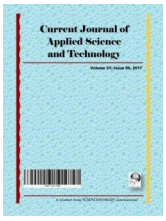

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Effect of Dates of Sowing and Topping on Seed Production of Tossa and White Jute in Red and Laterite Zone of West Bengal

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Authors' contributions

This work was carried out in collaboration between all authors. Author KG performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Author BCP designed the study, author KAC managed the analyses of the study, author SKS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To assess the effects of date of sowing and topping on seed production of tossa and white jute.
Design: Split plot.
Place and Duration of Study: Field experiment was conducted during Kharif season of 2014 and 2015 at Regional Research Sub-station, Raghunathpur, Bidhan Chandra Krishi Viswavidyalaya, Purulia, West Bengal, India.
Methodology: Two separate experiments were carried out on tossa jute, *Corchorus olitorius* L.(cv. JRO-8432) and white jute, *Corchorus capsularis* L. (cv.JRC-698), each having 3 replications, with 3 main plots of dates of sowing (D_1-15th June, D_2-15th July and D_3-15th August) and 4 sub plots for topping treatments [T_1-No topping, T_2-Topping at 30 Days After Sowing (DAS),T_3-Topping at 45 DAS and T_4-Topping at 60 DAS] under rainfed condition.
Results: In both the jute varieties, the first date of sowing (15th June) proved superiority over other

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sowing dates irrespective of topping, however, topping at 45 DAS revealed best results as compared to other topping treatments in both the years. First date of sowing (15th June) along with topping at 45 DAS (30th July) recorded the highest number of primary branches plant^{-1}, number of pods plant^{-1}and the highest seed yield which contributed to significantly higher gross and net return in both the varieties in both the years of experimentation.

Conclusion: Early sowing *i.e*. around 15th June and topping at 45 DAS could be recommended for enhancement of total seed production in *olitorius* as well as *capsularis* jute in red and laterite zone of West Bengal.

Keywords: Date of sowing; jute; seed yield; topping.

1. INTRODUCTION

Quality seed is an important input for higher fibre production [1]. It has been found that the fibre production can be boosted up more than sixteen percent if quality seeds are used instead of local seeds [2]. But, these quality seeds are generally unavailable to the jute growers of the West Bengal. The farmers usually meet their requirement by buying seeds from the National Seed Corporation where the seeds are grown under its supervision in the states like Bihar, Andhra Pradesh and Maharashtra, where seed production is profitable due to congenial atmospheric condition and less labour wages. Presently, the prices of seeds from non-fibre producing states are rising and very often jute seeds from non-fibre producing states are not available in time. In India, around 5000 tonnes of quality seed is required for sowing about 0.8 million hectare of jute area now under cultivation, while the annual seed production of certified seeds is only to the tune of 1500 to 2000 tonnes and it can cover only around 35% of total jute acreage in India [3]. So, farmers of Bengal face heavy cost of cultivation of jute since they can be successfully checked by extending seed production area in our country including different can be successfully checked by extending seed production area in our country including different districts of West Bengal like Bankura, Purulia, Midnapore and parts of Birbhum and Burdwan where agro-climate conditions are congenial for production of quality seed of the crop [4]. Jute seed production can be increased significantly by adopting improved agronomic techniques like adoption of optimum sowing time as jute requires a well distributed monsoon during the vegetative period with rain free spell during ripening to harvesting and processing of seed [5,6,7]. Another important factor is topping (clipping of apical buds) when the apical buds are clipped off at the correct stage, the auxiliary buds develop lateral branches which in turn increases the seed yield by producing more number of pods [8]. So, sowing and topping at appropriate time has synergistic effect on better expression of the crop growth to increase quality seed yield [9,10].

Keeping all these factors in mind a field experiment was conducted during the *kharif* season of 2014 and 2015 at Regional Research Sub-station, Raghunathpur, Bidhan Chandra Krishi Viswavidyalaya, Purulia, West Bengal with the objective to study and assess the optimum date of sowing and topping to achieve positive effect on production of quality seed of this crop.

2. MATERIALS AND METHODS

2.1 Experimental Site

Two separate experiments were conducted at Regional Research Sub Station (Red and Laterite Zone) of Bidhan Chandra Krishi Viswavidyalaya at Purulia, West Bengal in two consecutive years of 2014 and 2015. The experimental site was situated at 23.55°N latitude and 86.67°E longitudes and at an elevation of 155 m above mean sea level. The experiments were carried out, where the soils are coarse textured and with a pH of 5.5 (in 1:2. 5:: Soil: Water) and poor in organic matter, available phosphorus, potassium and lime content, and are highly susceptible to erosion hazards. The sand, silt and clay content were 66.2, 20.3 and 13.5% respectively [11]. Nutrient status of the experimental soil was 0.36% organic carbon, 0.039% total nitrogen, 15.50 kg ha^{-1} available phosphorus, and 100.33 kg ha^{-1} available potassium [12].

2.2 Experimental Design and Treatments

Two separate experiments were conducted in split plot design having 3 replications with plot size of 4 m×5 m with 3 main plots of dates of sowing (D_1-15th June, D_2-15th July and D_3-15th August) along with 4 sub plots of topping treatments [T_1- No topping,T_2-Topping at 30 Days After Sowing (DAS),T_3-Topping at 45 DAS and T_4-Topping at 60 DAS] for two jute varieties

namely, *Corchorus olitorius* L. (cv.JRO-8432) and *Corchorus capsularis* L.(cv.JRC-698). Fertilizer doses of N: P_2O_5: K_2O @ 60:30:30 kg ha^{-1} for JRC-698 and 40:20:20 kg ha^{-1} for JRO-8432 (half N, full P_2O_5& K_2O was applied as basal and rest N was top dressed at 30 DAS) were maintained. Seed rate of 6.5 kg ha^{-1} and spacing of 30 cm × 10 cm was maintained in JRC-698 (Shrabanti white), however, seed rate of 4.5 kg ha^{-1} and spacing of 30 cm × 10 cm was followed in JRO-8432 (Shakti tossa) under rainfed situation. All improved package of practices like weeding, intercultural operation and pest control were adopted.

2.3 Sampling and Statistical Analyses

The yield attributing characters were recorded at full growth stage of crop. The yield of jute crop was recorded after harvesting and threshing of crop. Records on yield attributing characters namely the number of primary branches $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1} and test weight (g) were taken at harvest by randomly taking 10 plants from each plot and finally converting the values to a single mean value. For measuring the seed yield and stalk yield of jute, the entire produce from the net plot area (from demarcated portion, leaving the border area) was harvested, threshed, winnowed and weighed after thorough drying under the sun. Seed yield from that area was converted to yield per hectare (kg ha^{-1}). While calculating gross return prevalent market price for sale of jute seed was taken as Rs 70.00 kg^{-1}. Price for sale of jute stick was considered as Rs10.00 kg^{-1}. Net return was calculated by deducting cost of cultivation from gross income and benefit/cost ratio (B: C) was calculated by dividing total cost of cultivation (Rs ha^{-1}) to gross return (Rs ha^{-1}). Benefit: cost ratio was estimated to compare differential response of agro-techniques on seed production by two varieties from two different species. The critical difference (CD) for estimated treatment contrasts was worked out using standard statistical procedures as outlined in [13]. The difference between treatment means were compared with CD value at 5% level of probability and the treatments with higher effect over others were identified.

3. RESULTS AND DISCUSSION

Number of primary branches $plant^{-1}$ and other yield attributing characters like number of pods $plant^{-1}$, number of seeds pod^{-1} and seed yield were instrumental in producing differential response in both the varieties.

3.1 Effect of Dates of Sowing and Topping on *olitorus* Jute Variety, cv. JRO-8432

In *olitorius* jute (cv.JRO-8432), significant effect of the date of sowing was observed in case of yield attributes like number of primary branches $plant^{-1}$, number of pods $plant^{-1}$ and number of seeds pod^{-1} (Table 1). The pooled value of mean number of branches $plant^{-1}$ was 6.82 during the1st date of sowing (15th June) which was significantly higher over other two dates of sowing (5.57 and 4.85). Consequently, the number of pods $plant^{-1}$ recorded from 15th June sowing (41.57) was significantly higher than15th July (35.34) and 15th August sowing (29.29). Likewise, significantly higher number of seeds pod^{-1} (256.20) was recorded from 15th June sowing compared to other two dates of sowing (249.70 and 228.30). However, test weight being a genetic character of a plant did not vary significantly across the three dates of sowing in both the years (Table 1). Maximum seed yield of 271.46 kg ha^{-1} (pooled value of both the years) was recorded on first date of sowing (15th June) followed by seed yield of second (15th July) and third date of sowing (15th August) of 223.42 kg ha^{-1} and 172.58 kg ha^{-1} respectively. However, between both the years of experimentation, 2015 recorded the higher seed yield as compared to seed yield in 2014. The pooled value of the stalk yield followed the similar trend and recorded that the highest stalk yield (8.80 t ha^{-1}) on first date of sowing (15th June) followed by second date (8.06 t ha^{-1}) and third date (6.10 t ha^{-1}) of sowing. It was observed that the first date of sowing performed better than the other two dates of sowing, this may be discussed as jute being a short-day plant, requires short day conditions to flower [14,15]. 15th June provided the conducive condition for advancing the date of flowering. Beyond the summer solstice (21st June), long day condition generally starts prevailing slowly, thereby affecting the performance of July and August sown plants [16] in a descending order.

Topping treatments proved to be beneficial in significantly affecting the yield and yield attributingcharacters in cv. JRO-8432.The highest number of primary branches $plant^{-1}$ (7.34), number of pods $plant^{-1}$ (41.87) and number of seeds pod^{-1} (252.90) was recorded (pooled value of 2014 and 2015)with the crop that were topped at 45 DAS (Table1); while

significantly lower number of primary branches plant^{-1} (4.32 from no topping, 6.12 from topping at 30 DAS and 5.23 from topping at 60 DAS) and pods plant^{-1} (27.97 from no topping, 37.15 from topping at 30 DAS and 34.62 from topping at 60 DAS) was recorded with the crop with the different topping practices in both the years of experimentation. However, the number of seeds pod^{-1} and test weight did not vary significantly due to topping treatments. The best seed yield (251.74 kg ha^{-1}) and stalk yield (8.15 t ha^{-1}) were observed when the crop was topped at 45 DAS which was significantly higher than the seed and stalk yields obtained from other topping treatments (208.84 kg ha^{-1} and 7.17 t ha^{-1} from no topping,234.29 kg ha^{-1} and 7.78 t ha^{-1} from topping at 30 DAS and 195.08 kg ha^{-1} and 7.51 t ha^{-1} from topping at 60 DAS. The increased number of branches due to topping at 45 DAS might be due to the suppression of apical dominance and improvement of lateral growth of the plants. Increased branch number ultimately led to increased number of pods overall. The increased number of seeds pod^{-1} in topped plants as compared to plants without topping mightbe the result of more photosynthate transfer to lateral branches and pods due to lack of apical dominance. Ultimately improved performance to yield attributes led to increase in overall seed yield [17].

The pooled value of the cost of cultivation was estimated to be equal for all the sowing dates whereas it varied with the different topping practices during both the years. The minimum cost of cultivation (Rs.28459.00 ha^{-1}) was observed under the no topping practices. The cost of cultivation was more for the other three topping practices (Rs.32419.00 ha^{-1}) as it includes the labour charges necessary for clipping off the apical portion at suitable growth phases (Table 3). However, the first date of sowing (15th June) realized significantly high gross return (Rs.83299.30 ha^{-1}) and high net return (Rs.51870.30 ha^{-1}) with B: C ratio of 2.65 as compared to the other dates of sowing (gross return and net return and B:C ratio of Rs. 74302.75 ha^{-1}, Rs. 42873.75 ha^{-1} and 2.37 respectively from 15th July sown crop and Rs. .35 ha^{-1}, Rs. 25051.35 ha^{-1} and 1.80 respectively from 15th August sown crop). B: C ratio did not vary significantly among the three dates of sowing.Topping at 45 DAS achieved a maximum gross return (Rs.77189.40 ha-1), high net return (Rs.44770.46 ha^{-1}) and a B: C ratio (2.38) due to the maximum yield realized under it over the other topping treatments (gross return, net return and B:C ratio of Rs.66897.40 ha^{-1}, Rs.38438.46 ha^{-1} and 2.35 respectively from no topping, Rs.73168.20 ha^{-1}, Rs.40749.20 ha^{-1} and 2.26 respectively from topping at 30 DAS and Rs.68188.06 ha^{-1}, Rs.35769.06 ha^{-1} and 2.10 respectively from topping at 60 DAS). However, B: C ratio did not vary significantly due to topping treatments. Among the interaction effects, the best treatment was observed in case of first date of sowing (15th June) and topping at 45days (30th July) which resulted in the highest gross return of Rs.89716.40 ha^{-1}, highest net return of Rs.57297.00 ha^{-1} and a B:C ratio of 2.77 (Table 4).

3.2 Effect of Dates of Sowing and Topping on *capsularis* Jute Variety, cv.JRC-698

In *capsularis* jute (cv.JRC-698), significant effect of dates of sowing and topping was observed on yield attributes like number of primary branches plant^{-1}, number of pods plant^{-1} and number of seeds pod^{-1} in both the years of experimentation (Table 5).The treatment supremacy based on the pooled values of the number of primary branches plant^{-1} (5.1), number of pods plant^{-1} (53.61) and number of seeds pod^{-1} (65.61) were established with the first date of sowing (15th June) which was significantly superior over the other sowing dates (number of primary branches plant^{-1}, number of pods plant^{-1} and number of seeds pod^{-1} were 4.49, 47.07 and 51.20 respectively from 15th July sown crop and 3.68, 42.28 and 43.80 from 15th August sown crop). However, the test weight did not vary significantly under different date of sowing in both the years. Highest seed yield of 314.34 kg ha^{-1}and stalk yield of 5.66 t ha^{-1} was recorded on first date of sowing (15th June) followed by seed yield of 258.09 kg ha^{-1} and 208.84 kg ha^{-1} and stalk yield of 4.77 t ha^{-1} and 3.85 t ha^{-1} from second(15th July) and third date of sowing (15th August) respectively. The higher values of yield attributes were instrumental in improving the overall crop yield (both seed and stalk yield) in the first date of sowing (15th June) making it superior over the other two dates of sowing. The cause behind the better performance of the crop (both the species) under 1st date of sowing (15th June) may be attributed to the fact that it is probably due to the greater interaction of the crop with the environmental factors such as temperature, humidity, rainfall etc. which in turn has favoured the growth of the crop considerably [18,19].

Table 1. Effect of dates of sowing and topping on yield attributes of cv.JRO-8432

Treatments	Primary branches plant^{-1}			Pods plant^{-1}			Seeds pod^{-1}			Test weight (g)			Seed yield (kg ha^{-1})			Stalk yield (t ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1 (15th June)	5.72	7.92	6.82	39.15	44.00	41.57	249.50	263.00	256.20	2.28	2.28	2.28	259.58	283.33	271.46	8.71	8.89	8.80
D_2 (15th July)	5.10	6.05	5.57	32.88	37.80	35.34	242.90	256.60	249.70	2.27	2.28	2.27	209.29	237.56	223.42	7.90	8.22	8.06
D_3 (15th August)	4.50	5.21	4.85	27.80	30.78	29.29	221.50	235.10	228.30	2.26	2.28	2.26	161.42	183.74	172.58	5.78	6.41	6.10
CD (*P*=0.05)	0.53	0.64	0.59	3.13	3.37	3.29	25.23	26.09	25.96	NS	NS	NS	17.17	17.56	17.31	0.41	0.72	0.51
T_1 (No topping)	3.93	4.70	4.32	25.33	30.60	27.97	232.40	244.20	238.30	2.27	2.27	2.27	196.58	221.10	208.84	6.94	7.40	7.17
T_2 (Topping at 30 DAS)	5.37	6.87	6.12	34.83	39.47	37.15	240.10	255.40	247.70	2.26	2.28	2.27	221.90	246.68	234.29	7.64	7.91	7.78
T_3 (Topping at 45 DAS)	6.47	8.21	7.34	39.70	44.03	41.87	247.00	258.80	252.90	2.28	2.28	2.28	238.28	265.21	251.74	7.96	8.34	8.15
T_4 (Topping at 60 DAS)	4.67	5.80	5.23	33.23	36.00	34.62	232.30	247.80	240.10	2.26	2.27	2.27	183.65	206.51	195.08	7.31	7.71	7.51
CD (*P*=0.05)	0.22	0.37	0.30	1.61	1.85	1.78	NS	NS	NS	NS	NS	NS	15.94	15.26	15.11	0.35	0.57	0.47

Table 2. Interaction effect of dates of sowing and topping on primary branches, yield attributes and yield of cv. JRO-8432

Treatments	Primary branches plant^{-1}			Pods plant^{-1}			Seeds pod^{-1}			Test weight (g)			Seed yield (kg ha^{-1})			Stalk yield (t ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1T_1	4.80	5.10	4.95	31.30	36.20	33.75	243.22	254.62	248.92	2.28	2.30	2.29	244.34	273.00	258.67	8.15	8.31	8.23
D_1T_2	5.50	8.20	6.85	41.70	46.20	43.95	251.30	267.50	259.40	2.26	2.28	2.27	269.40	292.34	280.87	8.75	8.89	8.82
D_1T_3	7.30	11.20	9.25	44.30	49.40	46.85	261.30	272.17	266.73	2.29	2.27	2.28	285.87	306.79	296.33	9.36	9.50	9.43
D_1T_4	5.30	7.20	6.25	39.30	44.20	41.75	242.10	257.70	249.90	2.29	2.27	2.28	238.74	261.20	249.97	8.56	8.86	8.71
D_2T_1	3.80	4.70	4.25	25.40	30.70	28.05	236.96	249.02	242.99	2.27	2.25	2.26	189.20	211.86	200.53	7.32	7.69	7.50
D_2T_2	5.30	6.80	6.05	33.50	38.60	36.05	246.94	260.60	253.77	2.26	2.28	2.27	229.40	258.60	244.00	8.19	8.45	8.32
D_2T_3	6.30	7.30	6.80	40.30	44.50	42.40	248.64	262.50	255.57	2.28	2.30	2.29	249.56	286.24	267.90	8.22	8.62	8.42
D_2T_4	5.00	5.40	5.20	32.30	37.40	34.85	238.86	254.20	246.53	2.26	2.28	2.27	169.00	193.54	181.27	7.87	8.13	8.00
D_3T_1	3.20	4.30	3.75	19.30	24.90	22.10	217.14	229.00	223.07	2.25	2.27	2.26	156.20	178.46	167.33	5.35	6.20	5.77
D_3T_2	5.30	5.60	5.45	29.30	33.60	31.45	222.19	237.95	230.07	2.27	2.29	2.26	166.90	189.10	178.00	5.97	6.40	6.18
D_3T_3	5.80	6.14	5.97	34.50	38.20	36.35	230.97	241.80	236.38	2.26	2.28	2.27	179.40	202.60	191.00	6.30	6.90	6.60
D_3T_4	3.70	4.80	4.25	28.10	26.40	27.25	215.84	231.62	223.73	2.24	2.26	2.25	143.20	164.80	154.00	5.50	6.15	5.82

Treatments	Primary branches plant^{-1}			Pods plant^{-1}			Seeds pod^{-1}			Test weight (g)			Seed yield (kg ha^{-1})			Stalk yield (t ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D × T	1.84	1.99	1.92	5.41	5.55	5.48	27.56	27.73	27.65	NS	NS	NS	19.70	19.46	19.58	0.90	1.21	1.14
CD (*P*=0.05)																		
T × D	0.47	0.59	0.53	3.05	3.11	3.08	NS	NS	NS	NS	NS	NS	21.55	21.38	21.46	0.77	0.83	0.80
CD (*P*=0.05)																		

(Note: D_1-15th June, D_2-15th July and D_3-15th August, T_1- No topping, T_2-Topping at 30 DAS,T_3-Topping at 45 DAS and T_4-Topping at 60 DAS)

Table 3. Effect of dates of sowing and topping on economics of seed production of cv. JRO-8432

Treatments	Gross return (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net return (Rs. ha^{-1})			B:C		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1 (15th June)	81702.00	84896.60	83299.30	30504.00	32354.00	31429.00	51198.00	52542.60	51870.30	2.68	2.63	2.65
D_2 (15th July)	72043.20	76562.30	74302.75	30504.00	32354.00	31429.00	41539.20	44208.30	42873.75	2.36	2.37	2.37
D_3 (15th August)	53374.00	59586.70	56480.35	30504.00	32354.00	31429.00	22870.00	27232.70	25051.35	1.75	1.85	1.80
CD (*P*=0.05)	5561.00	5732.12	5646.56	NS	NS	NS	3788.43	3912.45	3850.44	NS	NS	NS
T_1 (No topping)	64306.40	69488.50	66897.40	27534.00	29384.00	28459.00	36772.40	40104.50	38438.46	2.34	2.36	2.35
T_2 (Topping at 30 DAS)	71208.60	75127.70	73168.20	31494.00	33344.00	32419.00	39714.66	41783.73	40749.20	2.26	2.25	2.26
T_3 (Topping at 45 DAS)	74782.13	79596.80	77189.40	31494.00	33344.00	32419.00	43288.13	46252.80	44770.46	2.37	2.39	2.38
T_4 (Topping at 60 DAS)	65861.73	70514.40	68188.06	31494.00	33344.00	32419.00	34367.73	37170.40	35769.06	2.09	2.11	2.10
CD (*P*=0.05)	4987.13	5145.11	5066.12	31494.00	33344.00	32419.00	3244.00	3471.00	3357.50	NS	NS	NS

Table 4. Interaction effect of dates of sowing and topping on economics of seed production of cv. JRO-8432

Treatments	Gross return (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net return (Rs. ha^{-1})			B: C		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1T_1	76597.20	80010.00	78303.60	27534.00	29384.00	28459.00	49063.20	50626.00	49844.60	2.78	2.72	2.75
D_1T_2	82802.00	85617.20	84209.60	31494.00	33344.00	32419.00	51308.00	52273.20	51790.60	2.63	2.57	2.60
D_1T_3	88389.60	91043.20	89716.40	31494.00	33344.00	32419.00	56895.60	57699.20	57297.40	2.81	2.73	2.77
D_1T_4	79019.20	82916.00	80967.60	31494.00	33344.00	32419.00	47525.20	49572.00	48548.60	2.51	2.49	2.50
D_2T_1	66376.00	70778.80	68577.40	27534.00	29384.00	28459.00	38842.00	41394.80	40118.40	2.41	2.41	2.41
D_2T_2	75682.00	79838.00	77760.00	31494.00	33344.00	32419.00	44188.00	46494.00	45341.00	2.40	2.39	2.40
D_2T_3	77504.80	83239.20	80372.00	31494.00	33344.00	32419.00	46010.80	49895.20	47953.00	2.46	2.50	2.48
D_2T_4	68610.00	72393.20	70501.60	31494.00	33344.00	32419.00	37116.00	39049.20	38082.60	2.18	2.17	2.17
D_3T_1	49946.00	57676.80	53811.40	27534.00	29384.00	28459.00	22412.00	28292.80	25352.40	1.81	1.96	1.89
D_3T_2	55142.00	59928.00	57535.00	31494.00	33344.00	32419.00	23648.00	26584.00	25116.00	1.75	1.80	1.77
D_3T_3	58452.00	64508.00	61480.00	31494.00	33344.00	32419.00	26958.00	31164.00	29061.00	1.86	1.93	1.90

Treatments	Gross return (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net return (Rs. ha^{-1})			B: C		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_3T_4	49956.00	56234.00	53095.00	31494.00	33344.00	32419.00	18462.00	22890.00	20676.00	1.59	1.69	1.64
D × T	8893.45	9123.55	9008.50	NS	NS	NS	5934.14	6179.56	6056.85	NS	NS	NS
CD (*P*=0.05)												
T × D	9475.11	9644.00	9559.55	NS	NS	NS	6333.56	6576.23	6454.89	NS	NS	NS
CD (*P*=0.05)												

(Note: D_1-15th June, D_2-15th July and D_3-15th August, T_1- No topping, T_2-Topping at 30DAS, T_3-Topping at 45 DAS and T_4-Topping at 60 DAS)

Table 5. Effect of dates of sowing and topping on primary branches, yield attributes and yield of cv. JRC-698

Treatments	Primary branches plant^{-1}			Pods plant^{-1}			Seeds pod^{-1}			Test weight (g)			Seed yield (kg ha^{-1})			Stalk yield (t ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1 (15th June)	4.45	5.75	5.10	48.85	58.37	53.61	60.00	71.23	65.61	3.33	3.35	3.35	295.02	333.67	314.34	5.32	6.01	5.66
D_2 (15th July)	4.08	4.90	4.49	42.10	52.05	47.07	46.90	55.50	51.20	3.30	3.32	3.31	239.67	276.52	258.09	4.44	5.11	4.77
D_3 (15th August)	3.21	4.15	3.68	38.01	46.55	42.28	40.27	47.34	43.80	3.26	3.27	3.26	185.47	232.22	208.84	3.44	4.27	3.85
CD (*P*=0.05)	0.62	0.74	0.68	3.72	4.34	4.03	3.46	4.89	4.17	NS	NS	NS	12.85	18.67	15.76	0.29	0.38	0.33
T_1 (No topping)	2.90	3.90	3.40	35.60	43.10	39.35	40.40	47.70	44.00	3.28	3.30	3.29	162.00	206.50	184.20	3.60	4.24	3.92
T_2 (Topping at 30 DAS)	4.27	5.25	4.76	45.10	55.26	50.18	50.80	60.83	55.81	3.31	3.33	3.32	261.80	296.46	279.13	4.69	5.31	5.00
T_3 (Topping at 45 DAS)	4.82	6.08	5.45	49.40	61.30	55.35	58.96	68.84	63.90	3.33	3.34	3.33	319.63	358.10	338.86	5.22	6.12	5.67
T_4 (Topping at 60 DAS)	3.66	4.50	4.08	41.83	49.60	45.71	46.06	54.72	50.39	3.28	3.31	3.29	216.76	262.16	239.46	4.09	4.86	4.47
CD (*P*=0.05)	0.42	0.51	0.46	4.93	5.99	5.46	NS	NS	NS	NS	NS	NS	15.33	20.89	18.11	0.45	0.54	0.49

Table 6. Interaction effect of dates of sowing and topping on primary branches, yield attributes and yield of cv. JRC-698

Treatments	Primary branches plant^{-1}			Pods plant^{-1}			Seeds pod^{-1}			Test weight (g)			Seed yield (kg ha^{-1})			Stalk yield (t ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1T_1	3.40	4.60	4.00	43.40	51.00	47.20	51.90	57.60	54.75	3.31	3.33	3.32	225.66	266.30	245.93	4.49	5.38	4.93
D_1T_2	4.80	5.90	5.35	50.00	60.08	55.04	62.00	76.00	69.00	3.34	3.36	3.35	328.24	360.30	344.27	5.67	6.12	5.89
D_1T_3	5.20	6.90	6.05	53.90	67.20	60.55	69.50	82.76	76.13	3.34	3.37	3.35	353.76	394.10	373.93	6.02	6.80	6.41
D_1T_4	4.40	5.60	5.00	48.10	55.20	51.65	56.60	68.56	62.58	3.33	3.35	3.34	272.54	314.00	293.27	5.13	5.74	5.43
D_2T_1	3.00	3.90	3.45	33.20	40.50	36.85	35.90	45.20	40.55	3.28	3.30	3.29	153.16	194.70	173.93	3.45	4.09	3.77
D_2T_2	4.58	5.32	4.95	45.00	56.20	50.60	49.70	58.00	53.85	3.31	3.33	3.32	266.60	297.00	281.80	4.76	5.32	5.04
D_2T_3	5.03	6.07	5.55	49.10	60.70	54.90	57.30	65.90	61.60	3.33	3.35	3.34	318.20	351.10	334.67	5.43	6.21	5.82
D_2T_4	3.72	4.30	4.01	41.10	50.80	45.95	44.70	52.90	48.80	3.30	3.32	3.31	220.70	263.30	242.00	4.12	4.84	4.48
D_3T_1	2.30	3.20	2.75	30.25	37.80	34.02	33.40	40.33	36.87	3.25	3.27	3.26	107.36	158.50	132.93	2.86	3.26	3.06
D_3T_2	3.44	4.52	3.98	40.30	49.50	44.90	40.70	48.50	44.60	3.27	3.29	3.28	190.56	232.10	211.33	3.65	4.48	4.06
D_3T_3	4.23	5.29	4.76	45.20	56.10	50.66	50.10	57.80	53.98	3.32	3.30	3.31	286.90	329.10	308.00	4.22	5.37	4.79
D_3T_4	2.87	3.60	3.23	36.30	42.80	39.55	36.90	42.70	39.80	3.23	3.25	3.24	157.06	209.20	183.13	3.03	4.00	3.51
D × T	1.16	1.36	1.26	9.80	10.95	10.37	NS	NS	NS	NS	NS	NS	17.10	17.58	17.34	0.39	0.47	0.43
CD (*P*=0.05)																		
T × D	1.02	2.18	1.60	6.85	6.98	6.91	NS	NS	NS	NS	NS	NS	20.45	22.82	21.63	0.17	0.29	0.23
CD (*P*=0.05)																		

(Note: D_1-15th June, D_2-15th July and D_3-15th August, T_1- No topping, T_2-Topping at 30DAS, T_3-Topping at 45 DAS and T_4-Topping at 60 DAS)

Table 7. Effect of dates of sowing and topping on economics of seed production of cv. JRC-698

Treatments	Gross return (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net return (Rs. ha^{-1})			B:C		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1 (15th June)	73926.75	83457.25	78692.00	27150.00	28500.00	27825.00	46776.75	54957.25	50867.00	2.72	2.93	2.82
D_2 (15th July)	61177.25	70506.75	65842.00	27150.00	28500.00	27825.00	34027.25	42006.75	38017.00	2.25	2.47	2.36
D_3 (15th August)	47382.90	59030.75	53206.83	27150.00	28500.00	27825.00	20232.90	30530.75	25381.83	1.75	2.07	1.91
CD (*P*=0.05)	5711.78	5933.07	5822.42	NS	NS	NS	3954.23	4156.11	4055.17	NS	NS	NS
T_1 (No topping)	47341.87	56888.33	52115.10	27800.00	29800.00	28800.00	19541.86	27088.33	23315.10	1.70	1.91	1.80
T_2 (Topping at 30 DAS)	65259.33	73819.33	69539.33	32000.00	33500.00	32750.00	33259.33	40319.33	36789.33	2.04	2.20	2.12
T_3 (Topping at 45 DAS)	74607.67	86333.67	80470.67	32000.00	33500.00	32750.00	42607.66	52833.67	47720.67	2.33	2.58	2.45
T_4 (Topping at 60 DAS)	56107.00	66951.67	61529.34	32000.00	33500.00	32750.00	24107.00	33451.67	28779.34	1.75	2.00	1.87
CD (*P*=0.05)	5144.11	5342.90	5243.50	NS	NS	NS	3451.23	3675.09	3563.16	NS	NS	NS

Table 8. Interaction effect of dates of sowing and topping on economics of seed production of cv. JRC-698

Treatments	Gross return (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net return (Rs. ha^{-1})			B:C		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
D_1T_1	60689.20	72441.00	66565.10	27150.00	28500.00	27825.00	33539.20	43941.00	38740.10	2.24	2.54	2.39
D_1T_2	79676.80	86421.00	83048.90	32000.00	33500.00	32750.00	47676.80	52921.00	50298.90	2.49	2.58	2.53
D_1T_3	84963.20	95587.00	90275.10	32000.00	33500.00	32750.00	52963.20	62087.00	57525.10	2.66	2.85	2.75
D_1T_4	70377.80	79380.00	74878.90	32000.00	33500.00	32750.00	38377.80	45880.00	42128.90	2.20	2.37	2.28
D_2T_1	45221.20	54529.00	49875.10	27150.00	28500.00	27825.00	18071.20	26029.00	22050.10	1.67	1.91	1.79
D_2T_2	66262.00	73990.00	70126.00	32000.00	33500.00	32750.00	34262.00	40490.00	37376.00	2.07	2.21	2.14
D_2T_3	76576.80	86677.00	81626.90	32000.00	33500.00	32750.00	44576.80	53177.00	48876.00	2.39	2.59	2.49
D_2T_4	56649.00	66831.00	61740.00	32000.00	33500.00	32750.00	24649.00	33331.00	28990.00	1.77	1.99	1.88
D_3T_1	36115.20	43695.00	39905.10	27150.00	28500.00	27825.00	8965.20	15195.00	12080.10	1.33	1.53	1.43
D_3T_2	49839.20	61047.00	55443.10	32000.00	33500.00	32750.00	17839.20	27547.00	22693.10	1.56	1.82	1.69
D_3T_3	62283.00	76737.00	69510.00	32000.00	33500.00	32750.00	30283.00	43237.00	36760.00	1.95	2.29	2.12
D_3T_4	41294.20	54644.00	47969.10	32000.00	33500.00	32750.00	9294.20	21144.00	15219.10	1.29	1.63	1.46
D × T	9899.12	10112.76	10005.94	NS	NS	NS	6899.00	7009.56	6954.28	NS	NS	NS
CD (*P*=0.05)												
T × D	9522.56	9645.11	9583.83	NS	NS	NS	6656.60	6796.78	6726.69	NS	NS	NS
CD (*P*=0.05)												

(Note: D_1-15th June, D_2-15th July and D_3-15th August, T_1- No topping, T_2-Topping at 30DAS, T_3-Topping at 45 DAS and T_4-Topping at 60 DAS)

The highest number of primary branches plant^{-1} (5.45), number of pods plant^{-1} (55.35) and number of seeds pod^{-1} (63.90) was recorded (pooled value of 2014 and 2015) with the crop that were topped at 45 DAS (Table 5); while significantly lower number of primary branches plant^{-1} (3.40 from no topping, 4.76 from topping at 30 DAS and 4.08 from topping at 60 DAS) and pods plant^{-1} (39.35 from no topping, 50.18 from topping at 30 DAS and 45.71 from topping at 60 DAS) was recorded with the crop with the different topping practices in both the years of experimentation. However, the number of seeds plant^{-1} and test weight did not vary significantly due to topping treatments. The best seed yield (338.86 kg ha^{-1}) and stalk yield (5.67 t ha^{-1} were observed when the crop was topped at 45 DAS which was significantly higher than the seed and stalk yields obtained from other topping treatments (184.26 kg ha^{-1} and 3.92 t ha^{-1} from no topping, 279.13 kg ha^{-1} and 5.00 t ha^{-1} from topping at 30 DAS and 239.46 kg ha^{-1} and 4.47 t ha^{-1} from topping at 60 DAS). Among the interaction effects, first date of sowing (15th June) with topping at 45 days (30th July) was the best treatment as it resulted in the highest number of primary branches plant^{-1} (6.05), number of pods plant^{-1} (53.90) and number of seeds pod^{-1} (76.13) as well as highest seed yield (373.93 kg ha^{-1}) and stalk yield (6.41 t ha^{-1}) in 2014 and 2015, respectively overall other treatment combinations (Table 6). The reason is that the clipping off apical buds might have induced growth of new auxiliary branches and increases the other associated yield attribute like no. of pod plant^{-1} which consequently results in an increase of seed yield to a sufficient extent in the white jute variety, JRC-698. All these results are in concordance with the findings recorded by [20,21] in white jute (topping at 45 days) crop.

The cost of cultivation was estimated to be equal for all the sowing dates where as it varied with the different topping practices on cv.JRC-698 during both the years. The minimum cost of cultivation (Rs.278250.00 ha^{-1}) was observed under the no topping practices. Like *olitorius* variety, the cost of cultivation in *capsularis* variety, JRC-698 was more for the other three topping practices as it includes the labour charges necessary for clipping off the apical portion at suitable growth phases (Table7). However, the first date of sowing (15th June) gave significantly high gross return(Rs.78692.00 ha^{-1}), high net return (Rs 50867.00 ha^{-1}) and a B: C ratio (2.82) as compared to the other dates of sowing (gross return, net return and B: C ratio of Rs.65842.00 ha^{-1}, Rs.38017.00 ha^{-1} and 2.36 respectively from 15th July sown crop and Rs.53206.83 ha^{-1}, Rs.25381.83 ha^{-1} and 1.91 respectively from 15th August sown crop). However, B: C did not vary significantly across the sowing dates. Maximum gross return (Rs.80470.67 ha^{-1}) and a high net return (Rs.47720.67 ha^{-1}) with B:C of 2.45 was recorded from 45 DAS topped crop due to the maximum yield realized under it over the other topping treatments (gross return, net return and B: C ratio of Rs.52115.10 ha^{-1}, Rs.23315.10 ha^{-1} and 1.80 respectively from no topping, Rs.62539.33 ha^{-1}, Rs.36789.33 ha^{-1} and 2.12 respectively from topping at 30 DAS and Rs.61529.34 ha^{-1}, Rs.28779.34 ha^{-1} and 1.87 respectively from topping at 60 DAS). B: C did not vary significantly due to topping treatments. Among the interaction effects, the best treatment was observed in case of first date of sowing (15th June) and topping at 45 days (30th July) which resulted in the highest gross return of Rs.90275.10 ha^{-1}, highest net return of Rs.57525.10 ha^{-1}and B: C of 2.75 (Table 8).Though the employment of topping increased the cost of cultivation to some extent over the no topping practices but there was significant yield increase due to the adoption of topping which boosted the production to the sufficient extent, so, gross return and net return became higher over traditional cultivation of jute seed crop with no topping [22,23].

4. CONCLUSION

There is scope to improve total seed yield in jute by the adjustment of date of sowing and topping at appropriate stage of growth. Early sowing i.e. around 15th June and clipping of apical buds at 45 DAS could be recommended for enhancement of total seed yield in both *olitorius* as well as *capsularis* jute in red and laterite zone of West Bengal under rainfed situation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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