield (kg ha^{-1}) in a particular treatment,

ET = Total evapo-transpiration (mm) *i.e.* CU in concerned treatment.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Moisture studies:

Consumptive use :

From the data presented in Table 1, it is observed that mean total consumptive use was 325 mm. A higher frequency of irrigation increased the consumptive use of water. The highest consumptive use of 455 mm was observed under 1.0 IW/CPE treatment followed by 325 mm under 0.8 IW/CPE, 285 mm under 0.6 IW/CPE and 237 mm under 0.4 IW/CPE. The above results are in line with the findings of Dutta *et al.* (2000).

Different nitrogen levels had shown slight difference in total consumptive use. The highest consumptive use of 328 mm was recorded in 90 kg N ha^{-1} treatment followed by 325 mm under 60 kg N ha^{-1} and 323 mm under 30 kg N ha^{-1} treatment. The above results are in line with the findings of Sarkar *et al.* (2010).

Water use efficiency :

The mean value of water use efficiency was found to be 1.47 kg ha^{-1} mm. The highest water use efficiency

Table 1 : Nitrogen content and its uptake by crop, available N, P_2O_5, K_2O status in soil and water use efficiency (kg ha^{-1} mm) as influenced by different irrigation and nitrogen levels

Treatments	N content (%)		N uptake (kg ha^{-1})			Available nutrients (kg ha^{-1})			Consumptive use (mm)	Water use efficiency (kg ha^{-1} mm)
	Grain	Straw	Grain	Straw	Total	N	P_2O_5	K_2O		
Main plot										
Irrigation levels										
I_1- 0.4 IW/CPE	3.65	0.21	14.08	8.44	22.52	216.60	15.73	352.16	237	1.63
I_2- 0.6 IW/CPE	3.61	0.20	16.50	8.73	25.23	218.88	16.77	357.49	285	1.60
I_3- 0.8 IW/CPE	3.56	0.20	16.75	9.57	26.31	232.09	18.20	362.58	325	1.53
I_4- 1.0 IW/CPE	3.16	0.19	16.98	10.51	27.49	235.98	20.93	364.24	455	1.15
S.E. ±	0.04	0.0002	0.32	0.41	0.72	0.69	0.26	1.35	-	-
C.D. (P=0.05)	0.13	0.01	1.12	1.43	2.49	2.40	0.91	4.68	-	-
Sub plot										
Nitrogen levels										
N_1- 30 kg Nha^{-1}	3.47	0.20	15.67	8.03	23.70	222.36	17.01	357.05	323	1.42
N_2- 60 kg Nha^{-1}	3.50	0.20	16.10	8.96	25.05	226.21	17.52	360.04	325	1.46
N_3- 90 kg Nha^{-1}	3.52	0.21	16.47	10.95	27.41	229.10	19.19	360.24	328	1.55
S.E. ±	0.04	0.0002	0.19	0.23	0.40	0.58	0.33	1.28	-	-
C.D. (P=0.05)	0.12	0.01	0.57	0.68	1.21	1.75	1.00	3.85	-	-
Interaction effect										
S.E.±	0.08	0.00	0.38	0.45	0.81	1.17	0.67	2.57	-	-
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	-
General mean	3.50	0.20	16.08	9.31	25.38	225.89	17.90	359.11	325	1.47

NS=Non-significant

1.63 kg ha^{-1} mm was recorded under 0.4 IW/CPE followed by 0.6 IW/CPE with 1.60 kg ha^{-1} mm, 1.53 kg ha^{-1} mm with 0.8 IW/CPE and 1.15 kg ha^{-1} mm with 1.0 IW/CPE. The above results are in line with the findings of Sharma *et al.* (1989).

The water use efficiency was increased in the levels of nitrogen. It was highest with treatment 90 kg N ha^{-1} (1.55 kg ha^{-1} mm) followed by 60 kg N ha^{-1} (1.46 kg ha^{-1} mm) and 30 kg N ha^{-1} (1.42 kg ha^{-1} mm).

N content :

The data shown in the Table 1 revealed that, the nitrogen content in grain, stalk and total N content were significantly influenced by irrigation levels. Nitrogen content in grain, stalk and total were higher with irrigation scheduling at 0.4 IW/CPE and nitrogen application at 90 kg N ha^{-1}, over rest of the treatments. The interaction between irrigation and nitrogen levels on nitrogen content in grain and straw was found to be non-significant. Higher dry matter production due to increased availability of nitrogen might have increased the nitrogen content. Similar findings were also reported by Ravinder *et al.* (1996); Dutta *et al.* (2000); Garnayak *et al.* (2000) and Sarkar *et al.* (2010).

Uptake of nitrogen :

The data shown in the Table 1 revealed that, the nitrogen uptake by grain, stalk and total N uptake were significantly influenced by irrigation levels. Nitrogen uptake by grain, stalk and total uptake were higher with irrigation scheduling at 1.0 IW/CPE which were superior over 0.8 IW/CPE, 0.6 IW/CPE and 0.4 IW/CPE and nitrogen 90 kg ha^{-1} reported highest nitrogen uptake in grain, stalk and total, followed by 60 kg N ha^{-1} and 30 kg N ha^{-1} irrigation significantly increased the uptake of nutrients by plant. Irrigation through supply of soil moisture increased the nutrient concentration in plant parts as well as the seed and harvested biomass, which resulted in their higher uptake. This might be due to higher grain yield. Similar findings were also reported by Ravinder *et al.* (1996); Dutta *et al.* (2000) and Sarkar *et al.* (2010).

Available N, P and K :

The data pertaining to nutrient status of soil revealed that, irrigation at 1.0 IW/CPE ratio recorded higher available N, P and K, which was significantly superior over 0.8 IW/CPE, 0.6 IW/CPE and 0.4 IW/CPE. Application of 90 kg N ha^{-1} recorded significantly higher available N, P and K. Interaction effect of irrigation and nitrogen levels on available N, P and K was found to be non-significant.

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