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Effect of moisture stress on cotton genotypes

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Abstract
The seeds of ten cotton *(Gossypium hirsutum)* genotypes *viz*., AKH-09-5, AKH-2012-8, AKH-1301, AKH-1302, NH-545, AKH-9916, AKH-8828, PKV Rajat and NH-615 were sown in three replications. One set of genotypes was grown in field condition and another set was placed under rainout shelter, both were replicated thrice. The present investigation was conducted during *kharif* season of 2018-19 in Randomized block design at the experimental field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) under non stress and water stress condition. The conducted experiment indicates the physiological response of cotton genotypes at different level of water stress. Under control condition pot culture was maintained with desired quantity of irrigation up to initiation of bolls. Water stress was imposed at initiation of bolls for 12 days for every genotype and replication wise. Second stress was imposed 12 days after first stress. Genotypes under water stress condition was sown in 90 earthen pots with five holes of 2.5 cm deep. Different morpho-physiological traits like plant height, number of leaves, leaf area, total dry matter production, root length, root: shoot dry weight ratio, relative leaf water content, proline content, total chlorophyll content, chlorophyll stability index, yield and yield contributing characters were studied to determine the effect of moisture stress on genotypes. The result indicates that genotypes under water stress condition (control condition) were more affected by moisture stress while field condition retained the regular growth habits of genotypes (except in some environmental conditions).

Keywords: Moisture stress, cotton, water stress, physiological response

Introduction

Cotton is one of the most valuable crop for providing natural fibers for the textile industry globally. China, the United States, India, Pakistan, Uzbekistan, Turkey, and Brazil are the seven largest producers of cotton worldwide, while China, the United States, the Franc Zone of Africa, Uzbekistan, Australia, and India are the five leading exporters (Sahito *et al*., 2015) [14] China, the United States, and India provide most of the world's cotton. The productivity of cotton is detrimentally affected by biotic and abiotic stresses, such as fungi, harmful insects, drought, and soil salinity. Among abiotic stresses, drought was found to be the most serious stress that reduced cotton yields significantly. In India, maximum area of cotton cultivation, particularly hot and dry region of central and south zone under rainfed condition limits productivity due to moisture stress. Irrigated cotton partially solves the problem in north India, where productivity is higher than the rainfed condition (Anon., 2016).

Drought is one of the most critical abiotic stresses that limit crop growth and productivity worldwide. Drought is considered a multidimensional stress that leads to changes in the physiological, morphological, ecological, biochemical, and molecular characteristics of plants. The symptoms of drought stress also vary with the plant species, developmental stages, growth conditions, and the environmental factors (Bhargava *et al.*, 2013) [10]. Severe drought stress also inhibits photosynthesis of plants by causing changes in the chlorophyll content and damaging the photosynthetic apparatus (Dalton *et al*., 1998) [11]. The accumulation of proline in the tissues of numerous plant species is regarded as a common response to drought as well as other types of stresses (Per *et al*., 2017) [12]. Proline is a compatible osmolyte that controls osmotic regulation and alleviates stress in cell membranes. It also acts as a protective agent for enzymes' function and as a free radical scavenger (Kishor *et al*., 2014) [13]. Insufficient soil moisture can affect developing organs especially during blooming, flowering, and fruiting stages resulting in the negative effect on plant morphological traits and yield components (Soomro *et al*., 2011) [15].

Material and Methodology

The experiment was carried out on the experimental field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola located at 304.415meter altitude, 20º30' N latitude and 72º02' longitude during *Kharif* season of during *Kharif* season of 2018-19. Ten genotypes of *G. hirsutum* AKH-09-5, AKH-2012-8, AKH-1301, AKH-1302, NH-545, AKH-9916, AKH-8828, PKV Rajat and NH-615 were tested. Observations were recorded at 30, 60, 90, 120 days after sowing and at harvest.

A. Water stress condition

Pot culture was maintained with desired quantity irrigation up to initiation of bolls. Water stress was imposed at initiation of bolls for 12 days for every genotype, replication wise. Second stress was imposed 12 days after first stress. 90 earthen pots of 18×17×10 inch were maintained for water stress condition (3 pots per genotypes per replications). Five holes of 2.5 cm deep around the periphery were made in each pot and two seeds were sown per hill. After germination seedlings were thinned and maintained one plant per hill, thus there were three seedlings per pot was maintained. 120 polybags were sown as separate set for root parameter and dry matter production studies.

B. Non stress condition

Ten genotypes of *Gossypium hirsutum* replicated thrice at spacing of 60cm×30cm in field condition.

Result and Discussion

Effect of moisture stress on morpho-physiological characters

The result of conducted experiment revealed that the moisture stress imposed on *G. hirsutum* genotypes reduced both the growth and the yield significantly by means of affecting morpho-physiological characters of cotton genotypes. Plant height, number of leaves and leaf area was less under control (water stress) condition after the imposition of water stress in all genotypes than genotypes in field condition. Moisture stress severely restricted cotton growth and development, in terms of affecting plant height, leaf dry weight, stem dry weight, leaf area index, node number and root development (Loka *et al*.,2011) [6]. When compared with genotypes of field condition, genotypes of stressed condition were significantly less in total dry matter production. As water stress imposed to the genotypes, plant lead to reduction in the number of leaves and the growth which resulted in the reduction in leaf area and total dry matter of plants.

Relative leaf water content (RLWC) was maintained during initial growth stages of crop under both conditions but after imposition of water stress to the set of pot culture RWC starts to decline gradually during later stages up to the harvest. Ananthi *et al.* (2013) [1] reported that, significant decrease in RLWC under moisture stressed condition is due

to reduced absorption of water from the soil and inability to control water loss through the stomata.

Both root length and root: shoot ratio were less in stressed condition as compared to genotypes of field condition. Zhang *et al.* (2017) [8] stated that, root growth rates are commonly employed for estimating crop yield losses in cotton crop. Insufficient soil moisture restricts root growth and development and consequently impairs functioning of the aerial parts.

Number of monopodial and sympodial branches were also reduced in stressed condition which significantly affected the number of bolls and ultimately seed cotton yield. Near about all genotypes were significantly affected by moisture stress under pot culture where few genotypes like AKH-9916, AKH-8828, AKH-1301 and AKH-1302 respond better than the other genotypes for different individual characters. Drought stress causes a wide range of adverse effects on physiological traits as well as productivity of cotton crop (Fang *et al*.,2015) [2].

Effect of moisture stress on biochemical characters

Proline content was observed to be increased in pot culture (stressed condition) in response to moisture stress. Proline is the amino acid which is produced by plant to resist the drought stress/ abiotic stress. When genotypes of controlled condition were imposed by water stress, plants started synthesis of proline in response to stress. Therefore, the content of proline was less in genotypes of field condition (non-stress). Iqbal *et al.* (2016) [3] have reported that the accumulation of proline in drought-tolerant and drought-sensitive cultivars has revealed the significance of this osmolyte. Total chlorophyll content was lowered by pot culture during later stages of plant growth due to insufficient water content in plant. Zhang *et al.* (2017) [8] stated that, stomata closing in response to moisture stress results in a reduction in leaf photosynthetic capacity resulting in chloroplast dehydration and decreased CO_2 diffusion into the leaf. Chlorophyll stability index (CSI %) was found higher in the genotypes which were affected little by water stress. Sampathkumar *et al.* (2014) [7] stated that, a higher CSI helps the plants to withstand moisture stress through better availability of chlorophyll. The sufficient moisture level in the plant root zone might be the reason for higher CSI.

Effect of moisture stress on yield and yield attributes

Accelerated abscission of fruits and leaves in drought-stressed cotton crop could be associated with final yield reduction (Pettigrew, 2004). Number of bolls per plants were reduced in genotypes of stressed condition as a result of reduced plant growth and water content of plant. Number of bolls were higher in non-stress condition (field condition) due to the sufficient fulfillment of water requirement of plants which resulted in higher seed cotton yield than the water stressed genotypes. Water stress affected directly on the yield of crop when occurred during the later stages of growth. Reduced or improper boll formation in stress genotypes lead to reduction in test weight of seeds. Genotypes which were sown on field without moisture stress produced better seed cotton yield than the water stressed plants. Genotypes which gave better physiological response under stress condition (AKH-9916, AKH-8828, AKH-1301 and AKH-1302) also produced higher seed cotton yield than other stressed genotypes. These genotypes also performed better in field condition than other. In cotton, the sensitivity to drought stress during flowering and boll development has been well established and insufficient soil water at this stage lead to a reduced plant height, number of fruiting branches, boll shedding, developed bolls and seed cotton yield (Loka *et al.,* 2012) [5].

Table 1: Observations of morphological characters of *G. hirsutum* at 120 DAS/ At harvest

Sr. No.	Genotypes	Plant height (cm)		No. of leaves		Leaf area (cm^2/plant)		Total dry weight (gm/plant)		RWC (%)	
		At Harvest		120 DAS		120 DAS		At harvest		120 DAS	
		Non stress	stress	Non stress	stress	Non stress	stress	Non stress	stress	Non stress	stress
1	AKH-09-5	81.07	68.78	53.83	33.96	1687.56	952.02	47.66	26.50	76.13	67.20
2	AKH-2012-08	76.49	62.00	56.60	30.26	1798.69	744.41	44.03	22.73	70.80	65.13
3	AKH-1301	83.35	69.21	60.60	35.16	1930.50	980.60	51.06	32.23	79.36	66.16
4	AKH-1302	88.07	73.40	59.83	31.16	1892.41	887.31	55.96	29.30	76.76	68.96
5	P-688	76.53	64.39	55.10	26.03	1764.31	745.77	43.00	22.80	70.86	63.03
6	NH-545	70.76	57.54	43.76	20.66	1382.40	590.73	39.20	16.76	59.96	53.00
7	AKH-9916	87.6	77.88	61.83	36.13	1965.44	1030.04	58.20	33.53	78.50	70.86
8	AKH-8828	84.61	73.79	62.43	31.23	1917.19	864.91	55.33	30.63	75.83	68.56
9	PKV Rajat	78.43	69.80	45.73	27.23	1459.27	754.81	50.50	25.73	72.53	60.40
10	NH-615	74.78	61.15	50.53	22.09	1656.03	632.99	47.30	19.66	65.26	56.93
	GM	80.17	67.79	55.02	29.47	1745.38	818.36	49.22	25.99	72.60	64.02
	SE(m±)	1.30	1.86	1.42	0.84	38.72	28.88	1.51	0.51	1.29	1.48
	CD@5%	3.87	5.54	4.23	2.50	115.05	85.83	4.49	1.54	3.84	4.41

Table 2: Observations of biochemical and root characters of *G. hirsutum* at 120 DAS/ At harvest

Sr. No.	Genotypes	Proline content (µg/g fresh weight)		Total chlorophyll content (mg/g fr.wt.)		Chlorophyll stability index (%)		Root Length (cm)		Root: shoot dry weight ratio	
		120 DAS		120 DAS		120 DAS		At harvest		At harvest	
		Non stress	stress	Non stress	stress	Non stress	stress	Non stress	stress	Non stress	stress
1	AKH-09-5	65.03	71.16	1.26	1.01	29.82	20.41	53.13	40.73	0.263	0.140
2	AKH-2012-08	62.56	74.13	1.34	1.50	29.07	18.89	55.03	43.86	0.273	0.196
3	AKH-1301	50.43	81.80	1.86	1.54	32.65	24.89	56.43	49.53	0.303	0.250
4	AKH-1302	58.26	79.33	1.16	1.06	31.88	21.56	57.66	42.46	0.343	0.233
5	P-688	59.63	75.76	1.96	1.10	26.25	19.32	51.90	43.70	0.280	0.213
6	NH-545	42.90	69.16	1.36	1.05	23.51	18.72	47.96	37.66	0.253	0.163
7	AKH-9916	63.83	81.46	1.90	1.76	34.92	28.67	55.43	47.56	0.330	0.230
8	AKH-8828	60.60	77.26	1.53	1.37	32.96	22.48	53.40	51.83	0.270	0.183
9	PKV Rajat	51.63	70.50	1.50	1.45	24.24	16.42	49.43	40.93	0.226	0.173
10	NH-615	52.20	68.93	1.20	1.22	20.80	15.20	48.23	38.56	0.240	0.143
	GM	56.71	74.95	1.51	1.30	28.61	20.65	52.86	43.68	0.278	0.193
	SE(m±)	1.09	1.22	0.12	0.07	1.58	0.71	1.44	1.66	0.021	0.017
	CD@5%	3.26	3.64	0.36	0.23	4.71	2.12	4.30	4.96	0.065	0.052

Table 3: Observations of yield and yield attributes of *G. hirsutum* at harvest

Sr. No.	Genotypes	Number of bolls per plant		Seed cotton yield (gm/plant)		Test weight (gm/plant)	
		At harvest		At harvest		At harvest	
		Non stress	stress	Non stress	Non stress	stress	Non stress
1	AKH-09-5	13.96	9.03	38.96	25.03	96.88	74.54
2	AKH-2012-08	14.36	9.20	41.70	23.80	84.69	65.79
3	AKH-1301	15.26	10.4	47.13	31.63	92.20	69.91
4	AKH-1302	13.30	10.16	49.23	30.06	86.36	70.98
5	P-688	14.16	8.70	43.40	29.63	87.09	71.87
6	NH-545	10.73	7.13	32.03	19.43	78.86	69.61
7	AKH-9916	17.10	10.46	50.53	36.36	98.12	73.63
8	AKH-8828	16.40	10.40	48.66	34.86	92.11	71.29
9	PKV Rajat	13.46	9.90	40.84	29.96	84.20	68.04
10	NH-615	12.83	8.66	49.80	29.83	86.67	65.44
	GM	14.16	9.40	44.23	29.06	88.72	70.11
	SE(m±)	0.66	0.35	0.82	0.82	1.24	0.44
	CD@5%	1.98	1.05	2.44	2.45	3.69	1.31

Conclusion

In the given investigation, genotypes were tested under water stress and non-stress condition to determine the effect of moisture stress on cotton genotypes (*G. hirsutum*). Water stress imposed on pot culture affected both vegetative and reproductive growth of genotypes due to the necessity of water at every stage of crop growth. Generally, stress symptoms are mostly observed in the leaves of plants showing loss of turgor, drooping, wilting, etiolation, yellowing, and premature downfall. Stress occurrence during vegetative and flowering stages of crop may lead to decreased yield of crop. Seed cotton yield was also reduced in moisture stressed condition, where genotypes of field condition were influenced with normal growth and yield.

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