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Research Article

EFFECT OF DIFFERENT DROUGHT MANAGEMENT TECHNIQUES ON GROWTH, FIBRE YIELD AND ECONOMICS OF RAINFED TOSSA JUTE (*CORCHORUS OLITORIOUS* L.) IN GANGETIC PLAIN OF WEST BENGAL

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A B S T R A C T

A field experiment was conducted at ICAR-CRIJAF, Barrackpore under deficit rainfall condition (>50% from sowing to onset of monsoon) to realise better fibre yield from rain fed farming, mitigating the drought stress. In this experiment some drought management techniques (improved agronomic and soil moisture conservation practices) were imposed on jute cultivation in rain fed situation. Under rain fed condition, 16 to 37% jute fibre yield improvement was possible by adopting improved agronomic and soil water conservation techniques. Application of 30 kg elemental S/ha + N:P:K::60:30:30 yielded 37.75q/ha jute fibre which was recorded 10.29 q/ha higher than that of control treatment (N:P:K::40:20:20) (27.46 q/ha). One post sowing irrigation and N:P:K::60:30:30 improved jute fibre yield (33.5q/ha) by 22% over control. Under rainfed and deficit rainfall situation jute and pulse strip cropping gave an equivalent fibre yield of 38.84 q/ha. Deep ploughing (15-17cm) with mulch 2t/ha on seeded rows + (N:P:K::60:30:30) improved fibre yield (35.28q/ha) by 7.82 q/ha over control treatment. Higher cost benefit ratio was obtained from strip cropping (1.37 to 1.58), addition of mulch (1.16 to 1.35), sulphur (1.22-1.27) as well as residue recycling (1.13-1.41). These drought management techniques could be easily harnessed by jute farmers to increase jute fibre production under rainfed situation avoiding the drought stress.

INTRODUCTION

Jute is one of the most important commercial natural fibre crops of India. It plays a key role in the economy of the east India states, such as West Bengal, Assam, Bihar, Orissa and eastern Uttar Pradesh etc. It is important to mention that the current national average fibre yield is only 23q/ha over its yield potential of 35-40q/ha under optimum condition. This yield gap is primarily due to the poor water and nutrient management practices of rainfed jute cultivation adopted in the country. About 80 percent of the total jute cultivated area (6.4 lakh ha) is rainfed (Basu *et al*, 1997). The deficit moisture stress under rainfed farming is a major reason behind the yield gap. The germination of delicate jute seed is often hampered due to unassured moisture reserve and high temperature in the soil profile during summer months (March to May), which frequently leads to crop failure. Water stress due to deficit rainfall is very crucial and if continues for 10 days or so may lead to wilting or death of jute seedlings (Palit, 1997).

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These phasic drought spells can be avoided adopting suitable *insitu* soil moisture conservation and other agronomic management techniques in the jute field itself. Low cost rice straw mulch, residue recycling, deep plough and higher nutrition have been found to improve jute fibre yield under rainfed situation (Ghorai *et al.,*2008 and 2010*,* and Saren *et al.,* 2008). Mulching is very effective for places where sufficient moisture is not available during hot summer. It is any material applied on the soil surface to reduce evaporation, run off and weeds and increase the infiltration by insulating the soil surface from direct radiation or by obstructing vapour diffusion (Umarani *et al*, 1973). As very limited irrigation water is available in summer, rice/wheat straw mulch will be able to maintain better hydrothermal regime of jute soil and improve fibre yield from rainfed environment. Limited research findings on this aspect have been found. Keeping these things in mind field experiment was conducted at CRIJAF, Barrackpore under deficit rainfall condition (>50% from sowing to onset of monsoon) to realise better fibre yield from rainfed farming, mitigating these abiotic stresses. Some adoptable soil moisture conservation techniques and agronomic management practices were exploited to conserve rainwater under in-situ condition to mitigate drought stress in rainfed environment.

MATERIALS AND METHODS

The field experiment was conducted at ICAR-CRIJAF main farm on the drought management of *olitorius* jute under rainfed condition in the Gangetic belt of west Bengal for two consecutive years, 2008 & 2009. The climate of the location is tropical. The experimental soil was sandy clay in texture containing sand, silt and clay at 72.7, 13.1 and 14.2%, respectively with pH 7.42, organic carbon (OC) 0.59% and available N, P_2O_5 and K_2O were 418, 47.38 and 178 kg/ha, respectively. Bulk density of and field capacity of the soli were 1.45g/cc (0-60cm depth) and 22% respectively.

The experiment was conducted in Randomised Block Design with seven treatments replicated thrice. The treatments were i) T_1 – Control (N:P:K::40:20:20), ii) T_2 - Deep plough (15-17cm) with mulch 2t/ha on seeded rows + (N:P:K::60:30:30), iii) T_3 – 30kg elemental S/ha + (N:P:K::60:30:30), iv) T_4 - One irrigation (post sowing) + N:P:K::60:30:30 , (v) T_5 - 50:50 strip crop jute (N:P:K::60:30:30) + green gram (N:P:K::20:30:30), (vi) T_6 - Augmented P & K application + (N:P:K::60:40:40) and (vii) T_7 - Residue recycling + (N:P:K::60:30:30. In the experiment jute cultivar JRO-524 (Navin) and for intercropping green gram cultivar K-851 were used the seed rate was 6.25kg/ha.

Agronomic parameters like plant stand (number/m^2), plant height, basal diameter, leaf area index, root length, biomass yield, fibre and stick yield and were recorded at different days after sowing of jute crop following the standard methods. The change in soil quality has also been done. The data were pooled over 2 years and analysed using standard analysis of variance.

RESULTS AND DISCUSSION

Effect of different drought management practices on growth attributes of jute

Plant height and basal diameter of jute at maturity (120 DAS) varied significantly when grown under different drought management practices (Table 1). At harvest maximum plant height of jute, i.e, 318.7cm, 16.5% higher over control was found with the treatment T_5: Strip crop jute (4:4) with green gram (N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram) closely followed by treatment T_3: 30 kg elemental S / ha + N:P:K::60:30:30 (312.3 cm) and , T_2 : N:P:K::60:30:30 +deep plough (10-15 cm) + rice straw mulch @ 2t/ha (304.3cm) and treatments T_7 Residue recycling + N:P:K::60:30:30, (300.3 cm), Table 1. Similar tends were also found for basal diameters of jute plant of these treatments at maturity. The lowest plant height and basal diameter were under control (273.5cm and 1.32 cm) treatment which was statistically at par the treatment having augmented P and K application (Table. 2).

Strip cropping of green gram with jute with higher canopy coverage at full grown stage of green gram and jute and rice straw mulching helps to conserve soil moisture through reduced evaporation, it controlled weeds and thus leads to satisfactory growth and development of jute crop. Adequate availability of moisture to plants resulted in better cell turgidity and eventually higher meristematic activity, leading to better plant growth, more foliage development, greater photosynthetic rate and consequently favourable effect on sink developments. Addition of elemental sulphur along with NPK helped for balanced nutrition of jute which was reflected on its growth and development. The positive effect of sulphur on the growth of plant was also reported by Zafar *et al*. (2014). Researcher likes Repica *et al*. (1971) and Whatley (1971) reported that sulphur affects on plant growth, leaf size and stem elongation.

Tap root length were also influenced due to different management practices imposed on jute (Fig.1). Maximum tap root length was recorded with the application of treatment T_3: 30 kg elemental S / ha + N:P:K::60:30:30 (15.5 cm, 38% higher over control, Fig.2). The results are in agreement with the findings of Mandal *et al.* (2015) and Ghorai *et al.* (2008). Better tap root length of jute at harvest were primarily attributed to better nutrition and moisture to jute crop by improved agronomic management practices including addition of elemental sulphur, mulch and residue recycling etc.

Table 1 Effect of drought management techniques (improved agronomic and soil water conservation practices) on plant height of jute

Treatment	Plant height (cm)								
	At 60 DAS			At 90DAS			At 120DAS		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T 1	99.3	99.0	99.2	190.0	184.3	187.2	277.7	269.3	273.5
T 2	161.7	113.3	137.5	231.7	216.7	224.2	304.0	304.7	304.3
T 3	130.7	108.7	119.7	230.0	232.0	231.0	308.3	316.3	312.3
T 4	168.3	100.0	134.2	208.7	193.7	201.2	284.3	287.3	285.8
T 5	105.7	112.7	109.2	219.3	222.0	220.7	310.0	327.3	318.7
T 6	100.7	104.3	102.5	192.3	198.7	195.5	280.3	280.7	280.5
T 7	102.7	106.3	104.5	219.0	206.7	212.8	302.0	298.7	300.3
SEm(±)	3.18	1.86	1.756	4.07	2.40	2.198	2.28	6.47	3.261
CD (0.05)	13.86	8.12	10.625	17.76	10.48	13.299	9.93	28.19	19.733

T_1 = Control (N:P:K::40:20:20), T_2 - Deep plough (15-17cm) with mulch 2t/ha on seeded rows + (N:P:K::60:30:30), T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

Table 2 Effect of drought management techniques (improved agronomic and soil water conservation practices) on basal diameter of jute

Treatment	Basal diameter (cm)								
	At 60 DAS			At 90 DAS			At 120 DAS		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T 1	0.80	0.91	0.85	1.17	1.21	1.19	1.29	1.35	1.32
T 2	1.21	1.05	1.13	1.47	1.54	1.51	1.54	1.73	1.63
T 3	1.00	0.97	0.99	1.56	1.74	1.65	1.80	1.48	1.64
T 4	1.19	0.94	1.07	1.32	1.37	1.35	1.46	1.41	1.44
T 5	0.95	1.05	1.00	1.51	1.58	1.55	1.87	1.77	1.82
T 6	0.82	0.94	0.88	1.22	1.44	1.33	1.36	1.37	1.37
T 7	0.85	0.96	0.91	1.38	1.44	1.41	1.64	1.40	1.52
SEm(±)	0.04	0.02	0.02	0.05	0.05	0.03	0.07	0.06	0.04
CD (0.05)	0.16	0.09	0.12	0.20	0.21	0.18	0.29	0.25	0.24

T_1 = Control (N:P:K::40:20:20), T_2 - Deep plough (15-17cm) with mulch 2t/ha on seeded rows + (N:P:K::60:30:30), T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

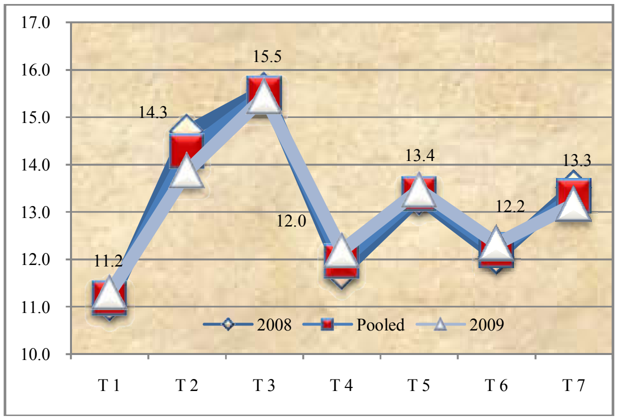

Fig 1 Effect of different moisture conservation techniques on tap root length (in cm)

T_1 = Control (N:P:K::40:20:20), T_2 = Mulch 2t/ha on seeded rows + N:P:K::60:30:30, T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

Effect of drought management techniques (improved agronomic and soil water conservation practices) on fibre yield of jute

Different drought management techniques also influenced plant population and fresh weight of jute at harvest during both the years and in pooled data (Table 3). The plant population and fresh weight of jute were recorded significantly higher with the application of T_3 (30 kg elemental S / ha + N:P:K::60:30:30),T_7 (Residue recycling + (N:P:K::60:30:30)) and T_2 (rice straw mulching @ 2t/ha on seeded rows + N:P:K :: 60:30:30) treatments.

Different agronomic management practices and soil moisture conservation techniques influenced jute plant population and green biomass yield of jute significantly (Table 3). Treatment T_3: 30 kg elemental S / ha + N:P:K::60:30:30 recorded maximum plant population of 4.72 lakhs/ha and it was 38% higher over control (N:P:K::40:20:20). This was statistically at par with the jute populations of treatments T_7: residue recycling + N:P:K::60:30:30 (4.39 lakhs/ha) and treatment T_2 : N:P:K::60:30:30 + deep plough (10-15 cm) + rice straw mulch @ 2t/ha (4.33 lakhs/ha). The maximum green biomass yield (618q/ha) was found from the treatment T_3: 30 kg elemental S / ha + N: P: K::60:30:30 (Table 3) and this biomass was 30 % higher over control. All other treatments also recorded significantly higher biomass at maturity over control because of better agronomic and soil moisture conservation practices imposed on jute.

Jute fibre yield was significantly influenced by different improved agronomic and soil moisture conservation techniques (Table 3) imposed on jute crop. For comparison among treatments jute fibre equivalent was calculated. The highest fibre equivalent yield of jute, 38.84 q/ha (pooled) 41 % higher over control (27.46q/ha) was recorded from the treatment T_5 = strip crop jute (4:4) with green gram (N:P:K::60:30:30 for jute and N:P:K::20:40:40 for green gram) and it was at par with the treatment received T_3: 30 kg elemental S / ha + N:P:K::60:30:30 (37.75q/ha). Addition of green gram (708 to 823kg/ha) in the system improved the fibre equivalent yield of the jute and green gram strip cropping system. Better fibre equivalent yield of treatment T_3: 30 kg elemental S / ha + N:P:K::60:30:30 was primarily attributed to its better plant height, basal diameter, plant population, developed tap root system and green biomass yield/ha (Table 1). Ghorai *et al*. 2010 reported higher fibre equivalent yield (53.11 q/ha) from strip crop (4:4) of jute (cv. JRO 204) with green gram (cv. RMG 62) over sole jute (39.17q/ha). Under rainfed situation, other agronomic and soil water conservation techniques imposed on jute, improved jute fibre yield from 16 (augmented NPK ,T_6) to 28% (T_2: = mulch 2t/ha on seeded rows + N:P:K::60:30:30) over control.

Table 3 Effect of different improved agronomic and soil water conservation techniques on plant population, fresh weight and fibre yield of jute in rain fed environment

Treatment	Plant population (lakh/ha)			Green biomass yield (q/ha)			Fibre equivalent yield (q/ha)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T 1	3.24	3.59	3.42	467	482	475	26.63	28.30	27.46
T 2	4.14	4.52	4.33	510	677	594	33.58	36.97	35.28
T 3	4.83	4.61	4.72	572	663	618	38.15	37.34	37.75
T 4	4.12	4.16	4.14	540	505	523	34.13	32.87	33.50
T 5	2.53	2.62	2.58	440	468	454	36.89	40.79	38.84
T 6	4.03	4.09	4.06	512	523	518	32.29	31.40	31.85
T 7	4.23	4.55	4.39	505	613	559	31.85	36.35	34.10
SEm(±)	0.13	0.12	0.09	10.67	9.79	6.853	0.67	0.75	0.46
CD (0.05)	0.58	0.54	0.56	46.51	42.67	41.471	2.94	3.27	2.83

T_1 = Control (N:P:K::40:20:20), T_2 = Mulch 2t/ha on seeded rows + N:P:K::60:30:30, T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

Effect of drought management techniques (improved agronomic and soil water conservation practices) on nutrient content in plant at harvesting

Different drought management techniques did not showed any significant influence on nitrogen content in plant at harvesting (Table 4). Maximum phosphorus content in plant was found with Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram] treatment whereas, maximum potash content in plant was recorded with residue recycling + (N:P:K::60:30:30).

Table 4 Impact of different improved agronomic and soil water conservation techniques on nitrogen, phosphorus and potash content in plant at harvesting (pooled data)

Treatment	Nitrogen (%)			Phosphorus (%)			Potash (%)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T 1	0.993	0.977	0.985	0.14	0.123	0.132	1.08	0.983	1.032
T 2	0.868	1.036	0.952	0.18	0.107	0.144	1.397	1.357	1.377
T 3	0.828	0.976	0.902	0.14	0.143	0.142	1.213	1.14	1.177
T 4	0.972	0.984	0.978	0.16	0.11	0.135	1.147	0.893	1.020
T 5	0.933	0.948	0.941	0.2	0.18	0.190	1.407	1.357	1.382
T 6	0.803	0.919	0.861	0.15	0.137	0.144	1.257	1.083	1.170
T 7	1.014	1.16	1.087	0.2	0.097	0.149	1.457	1.373	1.415
SEm(±)	0.096	0.059	0.547	0.012	0.009	0.007	0.068	0.023	0.049
CD (0.05)	NS	NS	NS	NS	0.398	0.042	NS	0.321	0.03

T_1 = Control (N:P:K::40:20:20), T_2 = Mulch 2t/ha on seeded rows + N:P:K::60:30:30, T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

Effect of drought management techniques (improved agronomic and soil water conservation practices) on available nutrient content in soil at harvesting

Different drought management techniques had a positive influence on the available nutrient content in soil at harvesting (Table 5). Available nitrogen content in soil was greater with the application of residue recycling + (N:P:K::60:30:30) treatment. Maximum available phosphorus content in soil was found in strip cropping of jute with green gram. Whereas different drought management techniques could not improve the available potash content in soil than the initial potash content in soil. Different drought management techniques had a significant impact on organic carbon content of soil at harvest. The organic matter content in soil was recorded significantly higher in residue recycling + (N:P:K::60:30:30) treatment closely followed by rice straw mulching @ 2t/ha + N:P:K::60:30:30 treatment. On the other hand different drought management techniques could not improve the electrical conductivity of the soil considerably over the initial data.

Table 5 Impact of different improved agronomic and soil water conservation techniques on physic-chemical properties of soil after the harvesting of jute (pooled data)

Treatment	Available Nitrogen (%)	Available Phosphorus (%)	Available Potash (%)	Available Organic Carbon (%)	Electrical conductivity (µs/cm^2)
T 1	359.81	24.02	92.78	0.509	187.92
T 2	406.83	34.77	109.32	0.580	233.80
T 3	410.06	48.90	107.65	0.552	225.52
T 4	363.38	21.65	90.82	0.514	213.57
T 5	384.47	49.55	98.15	0.490	204.58
T 6	377.98	26.92	94.30	0.520	188.77
T 7	428.97	29.83	95.60	0.594	200.62
Initial	362.97	42.01	128.57	0.572	248.24
SEm(±)	6.10	1.62	2.67	0.017	13.192
CD (0.05)	36.89	9.79	16.16	0.104	79.830

T_1 = Control (N:P:K::40:20:20), T_2 = Mulch 2t/ha on seeded rows + N:P:K::60:30:30, T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

Economics of jute cultivation as affected by different drought management techniques (improved agronomic and soil water conservation practices) in rain fed environment

Higher cost benefit ratio was obtained using jute and green gram strip cropping (T_5:1.37 to 1.58), addition of mulch (T_2:1.16 to 1.35), elemental sulphur (T_3: 1.22-1.27) as well as residue recycling (T_7:1.13-1.41).The cost benefit ratio of control was only 0.84 to 0.93 in different years (Fig 2.). Thus adoption of these drought management technics for jute will improve the cost benefit ratio of jute farming over traditional non profitable rain fed jute farming system.

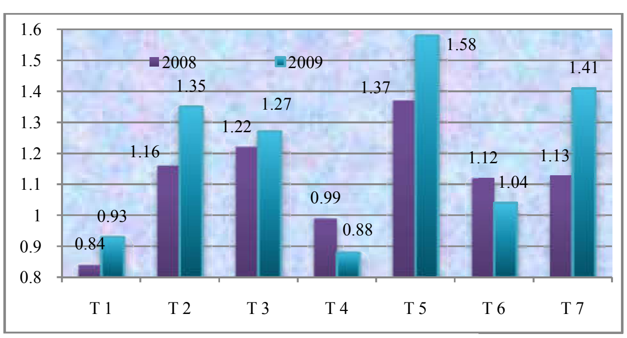

Fig 2 Effect of different moisture conservation techniques on benefit cost ratio

T_1 = Control (N:P:K::40:20:20), T_2 = Mulch 2t/ha on seeded rows + N:P:K::60:30:30, T_3 = 30 kg elemental S / ha + N:P:K::60:30:30, T_4 =One irrigation (post sowing) + N:P:K::60:30:30, T_5 = Strip crop jute (4:4) with green gram [N:P:K::60:30:30 for jute and N:P:K::20:40:40 for Green gram], T_6 = Augmented P & K application (N:P:K::60:40:40), T_7 = Residue recycling + (N:P:K::60:30:30).

CONCLUSION

Sixteen to 37% jute fibre yield improvement was possible adopting improved agronomic & soil water conservation techniques. Applying 30 kg elemental S / ha + N:P:K::60:30:30, the jute fibre yield increased up to 37.75q/ha over 27.46 q/ha under control (N:P:K::40:20:20). Under rainfed and deficit rainfall situation jute & pulse strip cropping gave an equivalent fibre yield of 38.84 q/ha. One post sowing irrigation improved fibre yield by 22% over control. Deep plough and mulch @ 2 t/ha in seeded rows improved fibre yield by 7.82 q/ha over control treatment. Higher cost benefit ratio was obtained using strip cropping, mulch, sulphur as well as residue recycling. These integrated approaches could be harnessed by farmers to improve jute fibre yield under rainfed situation avoiding drought stress. Adoption of these drought management technics for jute will improve the cost benefit ratio of jute farming over traditional non profitable rain fed jute farming system.

References

Basu, B. N. (1997). Studies of raw jute production in India. Proc. Central Level Workshop on Jute, Mesta, Sunnhemp and Ramie (SJDP), held at Barrackpore, April, 12 –25: p A1-A8.

Ghorai, A. K., Saha, S. and Hembram, P. (2008). Drought management of jute crop under deficit rainfall. In the proceed of "International Symposium on Jute and Allied Production, Utilization and Marketing" held at Kolkata, 9-12 jan.2008. p 45.

Ghorai, A. K., Mitra, S. and Mahapatra, B. (2010). Improved production technology of jute and mesta in India. Indian Farming. 59(12):14-16 &21

Ghorai, A. K., Saha, S., Jagannadham, G., Reddy, C. and Hembram, P. K. (2010). Drought management of roselle (*Hibiscus sabdarifa*) under deficit rainfall in changing climatic scenario. (Leaflet, CRIJAF) P-8.

Mandal, K., Saren, B. K., Ghorai, A.K., Kar, S. and Pramanik, K. (2015). Response of Tossa Jute (*Corchorus olitorious* L.) to different date of sowing and draught management techniques. *Journal of Agriculture, Forestry and Environmental Science*. Vol. 1 Issue 1 July – Aug' 2015: 9-11.

Palit, P. (1997). Physiological aspects of jute management. Proc. Central Level Workshop on Jute, Mesta, Sunnhemp and Ramie (SJDP), held at Barrackpore, April, 12 –25, pp

Repica, J., Saric, M., Marek, J. and Zima, M. (1971). Effect of macroelement deficiency on structure of chloroplast and productivity of photosynthesis in maize plants. Soviet Plant Physiology. 18, 938-943

Saren, B. K., Mandal, K. and Ghorai, A. K. (2008). Drought management of jute crop in red & lateritic belt of west Bengal. In the proceed of "International Symposium on Jute and Allied Production, Utilization and Marketing" held at Kolkata, 9-12 jan.2008: p 72.

Umarani, N. K., Pharande, K. S. and Quamarzaman, S. S. (1973). Mulching conserves extra moisture. Indian Farming. 23(5): p 24-25.

Whatley, J. M. (1971). Ultrastructural changes in chloroplasts of *Phaseolus vulgaris* during development under conditions of nutrient deficiency. New Phytology. 70, 725-742

Zafar, S., Nasri, M., Moghadam, H. R. T. and Zahedi, H.(2014). Effect of zinc and sulphur foliar application on physiological characteristics of sunflower (Helianthus annuus L.) underwater deficit stress. *International Journal of Biosciences* (12). 87-96.