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Effect of irrigation method and nitrogen on yield and quality of winter cotton (*Gossypium hirsutum*)

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 1994–95 and 1995–96 at Junagadh, to study the effect of irrigation methods and nitrogen levels on yield and quality of winter cotton (*Gossypium hirsutum* L.). Application of irrigtaion through drip method at 0.8 cumulative pan evaporation (CPE) recorded significantly higher growth and yield attributes, seed-cotton yield, oil content, seed and lint index than surface, alternate furrow method and drip irrigation at 0.4 CPE. Methods of irrigation did not show significant effect fibre length, fineness and bundle strength. Drip irrigation at 0.8 CPE recorded higher water-use efficiency in winter cotton besides water saving to the extent of 15% on unit basis. Almost all the growth and yield attributes, seed-cotton yield, oil content, seed and lint index increased linearly with the increase in nitrogen level from 80 to 120 kg N/ha.

Key words : Irrigation, Drip winter cotton, Nitrogen

Generally, cotton is grown in rainy season, but in Gujarat exploratory trials conducted at Navasari and Bardoli (Surat) during 1978–80 indicated the high potential of winter-planted cotton because of too bright sunshine, low relative humidity, less competition from weeds and better response to applied inputs owing to relatively controlled conditions. As water is one of the crucial factors for crop production, its economic and efficient utilization becomes quite imperative, and various technologies have been adopted for its higher use efficiency. In practice, maintaining available soil moisture at low water tension and almost constant for entire growth period through drip irrigation resulted beneficial in terms of economic yield. Since nitrogenous fertilizer is a costly input, efforts resulted be made to enhance its use efficiency. Loss of nitrogen in conventional method of fertilizer application is a major problem. However, this economical loss could be minimized by adopting drip method of irrigation. Since meagre work has been carried out on nitrogen

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requirement of drip irrigated winter *(rabi)* cotton, particularly in Gujarat, the present experiment was conducted.

MATERIALS AND METHODS

Semi-winter cotton 'G. Cot Hybrid' was sown at 90 cm × 30 cm spacing on 5 October 1994–95 and 28 September 1995–96 at the Instructional Farm, College of Agriculture, Junagadh. The treatments comprising 3 drip irrigation regimes (0.4, 0.6 and 0.8 CPE), alternate furrow and surface irrigation method as a main plot and 3 nitrogen levels (80, 120 and 160 kg N/ha) as subplot treatments, were laid out in split-plot design with 4 replications. The soil was medium black clayey with medium in available nitrogen (256 kg N/ha), phosphorus (31 kg P_2O_5/ha) and rich in potash (290 kg K_2O/ha). The average values of field capacity, permanent wilting point, bulk density, pH and electrical conductivity were 28.17%, 13.41%, 1.45 g/cc, 8.0 and 0.30 dS/m respectively. Entire dose of phosphorus (40 kg P_2O_5/ha) in the form of single superphosphate and one-fourth of the nitrogen as per treatments in the form of urea were applied in the hill at a depth of 8 cm as basal application. The remaining quantity of N was given in 3 equal splits as per treatments at 30, 60 and 90 days after sowing. Three common irrigations, each of 50 mm depth, were given to all the treatments for proper germination of seeds and establishment of crop, first immediately after sowing, second 6–7 and third 22–24 days after sowing. The required quantity of water was measured by water meter and applied at alternate days on the basis of evaporation in drip irrigation method. While in alternate furrow and surface method of irrigation a fixed depth of 50 mm irrigation water was applied at an IW : CPE ratio of 1.0. Plant height, spread, boll size, picked bolls and seed cotton weight/plant were recorded at harvest, while dry matter and green bolls/plant were recorded 150 days after sowing from randomly selected plants. Lint percentage, lint and seed index, oil content were determined after harvest of crop. Fibre fineness, 2.5% span length and bundle strength were measured with the help of micronaire, digital fibrograph and stelometer respectively.

RESULTS AND DISCUSSION

Irrigation method

Irrigation of winter hybrid cotton through drip irrigation method at 0.8 CPE recorded significantly maximum values of most of growth and yield-attributing characters than lower CPE ratios (0.4 and 0.6), surface and alternate furrow method (Table 1). Number of squares/plant and boll size were significantly highest when the crop was irrigated at 0.8 CPE and remained at par with CPE of 0.6. The superiorty of drip irrigation at 0.8 CPE to surface and alternate furrow method for growth and yield-attributing characters could be explained on the basis of moisture and nutrient availability in the soil in respect of these treatments. In drip treatments, the soil remains moist and soft because of alternate day irrigation and that too on the basis of evapotranspiration demand of the crop. Water is released strictly in the root zone drop by drop in right quantity, maintaining soil : air ratio at an optimum level for plant

Table 1. Effect of irrigation methods and nitrogen on growth and yield attributes of cotton (pooled data of 1994–95 and 1995–96)

Treatment	Plant height (cm)	Plant spread (cm)	Dry matter at 150 DAS (g/plant)	Squares/ plant at 150 DAS	Green bolls/ plant at 150 DAS	Boll size (g)	Picked bolls/ plant	Weight of seed cotton/ plant (g)
Method of irrigation								
I_1, 0.4 CPE	57.3	50.5	92.9	3.38	15.0	2.33	15.5	33.2
I_2, 0.6 CPE	61.9	59.1	107.0	4.33	19.2	2.43	20.1	41.6
I_3, 0.8 CPE	64.9	63.4	115.4	4.55	20.8	2.51	21.5	45.2
I_4, Alternate furrow	58.3	53.4	102.3	3.13	18.4	2.42	18.8	39.3
I_5, Surface irrigation	59.4	54.7	106.6	3.28	18.6	2.46	19.2	41.1
CD (P=0.05)	2.52	2.57	3.2	0.35	1.23	0.10	0.79	2.79
Nitrogen (kg/ha)								
N_1, 80	57.1	52.2	96.7	3.32	15.7	2.39	16.2	34.1
N_2, 120	61.1	56.5	107.4	3.71	19.7	2.43	20.3	42.6
N_3, 160	63.0	59.9	110.5	4.18	19.8	2.47	20.6	43.5
CD (P=0.05)	1.35	0.79	1.5	0.19	0.83	NS	0.56	1.77
I × N	NS	NS	NS	NS	NS	NS	NS	NS

DAS, Days after sowing

growth and development. This situation increased the availability of nutrient in soil throughout the growing season, which ultimately resulted in higher growth and development of plant. There was a little improvement in fibre fineness owing to dry moisture regime and bundle strength but slight reduction in fibre length, although the differences were non-significant (Table 2). Constable and Hearn (1981) reported that most of the quality parameters are genetically governed, but minor improvement could possibly made by modifying the plant environments. There was a significant decline in oil content, seed and lint index when the drip irrigation level was reduced from 0.8 to 0.4 CPE, indicating detrimental effect of drier regimes on these characters. Lower seed and lint index at lower moisture regimes was probably the manifestation of stunted plant growth. Adverse effects of decreasing irrigation level on seed and lint index were also reported by Marani and Amirav (1971). The greater oil content in higher regimes of drip (0.8 CPE) might be due to lower plant temperature resulting from continuous and uniform supply of water. These results are in confirmity with the results obtained by Harris *et al.*, (1978).

Application of irrigation through drip method at 0.8 CPE recorded significantly higher seed-cotton yield of 1,486, 1,585 and 1,535 kg/ha during 1994–95, 1995–96 and in pooled results, respectively, but it was at par with drip irrigation at 0.6 CPE during the individual years (Table 2). The drip irrigation at 0.4 CPE, alternate furrow and surface method were remained statistically at par with each other. In drip irrigation, water tension remains low and

almost constant for entire growth period of the crop as compared to surface method (Hapase, 1993). This is perhaps one of the main seasons for getting higher production under drip irrigation. The longer interval between 2 irrigations in surface method resulted in greater soil water tension towards the end of irrigation cycle. This lower availability of soil water may increase the soil temperature as compared to drip irrigation with sufficient moisture (0.8 CPE). Thus, the higher soil temperature along with less available soil moisture may result in closer of stomata which tend to raise the plant body temperature. This would lead to greater respiration and breakdown of the assimilates. This phenominon has special significance in cotton, a C3 plant, where higher temperature is conducive to photo-respiration and resulted in lower seed-cotton yield under surface and alternate furrow method, compared with drip irrigation at 0.8 CPE. These findings are in agreement with those of Vaishnav *et al.* (1995).

Water-use efficiency (WUE) was significantly higher under alternate furrow method than the surface method. This is because of the fact that in alternate furrow method water is applied in alternate furrows, so half quantity of irrigation water is required compared to surface method. In case of drip system, the water-use efficiency was found significantly higher under different CPE levels than surface methods. Greater WUE under these treatments could be ascribed to the minimum water loss through deep percolation, run-off and soil evaporation, as water is applied directly

Table 2. Effect of irrigation methods and nitrogen on quality parameters, water-use efficiency and yield of cotton (pooled data of 1994–95 and 1995–96)

Treatment	Seed index (%)	Lint index (g)	Oil content (%)	2.5% length of fibre (mm)	Fibre fineness (micronarie value, 10^6 g/m)	Bundle strength of fibre (g/tex)	Seed-cotton yield (kg/ha)			WUE (kg/ha-mm)	Total water applied (mm)	Saving of water surface-method (%)
							1994–95	1995–96	Pooled			
Method of irrigation												
I_1, 0.4 CPE	5.39	3.52	18.8	20.43	3.10	47.90	1,043	1,148	1,096	3.01	364	46.2
I_2, 0.6 CPE	5.79	3.76	19.8	21.20	3.14	47.64	1,388	1,475	1,431	3.05	471	30.9
I_3, 0.08 CPE	6.10	3.83	20.0	20.85	3.20	47.14	1,486	1,585	1,535	2.67	578	14.5
I_4, Alternate furrow	5.75	3.65	19.0	20.62	3.08	47.97	1,282	1,414	1,348	3.33	413	38.9
I_5, Surface irrigation	5.83	3.67	19.1	20.81	3.09	4.29	1,312	1,437	1,375	2.02	675	
CD (P = 0.05)	0.39	0.12	0.16	NS	NS	NS	149	129	92	0.20		
Nitrogen (kg/ha)												
N_1, 80	5.47	3.52	19.0	20.72	2.98	47.77	1,111	1,202	1,157	2.40		
N_2, 120	5.90	3.76	19.4	20.93	3.05	47.06	1,357	1,475	1,416	2.94		
N_3, 160	6.00	3.75	19.6	20.69	3.06	46.90	1,439	1,558	1,498	3.11		
CD (P=0.05)	0.30	0.10	0.16	NS	NS	NS	63	76	48	0.10		
I×N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		

near the root zone of crop is in right quantity. Mean water saving to the tune of 46.2, 38.9, 30.9 and 14.6% was achieved under drip irrigation at 0.4 CPE, alternate furrow method, drip irrigation at 0.6 and 0.8 CPE, respectively, compared to surface method (Table 2).

Effect of nitrogen

Almost all the growth and yield-attributing traits progressively increased with the increase in N levels from 80 to 160 kg/ha (Table 1). Significantly highest values of plant height (63.0 cm), spread (59.9 cm), dry matter (110.5 g/plant), number of squares (4.18), green bolls (19.8), picked bolls (20.6) and weight of seed cotton/plant (43.5 g) were recorded when crop fertilized with N @ 160 kg/ha and found at par with 120 kg N/ha for green bolls and picked bolls/plant. The better growth and yield attributes with higher dose of N may be owing to the fact that as meristamtic tissue have a very active protein metabolism, photosynthates transported to site of growth are used predominalty in the synthesis of nucleic acid and proteins. Thus during the vegetative stage N nutrient of the plant to a larger extent, controls the growth of plant.

Oil content, seed and lint index increased linearly due to N application and the maximum values were recorded at higher nitrogen level of 160 kg/ha (Table 2). These results are identical to those of Al-Hneidi (1994), who obtained positive and significant increase in oil content with increase in N levels from 140 to 380 kg/ha. Reduction in oil content at lower nitrogen levels was possibly the effect of significant decline in phosphorus uptake which is involved in biosynthesis of fats through formation of glycerophosphate. The results are in complete agreement with those reported by Tank (1995). Other quality parameters did not show any significant changes, except fibre fineness and bundle strength which slightly increased with the reduction in N levels.

Response of added N @ 160 kg/ha to seed-cotton yield was significant and recorded significantly highest seed-cotton yield of 1,439, 1,558 and 1,498 kg/ha during 1994–95, 1995–96 and in pooled results, respectively. Higher yield at 160 kg N/ha had evidently resulted from higher values of growth and yield attributes (Tables 1, 2). The main reason for decrease in yield below 160 kg N/ha seems to be lie in general reduction in growth and yield-attributing characters due to short supply of nitrogen. The findings corroborate the reports of Tank (1995). Fertilizing the crop @ 160 kg N/ha recorded significantly higher water-use efficiency than lower levels of N, 120 and 80 kg N/ha. It might be due to higher seed-cotton yield obtained under higher N level. Reduction in N dose, on the other hand tended to decrease water-use efficiency, it was partially because of marked decline in transpiring surface, less stomatal conductance and less extraction of available soil moisture in plant. These results are in line with the findings of Fangmeier *at al.* (1985).

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