Karnataka J. Agric. Sci., 22 (4) (755-758) : 2009

Agronomic response of cotton as influenced by drought management practices*

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(Received : February-2008)

Abstract: A field experiment was conducted during *kharif* season 2004 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the effect of drought management on growth and yield of cotton genotypes under rainfed condition. The experiment was laid out in split plot design, with four genotypes *viz.* Jayadhar, Rahs-14, Abadhita and LRA-5166 and five drought management treatments such as glycine betaine foliar spray @ 3%, proline seed treatment @ 0.1 %, $CaCl_2$ seed treatment @ 2%, integrated drought management (lDM) and control. The results revealed that the genotype Jayadhar recorded significantly higher yield (721.2 kg/ha) and the magnitude of yield increase was 45 per cent higher than the lowest yielding genotype Abadhita (390.0 kg/ha). The yield parameters like yield per plant, number of squares per plant, number of flowers per plant, number of bolls per plant and growth parameters like number of monopodia, leaf area index, leaf area duration, dry matter accumulation were higher with Jayadhar compared to other genotypes. Jayadhar also recorded significantly higher specific left weight and relative water contents. Significant difference among the drought management treatments with respect to growth and yield parameters, specific leaf weight, relative water contents and soil moisture were observed. The integrated drought management treatment recorded significantly higher yield (639.8 kg/ha) and it was 27.5 per cent higher than control (463.86 kg/ha). The growth and yield parameters were higher with IDM treatment compared to other treatments. IDM treatments showed higher soil moisture at 0-30 and 30-60 cm depths. The study indicated that Jayadhar has better agronomic response under rainfed situation and integrated drought management practices help in getting better yields of cotton.

Key words: Cotton, drought, relative water content, glycine betaine, proline

Introduction

Cotton, the white gold is also known as king of fibre crops, and is the main raw material for textile industry. It is the most important global cash crop and controls economy of many nations. Cotton provides gainful employment to several million people in cultivation, trade, processing, manufacturing and marketing, sustaining directly or indirectly about 10 per cent of the population of India. In spite of having over 28 per cent world acreage under cotton, India accounts for only 14 to 15 per cent of the global .on production. The productivity per hectare in our country is 404 kg/ha for the last few years with marginal ups and downs. The world's average is higher at about 688 kg/ha (Anon., 2005). The productivity in our country is lower as 70 per cent of cotton is under rainfed condition, which is characterized by uneven rainfall coupled with drought.

Drought stress significantly limits crop production worldwide. Cumulatively, these factors are estimated to be responsible for an average 70 per cent reduction in agricultural production. Drought stress threatens the ability of many countries to feed themselves. Drought not only causes a reduction in the average yield of crop but also causes, yield instability through high interannual variation in yield. Furthermore, it has been predicted that in the coming years rainfall pattern will shift and become more variable due to increased global temperature. Thus, there is an urgent need to concentrate on the drought management practices to overcome yield losses. Keeping this in view, an attempt was made to study the effect of drought management practices on agronomic response of cotton under rainfed condition.

Material and methods

A field experiment was conducted during *kharif* season of 2004 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on medium deep black soil. The experiment was laid out in split-plot design with three replications. Main plots were allotted with genotypes *viz.,* Jayadhar, Rahs-14, LRA-5166 and Abadhita. Sub-plots were allotted with drought management treatments *viz.,* glycine betaine foliar spray @ 3%, proline seed treatment @ 0.1 %, $CaCl_2$ seed treatment @ 2%, integrated drought management (IDM) and control. The integrated drought management (IDM) treatment comprised of FYM application @ 2 t/ha, seed treatment by $CaCl_2$ @ 2%, wide row planting (90 x 20 cm), mulching, KCl foliar spray @ 0.3% and kaoline spray @ 1.25%. The crop was sown in the month of July with a spacing of 60 x 30 cm. Fertilizers were applied as per the recommendation (40:20:20 N, P_2O_5 & K_2O kg/ha), 50% N, 100% P and K fertilizers were applied as basal and remaining 50% N was applied at 30 DAS. The total rainfall during cropping period was 315.3 mm, received in 33 rainy days. The rainfall during July, August, September, October, November, December, January and February was 45.5, 117.9, 30.8, 117.8, 3.2, 0, 0, 0 and rainy days were 10, 18, 4, 10, 1, 0, 0, 0, respectively. The soil moisture was measured by following the gravimetric method.

Result and discussion

Genotypes differ significantly with yield potential depending on many factors and are the resultant of a complex

* Part of M.Sc. (Agri) thesis submitted by the first author to the University of Agricultural Sciences, Dharwad - 580 005, India.

Table1. Effect of drought management practices on growth, yield and yield parameters in cotton genotypes under rainfed condition

	Plant height (cm)	Leaf area index	Leaf area duration (days)	Total dry matter accumulation (g)	No. of monopodial branches per plant	No. of sympodial branches per plant	No. of bolls per plant	Seed cotton yield (g/plant)	Seed cotton yield (kg/ha)
Genotypes (G)									
G1 - Abadhita	73.10	0.36	48.20	82.80	3.95	11.63	9.82	7.06	390.0
G2 - LRA-5166	79.68	0.47	54.50	87.00	4.69	11.74	12.56	8.26	455.6
G3 - Rahs-14	98.06	0.75	65.30	97.53	5.35	13.37	13.09	10.91	604.5
G4 - Jayadhar	104.19	0.86	78.54	103.86	6.73	14.76	14.46	12.98	721.2
S.Em±	1.249	0.016	0.58	0.785	0.088	0.234	0.219	0.224	11.056
CD at 5%	4.323	0.055	2.00	2.718	0.306	1.225	0.759	0.774	38.269
Treatments (T)									
T1 - Glycine betaine @ 0.3% foliar spray	89.34	0.63	62.49	94.91	5.36	13.20	12.67	9.80	543.13
T 2 - Proline @ 0.1 % seed treatment	87.09	0.57	59.51	90.25	4.90	12.20	11.96	9.08	504.16
T 3 – $CaCl_2$ @ 2% seed treatment,	89.08	0.66	64.40	93.66	5.46	13.59	13.05	10.16	563.89
T4 – IDM (FYM 2 t/ha, $CaCl_2$ 2% seed treatment, Wide row, Mulch, KCl 0.3%, Kaoline 1.25%)	92.53	0.70	66.95	98.16	5.77	14.25	13.86	11.56	639.89
T5 - Control	85.75	0.50	54.78	87.00	4.39	11.16	10.87	8.43	463.86
S.Em±	1.260	0.017	1.059	1.029	0.096	0.214	0.251	0.224	11.l80
CD at 5%	3.630	0.048.	3.050	2.964 .	0.277	0.829	0.722	0.644	32.21
G x T at same treatment									
S.Em±	2.520	0.034	2.117	2.057	0.192	0.428	0.501	0.447	22.361
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
G x T at same/different treatment									
S.Em±	3.577	0.034	2.136	2.001	0.J93	0.449	0.409	0.458	22.853
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

process occurring in various parts of plant involving many yield and morphological changes which are controlled by both genetic make up and environment. Yield potential of a genotype lies in its ability to produce more number of sympodial branches and bolls per plant. Among the genotypes studied, Jayadhar (721.2 kg/ha) Rahs-J4 (604.5 kg/ha) and LRA-5166 (455.6 kg/ha) recorded significantly higher yield (Table 1), and it was 45, 35 and 14.4 per cent higher than Abadhita (390.0 kg/ha). The higher cotton yield noted in these genotypes could be due to higher yield parameters such as number of sympodial branches, number of bolls per plant, seed cotton yield per plant and the growth parameters such as total dry mater accumulation, leaf area index, leaf area duration and specific leaf weight. The number of sympodial branches per plant in Jayadhar (14.7), Rahs-14 (13.3) and LRA-5166 (11.7) were 21.2, 13.0 and 0.94 per cent higher than in Abadhita (11.63). The number of bolls per plant in Jayadhar (14.4), Rahs-14 (13.0) and LRA-5166 (12.5) was 32.0, 24.6 and 22.2 per cent higher than in Abadhita (9.82)

The total dry matter accumulation in Jayadhar (103.8 g), Rahs-14 (97.5 g) and LRA- 5166 (87.0 g) was 19.4, 10.7 and 4.8 per cent higher than in Abadhita (82.80 g). The leaf area index in Jayadhar (0.86), Rahs-14 (0.75) and LRA-5166 (0.47) was 58.1, 52.0 and 23.4 per cent higher than in Abadhita (0.36). The leaf area duration of Jayadhar (78.59 days), Rahs-14 (65.30 days) and LRA-5166 (54.50 days) was 38.6, 21.8 and 11.6 per cent higher than Abadhita (48.20 days). The genotypes yield levels were less mainly because of insufficient rainfall to meet crop requirement. During cropping period (July-February), 315.3 mm total rainfall was received in 33 rainy days. Cotton crop experienced moisture stress in the months of November, December, January and February as total rainfall of only 3.2 mm was received and it was coincided with critical water requirement of cotton.

The drought management practices studied in this investigation have significantly increased the cotton yield compared to control. The cotton yield per ha due to drought management practices *viz.,* glycine betaine foliar spray, proline seed treatment, $CaCl_2$ seed treatment and integrated drought management recorded significantly higher yield and the extent of increase was 12.4, 8.7, 15.62 and 27.5 per cent higher than the control, respectively. The results in the present study corroborate the findings of Koraddi *et al.* (1992) who also reported 18 per cent higher cotton yield over control by following seed treatment with $CaCl_2$. Similarly, Naidu *et al.* (1995) reported that glycine betaine foliar spray resulted in 22 per cent higher yield over control. Gorham *et al.* (1998) reported that, seed cotton yields were highest with 3 and 6 kg/ha glycine betaine applied at squaring. Glycine betaine dose and time of application also significantly increased total dry matter production. The number of bolls per plant also had more nodes at maturity than the controls. But some of the characters that were not affected included mean boll weight and per cent flower and boll shedding. The integrated drought management recorded significantly higher yield to the extent of 27.5 per cent than control and was also higher their treatments tried individually. In the present study, the higher seed cotton yield in integrated drought management, $CaCl_2$ seed treatment, glycine betaine foliar spray and proline seed treatment is attributed to improvement in yield and growth parameters.

The number of sympodial branches per plant in glycine betaine foliar spray, proline seed treatment, $CaCl_2$ seed treatment and integrated drought management were 15.5, 8.5, 17.8 and 21.6 per cent higher than the control. The number of bolls per plant in glycine betaine foliar spray, proline seed treatment, $CaCl_2$ seed treatment and integrated drought management were 14.2, 9.1, 16.7 and 21.5 per cent higher than control. Leaf area index in integrated drought management treatment was 28.6 per cent higher than control. The leaf area duration in integrated drought management was 18.17 per cent higher than control, this is due to presence of higher moisture content over control and also due to use of anti-transparent and reduction in water loss. Among the genotypes, Jayadhar recorded significantly more soil moisture content (20.01 % & 23.64 % at 0-30 cm and 30-60 cm soil depth, respectively) as compared to Abadhita (16.33% & 18.44% at 0-30cm and 30-60 cm soil depth respectively) and it was followed by Rahs-14. Among the treatments, integrated drought management recorded significantly more soil moisture content (21.80 % & 23.32 % at 0-30 cm and 30-60 cm soil depth, respectively) over control treatment (15.62% & 18.88 % at 0-30 cm and 30-60 cm soil depth, respectively).

The results with respect to specific leaf weight and relative water contents differed significantly among different genotypes and drought management treatments at different stages of crop growth (Table 2). Among the genotype, Jaydhar recorded significantly higher specific leaf weight of 833.8 mg/dm^2 and 771.9 mg/dm^2 at 135 DAS and at harvest respectively as compared to Abadhita. But at early stage of crop growth ie at 45 DAS and 90 DAS the LRA - 5166 genotype recoded significantly higher specific leaf weight as compared to other genotypes. Where as in case of relative water content, the Jaydhar recorded significantly higher relative water content of 90.65 %, 83.12 % and 67.78 % at 60 DAS, 100 DAS and 140 DAS respectively as compared to Abadhita. The results with respect to specified leaf weight are in conformity with the results of Bharadwaj et.al (1988).

Among drought management treatments, the integrated drought management treatment recorded significantly higher Specific leaf weight of 623.3 mg/dm^2, 705.3 mg/dm^2, 854.6 mg/dm^2, 747.3 mg/dm^2 at 45 DAS, 90 DAS, 135 DAS and at harvest, respectively and also higher relative water content ie 93.15%, 79.91% and 66.86% at 60 DAS, 100 DAS and 140 DAS as compared to control and it was followed by $CaCl_2$ seed treatment, glycine betaine foliar spray and proline seed treatment. Similar results were reported by Patil (1987) in sorghum and Amaregouda *et.al.*(1994) in wheat.

Table 2. Effect of drought management practices on specific leaf weight and relative water content at different growth stages in cotton genotypes under rainfed condition.

	Specific leaf weight (mg/dm^2)				Relative water content (%)		
	45 DAS	90 DAS	135 DAS	At harvest	60 DAS	100 DAS	140 DAS
Genotypes (G)							
G1 - Abadhita	670.4	689.9	709.1	627.86	84.76	60.69	48.34
G2 - LRA-5166	712.6	435.02	758.4	630.30	86.23	70.88	59.87
G3 - Rahs-14	393.2	529.9	814.2	724.8	88.72	73.40	63.25
G4 - Jayadhar	490.8	560.6	83.8	771.9	90.65	83.12	67.78
S.Em±	26.47	16.82	14.31	10.27	1.481	0.981	0.797
CD at 5%	91.60	58.23	49.54	35.54	5.127	3.394	2.758
Treatments (T)							
TI - Glycine betaine @ 0.3% foliar spray	568.7	643.3	803.8	702.6	88.45	73.87	60.62
T2 - Proline @ 0.1% seed treatment	571.5	609.7	763.2	663.2	86.20	70.77	57.34
T3 - $CaCl_2$ @ 2% seed treatment,	597.4	677.9	832.8	730.17	89.23	75.05	62.85
T4 - IDM (FYM 2 t/ha, $CaCl_2$ 2% seed treatment, Wide row, Mulch, KCI 0.3%, Kaoline 1.25%)	623.3	705.3	854.6	747.3	93.15	79.91	66.86
T5 - Control	472.6	508.1	640.2	600.2	80.93	62.49	51.37
S.Em±	27.58	17.20	14.65	9.60	1.498	1.400	0.955
CD at 5%	79.44	44.55	42.21	27.67	4.316	4.033	2.750
G x T at same treatment							
S.Em±	55.15	34.40	29.30	19.21	2.990	2.800	1.909
CD at 5%	NS	NS	NS	NS	NS	NS	NS
G x T at same/different treatment							
S.Em±	55.98	35.06	29.86	20.02	3.062	2.689	1.884
CD at 5%	NS	NS	NS	NS	NS	NS	NS

Table 3. Effect of drought management practices and genotypes at different depth on soil moisture under rainfed condition

	Soil moisture at 140 days after (0-30 cm)	Soil moisture at 140 days after (30-60 cm)
Genotypes (G)		
G1 - Abadhita	16.33	18.44
G2 - LRA-5166	17.47	20.06
G3 - Rahs-14	18.56	21.80
G4 - Jayadhar	20.01	23.64
S.Em±	0.439	0.475
CD at 5%	1.520	1.645
Treatments (T)		
T1 - Glycine betaine @ 0.3% foliar spray	17.38	20.90
T2 - Proline @ 0.1 % seed treatment	17.38	20.25
T3 - $CaCl_2$ @ 2% seed treatment,	18.28	21.58
T4 - IDM (FYM 2 t/ha, $CaCl_2$ 2% seed treatment, Wide row, Mulch, KCl 0.3%, Kaoline 1.25%)	21.80	23.32
T5 - Control	15.62	18.88
S.Em±	0.503	0.650
CD at 5%	1.449	1.874
G x T at same treatment		
S.Em±	1.006	1.30 I
CD at 5%	NS	NS
G x T at same/different treatment		
S.Em±	1.001	1.257
CD at 5%	NS	NS

Under rainfed condition plant will suffer from terminal drought stress. The drought affects plant by reduction in soil moisture, excess transpiration from plant, stomatal activity is affected, for germination plant will take longer time, plant will lose turgor pressure, cytoplasm shrinks and plant cell losses water. IDM will takes control over these all factors, the mulching increases the soil moisture content, infiltration rate and conservation of soil moisture by suppressing excess evaporation. The FYM application increases the water holding capacity of the soil, infiltration rate and total porosity (Loganathan, 1990). The application of antitranspirant reduces excess transporation, increases leaf water potential and relative water content (Moreshet *et al.,* 1978). Seed hardening has been reported to induce drought resistance in the plants. The hardened seeds have usually greater capacity to withstand dehydration and over heating. The other beneficial effects of hardening are inducing better root growth, higher rate of photosynthesis and more dry matter accumulation (Hanckel, 1964). The KCl spray plays an important role in osmoregulation and helps in maintaining turgor pressure, thereby IDM enables the plant to acclimatize to the soil moisture stress. Thus the present study indicates that Jayadhar genotype is better under rainfed situation and IDM helps in attaining good cotton yields.

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