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Effect of Water Stresses on Growth Attributes in Jute I. Plant Height

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Abstract: The plant height was studied in *Corchorus capsularis* (cultivars D-154 and CVL-1) and *Corchorus olitorius* (cultivars O-4 and R-26) grown under various water regimes. The cultivars were grown under constant drought, constant saturation, alternate saturation and drought and different levels of standing water (5 cm, 10 cm, 20 cm and 30 cm) conditions. The cultivar O-4 had been found to be tolerant to drought but susceptible to waterlogging condition, particularly at the young stage. On the tolerance of submersion, the test cultivars could be placed as D-154 > CVL-1 > R-26 > O-4. The plants of CVL-1 became shorter than that of the O-4 in constant drought. On the contrary, the plants of O-4 and R-26 became shorter than that of the CVL-1 and D-154 in standing water conditions. The plants of O-4 and R-26 died earlier when they were exposed to standing water condition in young stage compared to those of the CVL-1 and D-154. It appears that the plant height is highly affected by constant drought in case of *Corchorus capsularis* and by standing water in case of *Corchorus olitorius*. The stressed plants of all the cultivars are shorter than their corresponding control plants.

Key words: Jute, *Corchorus* species, water stresses, plant height

Introduction

Jute plant requires plenty of water for its normal growth. This is particularly true for the later stage of its vegetative growth (Gupta and Dargan, 1970; Kundu *et al.*, 1959; Wahab, 1978). In the seedling stage the jute plant cannot stand waterlogged condition. Young seedlings even cannot withstand water above field capacity (Kundu *et al.*, 1959). The rate of growth of jute plant up to the age of six weeks is always impaired by excess water (Wahab, 1978). The requirement of water at different stages of growth of jute plants has not yet been established.

There are two cultivated species of jute, *Corchorus capsularis* L. and *Corchorus olitorius* L. The former can tolerate more water than the later. The cultivar D-154 of *C. capsularis* is extensively cultivated throughout the country. It is adapted to a broad agro-ecological condition. Quite successfully it can withstand waterlogged condition and drought to some extent. However, the growth feature of this cultivar under different water regimes is not clearly known. The cultivar CVL-1 of *C. capsularis* has recently been released by the Bangladesh Jute research Institute (BJRI), Dhaka. It is considered to be a fast growing, non-branching and high yielding white jute. It's adaptation to water at different stages of growth has not been reported. The adaptability to water of these two cultivars, D-154 and CVL-1, has not been compared.

Most of the cultivars of *C. olitorius* cannot tolerate standing water for long time. However, several cultivars can withstand waterlogging conditions for different periods (Shahnewaz *et al.*, 1984). In Bangladesh, O-4 is the most popular cultivar of *C. olitorius*. It is grown in the flood free area of the country as it cannot stand waterlogged condition. The effect of water in this cultivar at different stages of growth has not yet been investigated thoroughly. The cultivar R-26 of *C. olitorius* can withstand waterlogging condition for several weeks without seriously affecting its growth or even without much deterioration of the quality of its fibre (Anonymous, 1985). This red stemmed cultivar was developed from local varieties of Rajshahi District (Patel and Ghose, 1940). It produces one of the excellent bast fibres but the yield is low. Little is known about its growth feature under different moisture conditions. Therefore, the present work has been undertaken to investigate the effect of water in excess and deficit on plant height of *Corchorus capsularis* cv. D-154, CVL-1 and *Corchorus olitorius* cv. O-4, R-26 at different stages of growth.

Materials and Methods

The two species of jute plant, *Corchorus capsularis* L. cultivar CVL-1, D-154 and *Corchorus olitorius* L. cultivar O-4, R-26, were used for the present investigation. Seeds of these cultivars were obtained through the courtesy of Bangladesh Jute Research Institute (BJRI), Dhaka. With these plant materials, the experiments were conducted in the field and pots.

Field Experiment: The field experiment was conducted in the farm of Kishoreganj Regional Station, BJRI. The experimental plot (0.021 ha) was divided into 4 equal blocks. Each block was again divided into 4 equal plots of 3 m x 2 m in size. The cultivars were sown in the block randomly. The preparation of land, application of fertilizers and sowing of seeds were done as per recommendation of BJRI (Anonymous, 1985). Each block contained all 4 cultivars of jute. The standard methods of cultural practices and plant protection measures were taken as and when required. The crops were allowed to grow under natural climatic condition till the imposition of standing water treatment.

Treatments: The treatments of the field experiment were the control and 10 cm, 20 cm and 30 cm standing water. The control plants of cultivar CVL-1, D-154, O-4 and R-26 were grown in the field under natural conditions of weather till they were 120 days old. When the plants were 45 days old sufficient quantity of water was applied to the plots to submerge the lower parts of the plants up to 10 cm in height. Continuously enough water was supplied to maintain this level of water in each plot. Similarly 20 cm and 30 cm standing water were applied when the plants were 60 and 90 days old respectively. These plants were grown there till they were 12 days old.

Pot experiment: The pot experiment was conducted in the open net houses of Bangladesh Agricultural University, Mymensingh. Plastic pots (height 35 cm, top diameter 33 cm and base diameter 27 cm) were used in this experiment. The pots were sufficiently perforated at the bottom and side (each hole was approximately 5 mm in diameter) for quick drainage of excess water and for proper aeration. Each pot was filled in up to the top with light loam soil thoroughly mixed with

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cowdung at the ratio of 5:1. The soil was collected from the cultivated land of Bangladesh Agricultural University Farm. Fertilizers at the rate of 2 gm urea, 1 gm TSP and 2 gm MP were added with top soil of each pot. The total quantity of TSP and MP and 50% of urea were applied as basal dose and the rest 50% of urea as top dressing. In each pot 30 seeds were sown. On an average 25 of them were germinated. The seedlings were thinned out every week. Ultimately there were 7 or 8 healthy plants in each pot while they were 4 weeks old. Before commencement of the treatments, all the pots were kept under uniform condition of soil moisture of 20-25%. Cultural operations were done following standard procedure of jute cultivation. Plant protection measures were taken as and when necessary.

Treatments

The treatments of the pot experiment were as follows

Control: The plants of CVL-1, D-154, O-4 and R-26 were allowed to grow under natural condition of weather and soil moisture of 20-25%. When the soil moisture went below 20%, sufficient water was added to make it 25%. Excess water ..during heavy rainfall was drained out immediately.

Constant drought: The 30 days old plants of CVL-1 and O-4 were exposed to drought condition (soil moisture 8-10%). When the soil moisture went below 8%, sufficient quantity of water was applied to make it 16%. The plants were grown in this condition till they were 120 days old.

Constant saturation: The 30 days old plants of CVL-1 and O-4 were first exposed to saturated soil moisture condition (44-48%). Water was added 4 times a day so that saturated soil moisture status could be maintained. The plants were grown there till they became 120 days old.

Alternate saturation and drought: The 30 days old plants of CVL-1 and O-4 were exposed to saturated soil moisture condition (44-48%). The plants were allowed to grow in that condition for one week. In the 2nd week, the soil moisture status was within saturation and normal (28-40%). In the 3rd week, the soil moisture became within normal and drought condition (16-24%). In the 4th week, actual drought condition (8-16%) had been found to prevail. The same schedule was repeated and, as such, saturation was maintained in the 1st, 5th and 9th week and the drought condition had been found in the 4th, 8th and 12th week. The plants were grown in this condition till they were 120 days old.

Standing water: The 30, 45, 60 and 90 days old plants of all the cultivars of jute were exposed to 5 cm, 10 cm, 20 cm and 30 cm standing water respectively. These plants were grown there till they were 120 days old or died earlier. For 5 cm standing water treatment, water was directly applied to the pots and a level of 5 cm standing water above soil surface was maintained throughout the remaining period of plant growth. Before adding water to the pots, all the holes were sealed up. For other standing water treatments of 10 cm, 20 cm and 30 cm the water tanks (360 cm x 200 cm x 90 cm) were used. The tanks were provided with outlets so that stagnant or excess water could be expelled from the tanks as and when required. By placing raised platform, the pots were placed in the tank at different heights so that different pots got desired levels of standing water although a constant level of water

was maintained in the tank.

Collection of data: The plant heights of cultivar CVL-1, D-154, O-4 and R-26, grown in the field and pots at different levels of standing water and that of CVL-1 and O-4, grown in the pots at different soil moisture regimes, were recorded at 15 days intervals.

Results

The effects of different levels of soil moisture, such as, drought, saturated soil moisture and alternate saturation and drought condition of soil moisture on the plant height of *Corchorus capsularis* L. cv. CVL-1 and *C. olitorius* L. cv. O-4 were studied. The 30 days old seedlings of these cultivars were exposed to different degrees of water stress and were allowed to grow there till they became 120 days old or died earlier due to water stress. Effects of different levels of standing water on the plant height of CVL-1, D-154, O-4 and R-26 were investigated both in the field and pots. In the pots, the 30, 45, 60 and 90 days old plants were subjected to 5, 10, 20 and 30 cm standing water but in the field, the 45, 60 and 90 days old plants were exposed to 10, 20 and 30 cm standing water respectively. These plants were allowed to grow in standing water till they became 120 days old or died earlier. Plant heights of CVL-1, D-154, O-4 and R-26 cultivars as affected by water in excess or deficit are described below.

CuRiver CVL-1

Control: The cultivar CVL-1 of *Corchorus capsularis* was grown in pots as well as in the field under natural condition of soil moisture. The heights of these plants were 97.2, 137.0, 173.8, 202.6, 228.4 and 249.6 cm in the pots (Table 1) but 106.2, 182.3, 243.0, 279.2, 309.5 and 332.7 cm in the field at 45, 60, 75, 90, 105 and 120 days after sowing (DAS) respectively (Table 2). The plant height was more in the field than that in the pots. The fortnightly increase in plant height was 39.8, 36.8, 28.8, 25.8 and 21.2 cm in the pots (Fig. 1A) but 76.1, 60.7, 36.2, 30.3 and 23.2 cm in the field during the period, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively. From the seedling stage the fortnightly increase in plant height had been found to increase gradually up to 45 DAS in the pots but 60 DAS in the field and then it began to decline which continued throughout the remaining vegetative phase of the plants (Fig. 1A).

Constant drought: The 30 days old plants of CVL-1, exposed to and grown in constant drought condition of soil survived up to 90 DAS. The height of the stressed plants at the age of 45, 60, 75 and 90 days was 80.4, 95.1, 99.2 and 100.8 cm respectively (Table 1). In the present form of constant drought (10-14% soil moisture) the plants did not thrive beyond 90 DAS. The fortnightly increase in height of these plants was 26.8, 74.7, 4.1 and 1.6 cm during the period, 30-45, 45-60, 60-75 and 75-90 DAS respectively. It was found that the fortnightly increase in plant height sharply declined as the duration of drought extended (Fig. 1A). At the age of 60, 75 and 90 days, the heights of the plants, grown in constant drought, were 30.6, 43.0 and 50.2% less than their control plants.

Constant saturation: In the saturated soil moisture condition, the height of CVL-1 plants at the age of 45, 60, 75, 90, 105 and 120 days was 86.5, 111.6, 135.7, 157.3, 176.4 and

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Table 1: Effect of soil moisture and standing water on the plant height (cm) of *Corchorus capsularis* cv. CVL-1 and *C. olitorius* cv. O-4 grown in pots

Treatment	Cultivar	Age of plant (days)						
		30	45	60	75	90	105	120
Control	CVL-1	53.6	97.2	137.0	173.8	202.6	228.4	249.6
	O-4	47.8	92.8	128.9	162.7	191.4	217.8	241.0
Constant drought	CVL-1	80.4	95.1	99.2	100.8	d	d	
	O-4	74.2	91.4	104.8	113.0	118.2	120.6	
Constant saturation	CVL-1	86.5	111.6	135.7	157.3	176.4	194.6	
	O-4	70.0	86.8	101.3	113.9	125.7	135.3	
Alternate saturation and drought	CVL-1	88.4	118.2	141.5	162.0	181.5	197.7	
	O-4	79.6	104.0	123.8	142.4	159.1	173.6	
5 cm standing water	CVL-1	68.2	82.4	95.1	107.5	119.0	128.5	
	O-4	53.8	59.6	62.7	d	d	d	
10 cm standing water	CVL-1		118.0	135.6	151.7	165.9	178.5	
	O-4		100.9	107.1	112.5	d	d	
20 cm standing water	CVL-1			167.4	194.1	215.4	232.5	
	O-4			139.4	148.0	154.4	d	
30 cm standing water	CVL-1				224.6	243.51		
	O-4				201.6	212.0		
S.E.			±1.60	±3.32	±4.14	±4.33	±6.15	±7.09

d = dead

Table 2: Effect of standing water on the plant height (cm) of *Corchorus capsularis* cv. CVL-1 and *C. olitorius* cv. O-4 grown in the field

Treatment	Cultivar	Age of plant (days)					
		45	60	75	90	105	120
Control	CVL-1	106.2	182.3	243.0	279.2	309.5	332.7
	O-4	106.5	173.7	224.9	269.8	303.2	334.4
10 cm standing water	CVL-1	139.9	163.4	184.4	203.1	216.5	
	O-4	124.9	142.8	148.4	151.7*	d	
20 cm standing water	CVL-1		207.5	234.4	256.5	273.1	
	O-4		185.1	196.3	204.7	212.3*	
30 cm standing water	CVL-1				307.9	229.6	
	O-4				279.3	288.5	
S.E.			±1.85	±2.25	±4.09	±4.97	±4.86

d = dead, *75% of the total population died

Table 3: Effect of standing water on the plant height (cm) of *Corchorus capsularis* cv. D-154 and *C. olitorius* cv. R-26 grown in pots

Treatment	Cultivar	Age of plant (days)						
		30	45	60	75	90	105	120
Control	D-154	51.8	93.6	132.2	168.6	197.8	221.2	242.9
	R-26	48.4	90.4	127.8	162.0	192.8	220.4	242.6
5 cm standing water	D-154		68.6	86.2	102.9	117.0	129.2	140.0
	R-26		54.8	61.6	65.9	d	d	d
10 cm standing water	D-154			112.6	130.9	147.2	163.1	176.5
	R-26			105.4	116.6	125.9	132.1	d
20 cm standing water	D-154				159.0	182.8	203.5	219.8
	R-26				146.7	163.3	176.0	185.9
30 cm standing water	D-154						218.9	238.1
	R-26						208.9	221.5
S.E.			±2.25	±2.50	±4.40	±5.84	±5.29	±6.68

d = dead

Table 4: Effect of standing water on the plant height (cm) of *Corchorus capsularis* cv. D-154 and *C. olitorius* cv. R-26 grown in the field

Treatment	Cultivar	Age of plant (days)					
		45	60	75	90	105	120
Control	D-154	108.5	182.9	234.4	273.5	301.7	333.9
	R-26	107.4	176.7	231.1	273.1	306.4	336.1
10 cm standing water	D-154		136.0	180.7	180.7	198.0	210.4
	R-28		128.6	167.2	167.2	180.5	187.2*
20 cm standing water	D-154			231.0	231.0	251.1	265.0
	R-26			220.1	220.1	237.2	249.6
30 cm standing water	D-154					298.1	318.2
	R-26					287.1	302.2
S.E.			±3.05	±2.68	±5.02	±5.50	±5.89

*75% of the total population died

194.6 cm respectively (Table 1). The fortnightly increase in plant height of the stressed plants was 32.9, 25.1, 24.1, 21.6, 19.1 and 18.2 cm during the period, 30-45, 45-60, 60-

75, 75-90, 90-105 and 105-120 DAS respectively (Fig. 1A). In both the stressed and control plants the increase in plant height had been found to be maximum during 45-90 DAS. The

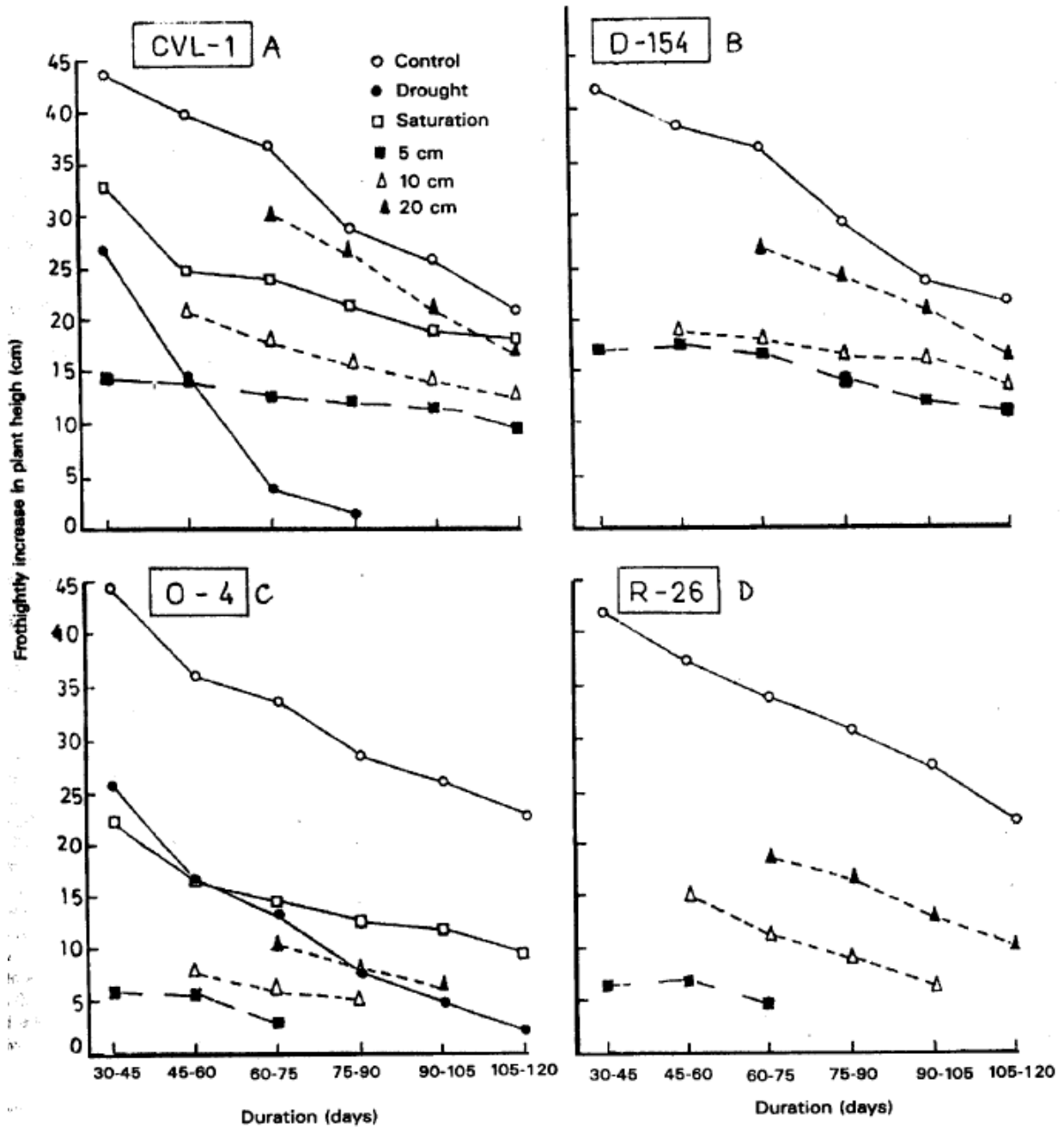


Fig. 1(A-D): Fortnightly increase in plant height of different cultivars of lute grown under various water regimes

height of CVL-1 plants, grown in constant saturated soil moisture condition, was 21.9%, 22.7% and 22.0% less than their control plants while they were of 90, 105 and 120 days respectively.

Alternate saturation and drought: The 30 days old plants of CVL-1 were exposed to and grown in saturated and drought soil alternately. The test plants exhibited similar but less pronounced plant growth as that of their corresponding control plants. The height of these plants at the age of 45, 60, 75, 90, 105 and 120 days was 88.4, 118.2, 141.5, 162.0, 181.5 and 197.7 cm respectively (Table 1). During the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS, the

fortnightly increase in height of the stressed plants was 34.8, 29.8, 23.3, 20.5, 19.5 and 16.2 cm respectively. The heights of the stressed plants at the age of 75, 105 and 120 days were 18.6%, 20.5% and 21.1% less than their control plants respectively.

5 cm standing water: When the 30 days old plants of CVL-1 were exposed to and grown in 5 cm standing water, they had been found to withstand waterlogging condition for the rest of their lives but they remained very much stunted. Among all the treatments the test plants, grown in 5 cm standing water, attained minimal plant heights, during the test period. The height of the 45, 60, 75, 90, 105 and 120 days old plants of

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CVL-1, grown in 5 cm standing water, was 68.2, 82.4, 95.1, 107.5, 119.0 and 128.5 cm respectively (Table 1). The fortnightly increase in plant height was 14.6, 14.2, 12.7, 12.4, 11.5 and 9.5 cm during the growth period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS, respectively (Fig. 1A). It had been found to decline as the duration of waterlogging condition continued. The heights of the stressed plants of 75, 105 and 120 days old were 45.2, 47.9 and 48.5% less than their control plants respectively.

10 cm standing water: The 45 days old plants of CVL-1 were grown in pots and field at 10 cm standing water. In the pots the height of the stressed plants at the age of 60, 75, 90, 105 and 120 days was 118.0, 135.6, 151.7, 165.9 and 178.5 cm respectively (Table 1). During the test period, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in plant height was 17.6, 16.1, 14.2 and 12.6 cm respectively (Fig. 1A). At the age of 75, 105 and 120 days the heights of the stressed plants were 21.9, 27.3 and 28.4% less than their control plants respectively.

On the other hand, the height of the test plants, grown in the field, was 139.9, 163.4, 184.4, 203.1 and 216.5 cm while they were of 60, 75, 90, 105 and 120 days old respectively (Table 2). During the period, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in plant height was 23.5, 21.4, 18.3 and 13.4 cm respectively. At the age of 75, 105 and 120 days, the height of the stressed plants was 32.7, 34.3 and 35.0% less than that of their corresponding control plants respectively.

20 cm standing water: The 60 days old CVL-1 plants, grown in pots and field, were subjected to 20 cm standing water. The height of the 75, 90, 105 and 120 days old stressed plants was 167.4, 194.1, 215.4 and 232.5 cm in the pots (Table 1) and 207.5, 234.4, 256.5 and 273.1 cm in the field (Table 2) respectively. During the period, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in plant height was 30.4, 26.7, 21.3 and 17.1 cm in the pots (Fig. 1A) and 29.3, 26.9, 22.1 and 16.6 cm in the field respectively. The stressed plants exhibited 3.7, 5.7 and 6.8% less height in the pots but 14.6, 17.1 and 17.9% less height in the field than those of their corresponding control plants while the plants were 75, 105 and 120 days old respectively.

30 cm standing water: The 90 days old plants of CVL-1 were grown in pots and field at 30 cm standing water. In waterlogging condition, the plant height of the 105 and 120 days old test plants was 224.6 and 243.1 cm in the pots (Table 1) but 307.9 and 329.6 cm in the field (Table 2) respectively. The fortnightly increase in height of the stressed plants was more or less similar to that of their control plants. The heights of the 105 and 120 days old stressed plants exhibited only 1.7 and 2.6% less in the pots and 0.5 and 0.9% less in the field than their corresponding control plants respectively.

Cultivar D-154

Control: In the pots, the height of the control plants of 30, 45, 60, 75, 90, 105 and 120 days old was 51.8, 93.6, 132.2, 168.6, 197.8, 221.2 and 242.9 cm respectively (Table 3). The fortnightly increase in plant height of the test plants was 41.8, 38.6, 36.4, 29.2, 23.4 and 21.7 cm during the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively (Fig. 1B). In the field the height of the control plants had been found to be 108.5, 182.9, 234.4, 273.5, 301.7 and 322.9 cm while the plants were of 45, 60, 75, 90, 105 and 120 days

old respectively (Table 4). The fortnightly increase in height of the test plants was 74.6, 51.5, 39.1, 28.2 and 21.2 cm during the period, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively.

5 cm standing water: The 30 days old plants of D-154 subjected to and subsequently grown in 5 cm standing water, had been found to withstand waterlogging condition for the rest period of their lives. The height of the 45, 60, 75, 90, 105 and 120 days old test plants was 68.6, 86.2, 102.9, 117.0, 129.2 and 140.0 cm respectively (Table 3). The fortnightly increase in height of the plants was 16.8, 17.6, 16.7, 14.1, 12.2 and 10.8 cm during the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively (Fig. 1B). Under such condition, the performance of D-154 had been found to be the best of all the cultivars investigated. The test plants at the age of 75, 105 and 120 days exhibited 38.9, 41.6 and 42.3% less height than their corresponding control plants respectively.

10 cm standing water: In 10 cm standing water, the height of the 60, 75, 90, 105 and 120 days old plants was 112.6, 130.9, 147.2, 163.1 and 176.5 cm in the pot (Table 3) and 163.0, 159.5, 180.7, 198.0 and 210.4 cm in the field (Table 4) respectively. The fortnightly increase in plant height was 19.0, 18.3, 16.3, 15.9 and 13.4 cm in the pot (Fig. 1B) but 27.5, 23.5, 21.2, 17.3 and 12.4 cm in the field during the period, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively. The stressed plants exhibited 22.3, 26.2 and 27.3% less height in the pots but 31.9, 33.9 and 34.8% less height in the field than their corresponding control plants while they were of 75, 90, 120 days old respectively.

20 cm standing water: The height of the test plants, grown in 20 cm standing water was 159.0, 182.8, 203.5 and 219.8 cm in the pot (Table 3) and 207.3, 231.0, 251.1 and 265.0 cm in the field (Table 4) while the plants were of 75, 90, 105 and 120 days old respectively. During the period, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in plant height was 26.8, 23.8, 20.7 and 16.3 cm in the pot (Fig. 1B) but 30.3, 23.4, 20.1 and 13.9 cm in the field respectively. The fortnightly increase in plant height was similar to but slightly less than that of the control (Fig. 1B). This was particularly true for the plants grown in pots. The plants of D154, grown in 20 cm standing water, exhibited 5.7, 8.0 and 9.5% less height in the pot but 11.5, 16.5 and 17.9% less height in the field than their corresponding control plants while they were of 75, 105 and 120 days old respectively.

30 cm standing water: In 30 cm standing water, the height of the 105 and 120 days old plants was 218.9 and 236.1 cm in the pot but 298.1 and 318.2 cm in the field respectively (Table 3, 4). During the period, 90-105 and 105-120 DAS, the fortnightly increase in plant height was 21.1 and 17.2 cm in the pot but 24.6 and 20.1 cm in the field respectively. The fortnightly increase in height of the test plants was similar to that of the control and as such, the ultimate height of the test plants was not affected adversely. At the age of 105 and 120 days, the plants grown in 30 cm standing water, exhibited 1.0 and 2.8% less height in the pot but 1.2 and 1.4% less height in the field than their corresponding control plants respectively.

Cultivar O-4

Control: The cultivar O-4 of *Corchorus olitorius* had been grown in pots and field under the natural condition of soil moisture. The height of the plants at the age of 45, 60, 75,

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90, 105 and 120 days was 92.6, 128.9, 162.7, 191.4, 217.8 and 241.0 cm in the pot (Table 1) and 106.5, 173.7, 224.9, 269.8, 303.2 and 334.4 cm in the field (Table 2) respectively. The fortnightly increase in height of the plants was 36.3, 33.8, 28.7, 26.4 and 23.2 cm in the pots (Fig. 1C) and 67.2, 51.2, 44.9, 33.4 and 31.2 cm in the field during the period, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively.

Constant drought: The 30 days old plants of O-4 had been found to withstand constant drought condition of soil throughout the remaining period of their lives. The height of the 45, 60, 75, 90, 105 and 120 days old test plants was 74.2, 91.4, 104.8, 113.0, 118.2 and 120.6 cm respectively (Table 1). The fortnightly increase in plant height was 26.4, 47.2, 13.4, 8.2, 5.2 and 2.4 cm during the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively (Fig. 1C). The growth of the test plants of O-4 had been found to be slower than that of the control plants. They, however, thrived successfully in the drought condition. The fortnightly increase in plant height decreased as the duration of drought extended. At the age of 75, 105 and 120 days, the height of the stressed plants was 35.7, 45.7 and 50.0% less than that of the control plants respectively.

Constant saturation: In saturated soil moisture condition, the height of O-4 plant at the age of 45, 60, 75, 90, 105 and 120 days was 70.0, 86.8, 101.3, 113.9, 125.7 and 135.3 cm respectively (Table 1). The fortnightly increase in height of these plants was 22.2, 16.8, 14.5, 12.6, 11.8 and 9.6 cm during the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively (Fig. 1C). The test plants, grown in saturated soil moisture, exhibited 37.7, 42.3 and 43.8% less height than their corresponding control plants, when they were of 75, 105 and 120 days old respectively.

Alternate saturation and drought: The combined effect of saturation and drought conditions of the soil was studied in pots with the 30 days old seedlings of O-4. In such a state of soil moisture stress, the plants became 79.6, 104.0, 123.8, 442.4, 159.1 and 173.6 cm tall while they were 45, 60, 75, 90, 105 and 120 days old respectively (Table 1). The fortnightly increase in height of these plants was 31.8, 24.4, 19.8, 18.6, 16.7 and 14.5 cm during the period, 30-45, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS respectively. The height of the 75, 105 and 120 days old stressed plants exhibited 23.9, 26.9 and 28.0 less than their corresponding control plants respectively.

5 cm standing water: The 30 days old plants of O-4, subjected to 5 cm standing water in pots, had been found to remain living up to the age of 75 days. During this period the growth was very poor. The growth sharply declined as the duration of waterlogging condition extended. At the age of 45, 60 and 75 days, the height of the test plants was 53.8, 59.6 and 62.7 cm respectively (Table 1). The fortnightly increase in height of the test plants was only 6.0, 5.8 and 3.1 cm during the period, 30-45, 45-60 and 60-75 DAS respectively (Fig. 1C). The rate of growth declined drastically. The plants, grown in 5 cm standing water, showed 53.7 and 61.4% less height than the control plants while they were of 60 and 75 days old respectively.

10 cm standing water: In the pots and field, the 45 days old plants of O-4 were exposed to and grown in 10 cm standing water. The height of these plants at the age of 60, 75 and 90 days had been found to be 100.9, 107.1 and 112.5 cm in

the pots (Table 1) and 124.9, 142.8 and 148.4 cm in the field respectively (Table 2). During the period, 60-75 and 75-90 DAS, the fortnightly increase in height of the stressed plants was 6.2 and 5.4 cm in the pots (Fig. 1C) but 17.9 and 5.6 cm in the field respectively. The rate of growth was very poor. The height of the stressed plants was 28.0, 55.6 and 78.9 cm less in the pots but 48.8, 82.1 and 121.4 cm less in the field than those of their corresponding control plants while they were of 60, 75 and 90 days old respectively. At the age of 75 and 90 days, the stressed plants exhibited 34.1 and 41.2% less height in the pots but 36.1 and 44.9% less height in the field than their corresponding control plants. Both in the field and pots all the plants of O-4 had been found to thrive in 10 cm standing water up to the age of 90 days. About 25% of the plants survived in the field up to the age of 105 days.

20 cm standing water: The 60 days old plants of O-4 were subjected to and grown in 20 cm standing water in both pots and field. They performed much better than those of the younger plants which were grown in 5 or 10 cm standing water (Fig. 1C). The height of the test plants, grown in 20 cm standing water, was 139.4, 148.0 and 154.4 cm in the pots (Table 1) and 185.1, 196.3 and 204.7 cm in the field (Table 2) while the plants were 75, 90 and 105 days old respectively. During the period, 60-75, 75-90 and 90-105 DAS, the fortnightly increase in height was 10.5, 8.6 and 6.4 cm in the pots but 13.9, 11.2 and 8.4 cm in the field respectively. In this treatment the rate of axial growth was higher than that in 10 cm standing water (Fig. 1C). At the age of 75, 90 and 105 days, the stressed plants exhibited 14.3%, 22.7% and 29.1% less height in the pots but 17.7, 27.2 and 32.5% less height in the field than their corresponding control plants respectively.

30 cm standing water: The 90 days old plants of O-4 had been found to withstand waterlogging condition quite satisfactorily. At the age of 105 and 120 days, the height of the stressed plants was found to be 201.6 and 212.0 cm in the pots (Table 1) but 279.3 and 288.5 cm in the field (Table 2) respectively. The fortnightly increase in height of these plants was 10.2 and 10.4 cm in the pot but 9.5 and 9.2 cm in the field during the period, 90-105 and 105-120 DAS respectively. The 105 and 120 days old stressed plants exhibited 7.4 and 12.0% less height in the pot but 7.8 and 13.7% less height in the field than their corresponding control plants respectively.

Cultivar R-26

Control: The plant height of the cultivar R-26, grown under normal condition of soil moisture had been found to be 90.4, 127.8, 162.0, 192.8, 220.4 and 242.6 cm in the pot (Table 3) and 107.4, 176.7, 231.1, 273.1, 306.4 and 336.1 cm in the field (Table 4) when they were of 45, 60, 75, 90, 105 and 120 days old respectively. During the period, 45-60, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in height of these plants was calculated as 37.4, 34.2, 30.8, 27.6 and 22.2 cm in the pot (Fig. 1D) and 69.3, 54.4, 42.1, 33.2 and 29.7 cm in the field respectively.

5 cm standing water: The 30 days old plants, exposed to and grown in 5 cm standing water, had been found to withstand waterlogging condition for 45 days. None of the plants survived beyond 75 days of age. In waterlogged condition, the growth of the plants was very poor. The plants gradually became pale and weak as the waterlogging condition continued. The height of the stressed plants at the age of 45, 60 and 75 days was found to be 54.8, 61.6 and 65.9 cm respectively (Table 3). The fortnightly increase in plant height

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was 6.4, 6.8 and 4.3 cm during the period, 30-45, 45-60 and 60-75 DAS respectively (Fig. 1 D). At the age of 60 and 75 days, the height of stressed plants showed 51.7 and 59.3% less than the corresponding control plants respectively.

10 cm standing water: The 45 days old plants of R-26, grown in the pots and field at 10 cm standing water, had been found to perform much better than those of the 30 days old ones grown in 5 cm standing water. The height of the stressed plants, grown in 10 cm standing water, seemed to be 105.4, 116.6, 125.9 and 132.1 cm in the pot (Table 3) but 128.6, 149.8, 167.2 and 180.5 cm in the field (Table 4) when the plants were of 60, 75, 90 and 105 days old respectively. In the field, the stressed plants had been found to live up to the age of 120 days but in the pot they survived up to 105 days. The fortnightly increase in height of the test plants was 11.2, 9.3 and 6.2 cm in the pot (Fig. 1D) but 21.2, 17.4 and 13.3 cm in the field during the period, 60-75, 75-90 and 90-105 DAS respectively. At the age of 75 and 105 days, the stressed plants exhibited 28.0 and 40.1 % less height in the pot but 35.1 and 41.1% less height in the field respectively than their corresponding control plants.

20 cm standing water: In the pots and field, the 60 days old plants of R-26 had been found to withstand 20 cm standing water with success. The height of these plants was found to be 146.7, 163.3, 176.0 and 185.9 cm in the pot (Table 3) but 199.9, 220.1, 237.2 and 249.6 cm in the field while they were of 75, 90, 105 and 120 days old (Table 4) respectively. During the period, 60-75, 75-90, 90-105 and 105-120 DAS, the fortnightly increase in height of the stressed plants was 18.9, 16.6, 12.7 and 9.9 cm in the pot (Fig. 1D) but 21.5, 20.2, 17.1 and 12.4 cm in the field respectively. The stressed plants exhibited 20.1 and 23.3% less height in the pots but 22.5 and 25.7% less height in the field than their corresponding control plants when they were of 105 and 120 days old respectively.

30 cm standing water: The height of R-26 plants, grown in 30 cm standing water, was found to be 208.9 and 221.5 cm in the pot but 287.1 and 302.2 cm in the field when they were of 105 and 120 days old respectively (Table 3, 4). Within the growth period, 90-105 and 105-120 DAS, the fortnightly increase in height of the stressed plants was 16.1 and 12.6 cm in the pots but 14.0 and 15.1 cm in the field respectively. The plants of R-26, grown in 30 cm standing water, exhibited 5.2 and 8.7% less height in the pot but 6.3 and 10.1% less height in the field than their corresponding control plants when they were of 105 and 120 days old respectively.

Discussion

The plant height of *Corchorus capsularis* L. (cv. CVL-1 and cv. D-154) and *Corchorus olitorius* L. (cv. O-4 and cv. R-26) was studied under different water regimes. The results of the present investigation have been discussed below in context to water stresses.

The cultivar O-4 had been found to be more drought tolerant than cultivar CVL-1. In constant drought, the plants of O-4 survived up to the age of 120 days with 50% reduction in plant height while CVL-1 survived up to 90 DAS with 50% reduction in height as compared to the control. The height of the test plants of O-4 showed 29, 36, 41, 45 and 50% less than their control plants when they were of 60, 75, 90, 105 and 120 days old but those of CVL-1 were 31, 43 and 50% less than their control plants when they were of 60, 75 and 90 days old respectively. The *Corchorus capsularis* is water

loving and *Corchorus olitorius* is drought loving and, as such, the former is grown in low land and latter in high land (Basak and Chaudhury, 1967; Choudhury, 1946, 1951; Ghosal and Chattapadhyay, 1977). According to Chaudhury and Basak (1969), the reduction in plant height was 17% in *Corchorus capsularis* but 13% in *C. olitorius* when the plants were periodically subjected to drought. The cultivars TRO 632 (*C. olitorius*) and TRO 212 (*C. capsularis*), subjected to chronic moisture stress, showed 10 and 18% reduction in height respectively as compared to the control (Ghosal and Chattapadhyay, 1977). Bisaria and Saraswat (1983), however, reported that at early stage of growth, *C. capsularis* could tolerate drought better than *C. olitorius*. According to these reports *C. olitorius* is more tolerant to drought than *C. capsularis*. The findings of the present investigation are in conformity with these reports.

In saturated soil moisture condition, the plant height was 22% less in CVL-1 and 44% less in O-4 than their control plants while they were of 120 days old. The reduction in height of CVL-1 was one half to that of O-4. In alternate saturation and drought condition of soil moisture, the height of the 120 days old plants of CVL-1 and O-4 was found to be 21 and 28% less than their control plants respectively. The CVL-1 plants showed similar growth habit in both saturated and alternate saturation and drought conditions of soil moisture while the O4 plants exhibited more desirable growth habit in alternate saturation and drought compared to saturated soil (Fig. 1) indicating the drought loving character of *C. olitorius*. In contrast to the present findings, Choudhury (1951) found that the 5th weeks' old C.G. and D-154, were grown in saturated soil moisture condition (puddling) for 7 weeks, showed 2% more plant height in C.G. and 17% more height in D-154 than their corresponding control plants. The author did not mention the percentage of soil moisture in which the control plants were grown. From the data on the plant height of these two cultivars, it appears that the control plants were grown under the sub-optimal soil moisture condition. For a hydro-sensitive plant like jute, the soil moisture below or above the optimum, affects the plant growth and, as such, reduces the plant height.

In all the test cultivars, the height of the plants was affected in waterlogging condition. Different cultivars were affected to different degrees. In the standing water treatments, four factors, such as, the variety, age of the plant, duration of submersion and the level of standing water responsible to affect the plant growth. The age of the plant had been found to be the more critical of all the factors. When the 30 days old plants were grown in pots at 5 cm standing water, all the test cultivars were affected to different degrees. At the age of 75 days, the height of the stressed plants of D-154, CVL-1, R-26 and O-4 was approximately 39, 45, 59 and 61% less than that of their control plants respectively. The 30 days old plants of O-4 did not survive in 5 cm standing water beyond 75 days of age while the 60 days old plants survived up to the age of 105 days at 20 cm standing water. At the age of 105 days, the height of D-154, CVL-1, R-26 and O-4 plants, grown in 20 cm standing water was approximately 8, 6, 20 and 29% less than that of their control plants respectively. When the 90 days old plants were submerged in 30 cm standing water, the height of the stressed plants of D-154, CVL-1, R-26 and O-4 was about 3, 3, 9 and 12% less than that of their corresponding control plants respectively while they were of 120 days old. Similar trend of reduction in height was observed in all the test cultivars grown in the field. In different treatments, the plants grown in pots, showed 15-27% less height than those grown in the field. Irrespective of variety, the fortnightly increase in

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plant height had been found to decline sharply in the younger plants, subjected to standing water treatment (Fig. 1). The declination in plant height had been found to proceed sharply as the duration of submersion was prolonged. When the older plants were submerged in standing water, the fortnightly increase in plant height had been found to be slightly less than that of the control plants. Both the cultivars of *C. capsularis* showed similar reaction to standing water treatment while the R-26 cultivar showed better performance in waterlogged condition than O-4, irrespective of age and duration of submersion.

Similar results on plant height have been reported by a number of workers (Bhattacharyya and Palit, 1982, 1984; Bisaria and Saraswat 1983; Chaudhury and Basak, 1969; Choudhury, 1946, 1951; Wahab, 1978). According to Choudhury (1951) the deep waterlogging condition (about 9 inches of standing water above soil surface) reduced the plant height of both *C. capsularis* cv. D-154 and *C. olitorius* cv. C.G. The reduction was 29% in D-154 and 30% in C.G. The shallow waterlogging condition (above 6 inches of standing water) did not affect the plant height of either species. Without referring the age of the plants, the author further commented that *C. capsularis* was not better adapted to withstand waterlogging condition than *C. olitorius*. When 8 varieties of *C. capsularis* and 7 varieties of *C. olitorius* were grown under 10 cm standing water, there were 3.6 and 22.7% less plant height than their control plants (Chaudhury and Basak, 1969). At the young stage of growth, the height of *C. olitorius* had been found to be seriously affected when plants were grown under waterlogged condition (Bhattacharyya and Palit, 1984; Bisaria and Saraswat, 1983; Wahab, 1978). At later stages of growth, the height is not affected. The plants of *C. capsularis* had been found to withstand waterlogging condition after they obtain a height of 3-4 feet (Kundu, 1956). According to Bhattacharyya and Palit (1984), the 30 days old plants of *C. capsularis* and *C. olitorius* show heavy reduction in growth while the 90 days old ones exhibit no significant reduction in plant height.

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