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Effect of Soil Moisture Stress against Irrigated Condition on Tossa Jute

Sawarkar A*, Yumnam S, Mukherjee S and Sarkar KK

Abstract

Drought is worldwide major abiotic stress in agriculture which affecting yield and yield stability of food cereals and this stress acts simultaneously on many traits leading to a decrease in total biomass. Approximately 16% of India's geographic area, mostly arid, semi-arid and sub-humid is drought prone area. The main reason of drought is irregular rainfall, deforestation, industrialization, wide variation in climatic conditions etc.

Keywords

Soil moisture; Crop; Jute; Heritability

Introduction

In recent years, drought situations get worsened results into reduced water levels, damage to wild life habitat, increased the mortality rate of livestock, increase insect infestations, increase plant disease and increase the wind erosion. Ultimately this reduced the farmers income, increased unemployment, crime, insecurity leads to the migration. Therefore drought is not only have significant economic, environmental effects but also social impacts. To overcome such problems breeding of drought tolerance in many crops need to be paid attention [1]. Farmer need's to adopt new practices and policies to mitigate stress conditions. Jute is the most important bast fibre crop being cultivated in Eastern India, Bangladesh, Nepal and South Asian countries and rank second after cotton in terms of production, productivity, consumption and availability. In India jute is grown in West Bengal, Assam, Odisha, Uttar Pradesh, Meghalaya. The complete life cycle of jute from cultivation to usage and disposal are biodegradable and ecofriendly [2]. The most common use of jute fibre is in packaging materials such as hessian, sacking and ropes. A variety of products, such as floor coverings, home textiles, agro-textiles, blankets, handicrafts and fashion accessories, are also made from jute. In recent years, jute has been used for making pulp and papers in the paper industry [3]. It was found that one hectare of jute plants can consume up to 15 tons of carbon dioxide and release 11 tons of oxygen during the jute growing season (about 100 days). In recent years requirement of jute fibre tremendously increased in China. Though India, top in production, productivity and area, there is always fluctuating in yield components and fibre quality. The foremost reason for such unstable yield and substandard or poor quality fibre is due to abiotic stress and faulty package of practices. [4]. It is well known fact that jute is a short day plant and the critical day length has been worked out to be 12.5 hours. The reproductive phase would be induced if the day length went below 12.5 hours. This is the most unwanted phenomenon as far as best fibre crops are concerned [5]. In West Bengal, jute is sown first fortnight of April is often accompanied by unpredictable and low rainfall leads crop subjected to phasic spell drought. If jute crop can survive the adverse initial dry spell with timely monsoon and favourable weather conditions luxuriant growth and yield can occur. Therefore, necessity of evaluation of drought tolerant plants is important at different growth stage. The present investigation was carried out to find out effect of drought in terms of yield and quality in sixty *Corchorus olitorius* jute accessions by creating artificial stress condition against normal in field and to screen genotypes for drought tolerance.

Materials and Methods

Sixty *olitorius* jute accessions, including 16 standard varieties were grown at the Instructional Farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, in West Bengal under two water regimes *viz.*, i) fully irrigated field and ii) moisture stress field. The experiment in each environment was laid out in Randomized Block Design with three replications in a plot of 5 rows of 3 meter length maintaining 30 cm space between the rows (3 m × 1.5 m). In fully irrigated field recommended doses of major nutrients (N, P and K) mixed with FYM were applied and normal cultural practices were followed. The moisture stress was created in field by watering the field upto 50% field capacity (half of the field capacity of the field). When the plants started dying (failed to recover from wilting next morning) the drought field again irrigated for half of the field capacity. Accessions were sown in first fortnight of April, 2012 and 2013 in two consecutive years and harvested the crop after maturing fibres. Except days 50% flowering, which was studied on plot basis, plant height (cm), internode length (cm), base diameter (cm), bark thickness (mm), green weight (g), dry stick weight (g) and fibre weight (g) were recorded from ten plants randomly selected from each genotype from each replication of two water regimes. The percentage of reduction was calculated by, % R = [Mean performance as measured for a character under artificial drought generated field condition- Mean performance as measured for the same character under irrigated field condition / Mean performance as measured for the same character under irrigated field condition] ×100. The analysis of variance based on pooled data of two consecutive years was calculated. Correlation coefficient were performed as per [6], heritability (H) in broad sense was calculated following [7], genetic advance (GA) and genetic advance as percent of mean as per [8] and direct and indirect effects of component characters of fibre yield through path analysis were done as suggested by [9] at genotypic levels. All these statistical analysis were performed with the help of INDOSTAT software.

Result and Discussions

All the characters were shown significant differences among the genotypes of both water regimes. The genotypes grown in two water regimes found some genotypes were tolerant, some had susceptible and some had little influence of drought. The most reduced effect of stress observed days to 50% flowering for the genotype OIN 970 and

***Corresponding author:** Sawarkar A, Department of Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur - 741 252, Nadia, West Bengal, India, E-mail: annu.sawarkar@gmail.com

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it followed by JRO 3690, OIJ 216. The least effect of drought was found in OIN 990 and it followed by OIJ 054, OIJ 177 and OIN 915. Earliness in flowering is advantageous character to sustain the growth during drought prone areas. All the genotypes found decrease in the plant height in artificial stress generated field and minimum reduction over irrigated was recorded in OIJ 218 and OIJ 216 and maximum reduction was observed in OIJ 214, JRO 8432 and JRO 524. Three genotypes, namely, OIN 623, OIN 082 and OIN 378 was indicated increment in the internode length in moisture stress field over irrigated and remaining genotypes were susceptible (Table 1). OIJ 168 had most decreased internode length followed by OIN 915, OIN 196. In case of base diameter, all the genotypes had reduced in performance except OIJ 177, OIN 666 and OIN 926. The most reduction in base diameter had recorded in OIJ 214 and followed by JRO 8432 and JRO 524 in moisture stress field. OIN 937, JRO 2407 and TJ 40 had little increment in bark thickness and reduction was found in JRO 204 and it followed by OIN 515, OEX 19 and S 19. Green weight means the total biomass of the plant. It is important parameters for screening drought tolerant plant. All the genotypes showed reduced green weight in stress field as compared to irrigated. The minimum reduction was observed in OIN 515 and OIN 259. Whereas, maximum reduction was found in JRO 8432 and it followed by OEX 014, OIN 937 and JRO 524.Surprisingly, increment was found in the dry stick weight for all genotypes in moisture stress field. The maximum increase in the dry stick weight was observed in OIN 533 followed by OIJ 937 and OIJ 168. All the genotypes were recorded reduction in fibre yield against irrigated field condition. The minimum reduction in fibre weight was recorded in OEX 29 and it followed by OIN 791 and OIJ 177. Poor performance in fibre yield was recorded for JRO 7835 and it followed by Bidhan Rupali, JRO 632. Table 2 showed the mean, range, PCV, GCV, H^2 GA, GA over percentage of mean of two environment. The mean performance for all characters showed lower in performance in moisture stress field over irrigated. The value of range showed the wide variation for every character under both regime. The difference between minimum and maximum

Table 1: Ranking of genotypes based on (%) reduction on moisture stress field over irrigated condition.

Top 10 genotypes showing some increment or minimum (%) reduction on moisture stress field over irrigated condition																	
Days to 50%flowering			**Plant height(cm)**			**Internode length(cm)**			**Base diameter(cm)**			**Bark thickness(mm)**			**Green weight(g)**		
	Genotype	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**
1	OIN 990	-0.69	1	OIJ 218	-3.82	1	OIN 623	10.15	1	OIJ 177	4.58	1	OIN937	0.68	1	OIN 515	-2.40
2	OIJ 054	-0.79	2	OIJ 216	-3.91	2	OIN 082	6.01	2	OIN 666	2.08	2	JRO2407	0.38	2	OIN 259	-3.87
3	OIJ 177	-0.89	3	OIN 791	-4.30	3	OIN 378	1.45	3	OIN 926	1.76	3	TJ 40	0.02	3	JR0 128	-5.78
4	OIN 915	-0.89	4	OEX 014	-4.95	4	OEX 039	-0.18	4	OIJ 216	-1.02	4	JRO 632	-0.12	4	OEX 29	-6.27
5	OEX 29	-2.05	5	OIJ 104	-5.11	5	KOM 62	-0.56	5	OIJ 263	-1.50	5	OIN 259	-0.83	5	OIN 666	-6.80
6	OIN 309	-2.08	6	OEX 29	-5.58	6	OEX 29	-0.61	6	OIJ 257	-2.79	6	OIJ 937	-1.46	6	JRO 204	-7.18
7	OIN 791	-2.26	7	OIJ 054	-5.60	7	IRA	-0.61	7	OIJ 266	-2.92	7	OIN 666	-1.98	7	OIJ 263	-8.66
8	JR0 128	-2.30	8	OIJ 177	-6.07	8	CO 58	-0.91	8	OIJ 264	-3.17	8	OIN 959	-2.15	8	OIJ 104	-8.87
9	OIJ 263	-2.38	9	OIN 937	-6.25	9	OIJ 263	-1.25	9	OIN 791	-3.65	9	OEX 019	-2.32	9	OIN 309	-8.93
10	OIJ 266	-2.47	10	OIN 409	-6.26	10	OIN 937	-1.37	10	OIJ 218	-4.19	10	OIJ 213	-2.35	10	OIN 975	-8.98
Top 10 genotypes showing maximum % reduction on moisture stress field over irrigated condition																	
Days to 50%flowering			**Plant height(cm)**			**Internode length(cm)**			**Base diameter(cm)**			**Bark thickness(mm)**			**Green weight(g)**		
	Genotype	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**
1	OIN 970	-9.16	1	OIJ 214	-19.89	1	OIJ 168	-24.77	1	OIJ 214	-26.19	1	JRO 204	-30.18	1	JRO 8432	-42.10
2	JRO3690	-8.21	2	JRO 8432	-19.69	2	OIN 915	-23.82	2	JRO 8432	-23.02	2	OIN 515	-28.37	2	OEX 014	-38.33
3	OIJ 216	-7.97	3	JRO 524	-19.09	3	OIN 196	-23.33	3	JRO 524	-21.99	3	OEX 29	-25.80	3	OIN 937	-36.99
4	JRO 878	-7.95	4	OIN 427	-18.38	4	OIN 666	-22.55	4	JRO 2407	-21.54	4	S 19	-25.29	4	JRO 524	-36.90
5	JRO 524	-7.74	5	S 19	-18.36	5	OIJ 266	-19.51	5	OIJ 937	-19.39	5	JRO 7835	-22.44	5	OIN 427	-35.39
6	OIJ 214	-7.74	6	JRO 3690	-18.01	6	OIJ 216	-18.52	6	OIN 581	-18.94	6	JRO 8432	-22.24	6	OEX 05	-35.32
7	OIN 196	-7.74	7	JRO 632	-17.81	7	OIN 427	-13.84	7	JRO 3690	-18.89	7	OIJ 257	-21.83	7	OIJ 214	-34.81
8	OIN 581	-7.68	8	JRO 2407	-15.66	8	OIJ 937	-12.90	8	JRO 632	-18.88	8	JRO 878	-21.40	8	OIJ 054	-34.61
9	OEX 05	-7.27	9	JRO 204	-15.48	9	OIN 409	-12.87	9	OIN 427	-18.80	9	OIN 990	-21.13	9	JRO 632	-34.60
10	JRO 632	-6.73	10	OIN 970	-15.17	10	OIJ 218	-12.37	10	S 19	-17.31	10	OIN 378	-21.12	10	JRO 878	-33.48

Top 10 genotypes showing some increment or minimum % reduction on moisture stress field over irrigated condition						Top 10 genotypes showing some increment or maximum % reduction on moisture stress field over irrigated condition					
Dry stick weight(g)			**Fibre weight(g)**			**Dry stick weight(g)**			**Fibre weight(g)**		
	Genotype	**%R**		**Genotype**	**%R**		**Genotype**	**%R**		**Genotype**	**%R**
1	OIN 533	208.30	1	OEX 29	-14.26	1	OIN 915	0.11	1	JRO 7835	-45.06
2	OIJ 937	179.34	2	OIN 791	-15.97	2	KOM 62	2.01	2	Bidhan Rupali	-44.54
3	OIJ 168	125.36	3	OIJ 177	-15.99	3	OIN 990	2.12	3	JRO 632	-44.40
4	OIN 791	117.02	4	S 19	-18.86	4	OIN 666	4.26	4	OIN 515	-43.74
5	Bidhan Rupali	114.92	5	OEX 039	-21.28	5	OIN 124	4.61	5	JRO 8432	-43.33
6	OIJ 177	107.11	6	JRO 2407	-21.89	6	OIN 082	5.44	6	JRO 3690	-41.19
7	OEX 014	106.84	7	OIJ 266	-22.62	7	OIJ 104	9.30	7	JRO 524	-41.08
8	OIJ 284	95.12	8	OIJ 218	-22.77	8	OIN 714	10.64	8	OIN 937	-40.42
9	JRO 2407	92.02	9	OIJ 263	-23.33	9	OIN 975	11.58	9	OIN 990	-40.05
10	TJ 40	91.01	10	OIJ 264	-24.25	10	OIN 981	12.37	10	IRA	-38.80

Table 2: Pooled analysis on variability and different genetic parameters for different yield attributing characters of *C olitorius* under two environment.

Parameters		Mean	Range	PCV	GCV	Heritability (Broad Sense)	Genetic Advance	Genetic Advance as % of mean
Days to 50% flowering	A	107.06	100.48-115.50	3.72	3.09	0.68	5.66	5.28
	B	102.36	95.32-112.89	3.98	3.39	0.72	6.11	5.97
Plant height (cm)	A	295.95	261.06-353.25	6.83	6.50	0.90	37.80	12.77
	B	264.25	244.75-299.49	5.44	5.03	0.85	25.30	9.57
Internode length (cm)	A	4.63	3.68-5.38	8.97	8.71	0.94	0.80	17.42
	B	4.29	3.05-5.28	10.18	9.94	0.95	0.86	20.01
Base diameter(cm)	A	1.30	1.10-1.49	7.11	6.37	0.80	0.15	11.79
	B	1.16	0.94-1.35	7.08	6.72	0.90	0.15	13.14
Bark thickness(mm)	A	0.89	0.67-1.24	14.05	13.88	0.97	0.25	28.26
	B	0.78	0.58-0.92	11.01	10.81	0.96	0.17	21.86
Green weight (g)	A	187.36	130.28-265.31	15.40	15.25	0.98	58.31	31.12
	B	148.74	105.51-210.35	16.97	16.83	0.98	51.14	34.38
Dry stick weight (g)	A	16.78	10.95-23.32	17.47	17.32	0.98	5.93	35.36
	B	25.49	15.77-40.00	21.32	21.20	0.98	11.07	43.44
Fibre weight (g)	A	9.80	7.48-11.86	11.18	10.94	0.95	2.16	22.05
	B	6.73	4.69-9.29	16.83	16.69	0.98	2.29	34.09

A- Irrigated field; B-Moisture stress field

values of characters revealed the effect of stress upto harvesting. All the characters showed PCV is less than the GCV in both environment and the difference between PCV and GCV were little for all the characters, suggesting that these characters were less influenced by the environment [10]. The characters like Days to 50% flowering, internode length, green weight, dry stick weight and fibre weight had high PCV & GCV in moisture stress field than irrigated except plant height and bark thickness. These two character were high in PCV and GCV in irrigated field against moisture stress. "Base diameter was the only character showed higher PCV in irrigated field and GCV in moisture stress. High GCV for different fibre yielding attributes of white and tossa jute has been reported by Chaudary et al. [11-15]". The effectiveness of selection according to quantitative characters is largely dependent on the ratio between the levels of their environmental and genotypic variabilities within a population [16]. Johnson et al. stated that heritability and genetic advances should always be considered jointly during selection of a suitable line or progeny. Heritability estimates with genetic gain (as % mean) are normally more helpful in predicting the gain under the selection. High heritability coupled with high genetic advance was observed for the green weight, under both environment indicating the presence of additive genes which would be effective for selection. Similar results were also reported by Nayak et al. [17]. Similarly, under both environment, fibre weight and dry stick weight had high heritability with low genetic advance revealed presence of non-additive gene action Therefore selection of such traits may not be useful Plant height showed low heritability coupled with moderate to high genetic advance indicating the character is governed by additive gene effects. The possible reason to low heritability might be due to high environmental effects. Selection of such characters may or may not be worth. In both environment the GA% mean were greater for dry stick weight and it followed by green weight and bark thickness. The fibre weight recorded higher GA% in moisture stress field than irrigated. Table 3 showed the genotypic and phenotypic correlation coefficient among different yield attributing characters under both water regime. Significant positive genotypic as well as phenotypic correlation were evident between fibre weight and all other characters in moisture stress environment. Similar results were also evidenced in irrigated field except green weight and dry stick weight where green weight showed significant association unlike moisture stress environment at phenotypic level with fibre weight. Under moisture stress generated field, highly significant genotypic and phenotypic correlation was evident between days to 50% flowering and plant height, internode length, base diameter, bark thickness, green weight, dry stick weight, between plant height and internode length, base diameter, bark thickness, green weight and dry stick weight, internode length with base diameter, bark thickness and green weight. It indicates, that taller, thicker and total weight of the plant gives higher fibre yield. Similarly under irrigated, days to 50 % flowering revealed highly significant positive and genotypic correlation with plant height, internode length, base diameter, bark thickness, plant height with internode length, base diameter, bark thickness, green weight, internode length with base diameter, bark thickness, base diameter with bark thickness and green weight with dry stick weight. Table 4 showed direct and indirect effect of yield attributing characters under moisture stress field as well as irrigated [18-23] showed significant positive correlation coefficients between fibre yield and yield attributed characters. Table 4 showed the direct and indirect effect of yield attributing characters on fibre weight at genotypic level screen under both environment. In case of irrigated field, four characters showed positive direct effect and three showed negative direct effect. Whereas, in moisture stress field except green weight rest of the characters showed positive direct effect. Both environment plant height showed highest positive direct effect and it followed by base diameter, internode length, and bark thickness in irrigated field and internode length, dry stick weight, days to 50% flowering and bark thickness in moisture stress field. Similar result was also reported by Pervin et al. [24]. Therefore the direct selection based on these characters would be feasible. Plant height also recorded highest positive indirect effect via base diameter, days to 50% flowering, internode length, bark thickness, green weight via plant height and dry stick weight via base diameter in irrigated field. Whereas in stress field, days to 50% flowering, internode length, base diameter, bark thickness and green weight showed highest positive indirect effect on fibre weight via plant height. These all characters had significant positive correlation with fibre yield indicated that the indirect selection could be made for high yielding tossa jute. The residual effect (R) was very small for both environment indicating there were also some other characters which although not studied but influenced the fibre yield.

Table 3: Pooled analysis for genotypic (G) and phenotypic (P) correlation co-efficient among different yield attributing characters of *C. olitorius* under two water regimes.

Characters			Plant height (cm)	Internode length (cm)	Base diameter (cm)	Bark thickness (mm)	Green weight (g)	Dry stick weight (g)	Fibre weight (g)
Days to 50% flowering	**A**	G	**0.335*** **	**0.302*** **	**0.263*** **	**0.275*** **	**0.122**	**0.107***	**0.302*** **
		P	0.431***	0.372***	0.358***	0.307***	0.176***	0.152**	0.347***
	B	G	**0.406*** **	**0.221*** **	**0.276*** **	**0.182*** **	**0.332*** **	**0.203*** **	**0.378*** **
		P	0.519***	0.289***	0.377***	0.251***	0.346***	0.225***	0.386***
Plant height (cm)	**A**	G		**0.584*** **	**0.866*** **	**0.510*** **	**0.148** **	**0.053**	**0.920*** **
		P		0.610***	0.827***	0.525***	0.181***	0.086	0.914***
	B	G		**0.548*** **	**0.787*** **	**0.564*** **	**0.312*** **	**0.199*** **	**0.736*** **
		P		0.571***	0.803***	0.584***	0.334***	0.222***	0.723***
Internode length(cm)	**A**	G			**0.471*** **	**0.490*** **	**-0.022**	**0.019**	**0.579*** **
		P			0.479***	0.505***	0.010	0.045	0.592***
	B	G			**0.477*** **	**0.525*** **	**0.088**	**0.006**	**0.561*** **
		P			0.500***	0.541***	0.110*	0.026	0.569***
Base diameter(cm)	**A**	G				**0.420*** **	**0.045**	**0.107***	**0.875*** **
		P				0.414***	0.080	0.132*	0.823***
	B	G				**0.679*** **	**0.248*** **	**0.073**	**0.617*** **
		P				0.688***	0.270***	0.098	0.619***
Bark thickness(mm)	**A**	G					**0.039**	**0.189*** **	**0.479*** **
		P					0.058	0.202***	0.491***
	B	G					**-0.014**	**0.096**	**0.484*** **
		P					0.010	0.113*	0.495***
Green weight(g)	**A**	G						**0.177*** **	**0.084**
		P						0.190***	0.107*
	B	G						**0.515*** **	**0.292*** **
		P						0.521***	0.304***
Dry stick weight(g)	**A**	G							**0.026**
		P							0.047
	B	G							**0.273*** **
		P							0.282***

Table 4: Path coefficient (genotypic) analysis showing direct (bold) and indirect effects of yield attributing traits of *C. olitorius* under two environment.

		Days to 50% flowering	Plant height(cm)	Internode length(cm)	Base diameter(cm)	Bark thickness(mm)	Green weight(g)	Dry stick weight(g)	Fibre weight(g)
Days to 50% flowering	**A**	**-0.003**	-0.001	-0.001	-0.001	-0.001	0.000	0.000	0.302***
	B	**0.120**	0.049	0.027	0.033	0.022	0.040	0.024	0.378***
Plant height(cm)	A	0.188	**0.561**	0.328	0.486	0.286	0.083	0.030	0.920***
	B	0.163	**0.401**	0.220	0.316	0.226	0.125	0.080	0.736***
Internode length(cm)	**A**	0.015	0.029	**0.050**	0.023	0.024	-0.001	0.001	0.579***
	B	0.052	0.129	**0.235**	0.112	0.124	0.021	0.002	0.561***
Base diameter(cm)	A	0.088	0.290	0.158	**0.335**	0.141	0.015	0.036	0.875***
	B	0.022	0.062	0.038	**0.079**	0.054	0.020	0.006	0.617***
Bark thickness(mm)	**A**	0.005	0.009	0.09	0.07	**0.017**	0.001	0.003	0.479***
	B	0.005	0.017	0.016	0.020	**0.030**	0.000	0.003	0.484***
Green weight(g)	A	-0.011	-0.013	0.002	-0.004	-0.003	**-0.088**	-0.016	0.084
	B	-0.009	-0.008	-0.002	-0.006	0.000	**-0.026**	-0.013	0.292***
Dry stick weight(g)	**A**	-0.007	-0.003	-0.001	-0.007	-0.012	-0.011	**-0.062**	0.026
	B	0.029	0.028	0.001	0.010	0.014	0.073	**0.141**	0.273***

A- Irrigated field; B-Moisture stress field ; *Significant at 5% level ** Significant at 1% level *** Significant at 0.1% level Residual effect of A= 0.318 and B=0.601

The above results of the investigation revealed that accessions were selected for the research work had inherent property to resist the drought and could sustain in the moisture stress with minimum reduction. Namely, OEX 29, OIN 791, OIJ 177, OIJ 216 and JRO 2407 showed consistency in performance in fibre yield with most of the characters like plant height, internode length, base diameter, bark thickness etc. These genotypes could be considered as most adaptable in moisture stress environment and can also be utilized as donor parents for breeding improvement of other promising varieties like JRO 524, JRO 3690, JRO 8432, Bidhan Rupali and JRO 632 but susceptible to such moisture stress environment.

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Author Affiliations

Top

Department of Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India