Pak. Jour. Agri. Sci.
23 (1), 31, 1986

RESPONSE OF COTTON TO TRANSIENT OXYGEN STRESS

Nazir Ahmad, R. H. Qureshi and Abdul Aziz Cheema

Effect of transient oxygen stress on cotton at various growth stages of cotton was investigated in soil culture under wirehouse conditions during 1981-83. Eighteen days submergence at pre-flowering stage markedly retarded cotton plant growth. Submergence for 7 days of 15-day old plants was as deleterious as submergence for 14 days of 35-day old plants indicating that cotton was more sensitive to oxygen stress at early stages of growth. Longer period (10-days) of sumbergence proved more detrimental to 1-2 weeks old plants than the short submergence period (5 days).

INTRODUCTION

Although Pakistan ranks fifth in the world as far as the cotton acrage is concerned, yet its yield per unit area is low due to multiple factors; salinity and waterlogging being the most detrimental. Active growth period of cotton coincides with the rainy season and heavy rains often cause temporary flooding in the fields depending upon the watertable and infiltration rate of the soil.

Flooding fills the soil pore space with water and gas exchange between soil and atmosphere is virtually eliminated. The rate at which dissolved oxygen in the soil water is depleted depends sensitively on the soil temprature and respiration rate of roots and microorganisms (Drew, 1983). With warm temperatures depletion may be complete in only hours (Trought and Drew, 1980; Trought and Drew, 1982). At the same time, the ability of cotton roots to survive continuously anaerobic conditions is of short duration, ranging from 0.5-3.0 h (Huck, 1970) and cotton growth is adversely affected by lack of oxygen. In this paper we report the response of cotton to transient oxygen stress at different stages of growth cycle.

MATERIALS AND METHODS

The methodology used in various experiments is briefly described below.

Experiment 1

Cotton variety B-557 was grown in pots containing 10kg normal sandy clay

*Deptt. of Soil Science, University of Agriculture, Faisalabad.

loam soil. At preflowering stage plants were subjected to different degrees of transient oxygen stress using canal water and synthetic saline water of EC 3 dS m^{-1} and SAR 15. After the stress period (18 days) normal irrigation was maintained with respective waters. Following treatments were applied according to completely randomized design with five repeats.

T_1 Normal irrigation with canal water throughout the growth cycle (control).
T_2 Irrigation with saline water starting at preflowering stage.
T_3 Saturated condition with canal water for 18 days at preflowering stage.
T_4 Saturated condition with saline water for 18 days at preflowering stage.
T_5 Submerged condition with canal water for 18 days at preflowering stage.
T_6 Submerged condition with saline water for 18 days at preflowering stage.

Experiment 2

Cotton plants were grown as in axperiment No-1 and were submerged with canal water at two growth stages.

Stage I : 15-day old plants.

Stage II : 35-day old plants.

Following treatments were applied in completely randomized design with five repeats :

T_1 Normal irrigation throughout the growth period.
T_2 Submerged conditions for 7 days at stage I.
T_3 Submerged conditions for 14 days at stage II.

Experiment 3

Cotton (var. Express) plants were grown in 10 kg sandy clay loam normal soil contained in glazed pots. One week old (Set-I) and two week old (Set-II) plants were exposed to oxygen stress and cotton response was evaluated after 7 weeks of growth. Experiment was conducted in completely randomized design with three repeats in Set I and four repeats in Set II.

RESULTS AND DISCUSSION

The data presented in Table 1 revealed that cotton growth was significantly affected by various treatments. Saturted soil conditions (T_3 and T_4) markedly decreased the plant height, boll number and dry matter yield as compared with control. The submerged conditlons with both waters (T_5 and T_6) proved the most detrimental. It is clear from the results that the extent of

oxygen stress caused the retardation in plant growth while the quality of water had little effect in this regard. This reduction in plant growth may be attributed to the toxic substances produced under waterlogged conditions (Kramer, 1951; Leyshon and Sheard, 1978). The excess water adversely affected the physiological functions of the root system; probably the absorptive capacity of the root (Minchin *et al.*, 1978).

The data presented in Table 2 show that cotton growth was significantly affected by different periods of submergence at various stages of growth. The survival percentage was the lowest in case of soil submergence for 7 days at the first stage (T_2). The plant mortality was less severe at the second stage (T_3). At this stage a significant improvement in plant survival was expected but because of the increased submergence period, the improvement in plant survival was masked. The results of this experiment indicate that 7 days submergence at first stage was as serious as 14 days submergence at the second stage. This finding is in agreement with the results of the experiments conducted at IRRI (1978) on a number of crops.

Table 1. *Effect of oxygen stress on growth of cotton variety B-557.*

Treatment	Plant height (cm)	No. of Bolls pot^{-1}	Dry matter (g pot^{-1}
T_1	89.6a	9.0b	39.9a*
T_2	98.0a	11.0a	42.8a
T_3	74.6b	3.0a	21.4b
T_4	75.6b	4.0c	23.6b
T_5	59.0c	0.2d	17.1c
T_6	61.4c	0.2d	17.1c

*Mean sharing the same letter differ non-significantly at 5% level.

Table 2. *Effect of submergence period on cotton (Var. B-557) growth at different stages of growth.*

Treatment	Plant survival (%)	Plant height (cm)	Dry matter (g/pot^{-1})
T_1	100a	44.6a	38.0a
T_2	30b	22.2c	12.1c
T_3	33b	29.0b	15.8b

*Means sharing the same letter differ non-significantly at 5% level.

Ten days submergence of one week old plants (Set I) resulted in hundred percent mortality of cotton plants (Table 3). Five days submergence reduced plant height by about 19%, fresh weight by 72% and dry weight by 74%. Water stress (T_2), on the other hand, reduced these growth parameters by 40%, 68% and 77% respectively. This reduction in plant growth by water stress and oxygen stress was statistically significant.

At second stage (Set II), oxygen stress decreased cotton growth significantly compared with control (Table 3). Longer oxygen stress was more serious even at this stage. However, only about 40% of the plants died as compared to 100% plant mortality at the first stage. At this stage, growth sensitivity of the cotton plants to oxygen stress was similar to that at the first stage.

Table 3. *Effect of oxygen stress on cotton (Var. Express) at different stages of growth.*

Treatment	Plant height (cm)	Dry matter (g pot^{-1})
	Set-1 (One week old plants)	
Control	32.8a	19.2a*
Submergence for 5 days	26.5b	5.0b
Submergence for 19 days**	—	—
	Set II (Two week old plants)	
Control	26.9a	11.9a
Submergence for 5 days	19.5b	3.4b
Submergence for 10 days	13.4c	1.4c

*Mean sharing the same letter differ non-significantly at 5% level.

**All plants died.

REFERENCES

Drew, M.C. 1983. Plant injury and adaptation to oxygen deficiency in the root environment; A review. Plant and Soil 75 : 179-199.

Huck, M.G. 1970. Variation in tap root elongation rates as influenced by composition of the soil air. Agron. J. 62 : 815-818.

IRRI. 1978. Susceptibility of six upland crops to periodic flooding. Annual Report, IRRI, 1977. pp. 440-441.

Kramer, P.J. 1951. Causes of injury to plants resulting from flooding of the soil. Plant Physiol. 27 : 722-736.

Leyshon, A.J. and R.W. Sheard, 1978. Growth and yield of barley in flooded soil. Ethylene generation and Eh relationships. Canadian J. Soil Sci. 58 : 347-355.

Minchin, F.R.,R.J. Summerfield, A.R.J. Eaglshan and K.A. Stewart, 1978. Effect of short-term waterlogging on growth and yield of cowpeas. J.Agri. Sci. 90 : 355-356.

Trought, M.C.T. and M.C. Drew, 1980. The development of waterlogging damage in wheat seedlings (*Triticum aestivum* L.) I. Shoot and root growth in relation to changes in the concentrations of dissolved gases and solutes in the soil solution. Plant and Soil. 54 : 77-94.

Trought, M.C.T. and M.C. Drew, 1982. Effects of waterlogging on young wheat plants (*Triticum aestivum* L.) and on soil solutes at different soil temperatures. Plant and Soil 69 : 311-326.