

Development of Pre-mature Flowering Resistant Tossa Jute (*Corchorus olitorius* L.) Varieties for Early Sowing with Specific Reference to Study of DNA Profiles

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ABSTRACT

Considering the importance of availability of tossa jute (*C. olitorius*) variety for early sowing (1st week of March) and to suitably fit the crop in jute-paddy cropping system as well as intercropping with *mung* bean, an effort was made to develop premature flowering resistant variety along with higher fibre yield. A total of four new varieties of such kind were developed and evaluated with popular checks (JRO 524 & JRO 204) under six staggered sowing at 12 days interval starting from 20th February in two consecutive years. Out of four new varieties (viz, NJ 7050, NJ 7055, NJ 7010 and NJ 7005), the first two showed very remarkable level of resistance to pre-mature flowering along with higher fibre yield under very early (20th of February) and early (4th March) sowing. The other two varieties e.g., NJ 7010 (Rani) and NJ 7005 (Raja) had also recorded acceptable level of resistance to pre-mature flowering and higher fibre yield under both early (4th March) and timely (16th March to 9th April) sowing schedule. In addition, the 4th jute variety NJ 7005 (Raja) had also nicely demonstrated its suitability under late sowing schedule too (21st April). In the present paper details of the materials under study along with pedigree, DNA profile and field data have been presented and inferences drawn.

Keywords: Pre-mature flowering, date of sowing, fibre yield

In West Bengal and in neighbouring Bangladesh, jute (*Corchorus olitorius*) is the major commercial crop. It sustains livelihood of millions of small to marginal farmers and industrial workers. Being a four month old fibre crop (120 days), its sowing starts, in most cases, from 4th week of March (2nd week of Chaitra as per Bengali month) to 4th week of April (2nd week of Baisakh) based on on-set of Nowester rains or irrigation facilities. The crop is harvested during 1st week of July to end of July (105-130 days crop) as per need or tradition and the land is mostly used for *kharif* paddy cultivation.

Under given situation, if a farmer harvest his jute crop in 1st week of July (at 105 days), he has to sacrifice fibre yield but his paddy transplanting will be in time. But, if he don't sacrifice fibre yield and harvest the crop in 4th week of July (120-125 day old), then paddy transplanting will be delayed and he has to sacrifice paddy yield. So, the best choice is

to sow jute seed by 1st week of March and harvest the crop during 4th week of June to 1st week of July (120-127 day old crop) and transplant rice seedlings in optimum time (2nd -3rd week of July).

Not only is this, the ICAR-CRIJAF, Barrackpore has been strongly advocating *mung* bean cultivation along with jute as inter-crop or mixed-crop for assuring maximum possible benefit to the farmers (Ghorai *et al.* 2015; Ghorai *et al.* 2016 & Ghorai *et al.* 2016). This also needs sowing of jute seed with *mung* beans during 1st to 3rd week of March to ensure *mung* harvesting (a 70-75 days crop) during 3rd week of May to 1st week of June, i.e., before on-set of monsoon by 10th-15th of June.

So, the demand of the said situations is the availability of suitable jute variety (ies) which can be sown in 1st week of March to 3rd week of March. But the present days varieties like JRO 524 (Navin),

JRO 8432 (*Shakti tossa*) or JRO 204 (Suren) are not suitable for this, as these show no resistance to pre-mature flowering under 1st – 3rd week of March sowing. Initially it was supposed that JRO 204 would be appropriate over JRO 524 for mid-March sowing. But observed, later on, that JRO 204 too produce flower & branches even upto 3rd week of March sowing. In such a situation, development and availability of jute variety which is(are) highly resistant to pre-mature flowering for early March sowing without producing any unwanted flowers and branches should get top most breeding priority (Rahaman, 2016).

Keeping these facts in mind, most of the jute breeders (both at public & private sectors) have been trying to breed tossa jute variety (ies) suitable for sowing from the very 1st day of March. The breeders of Nuziveedu Seeds Ltd have also tried and developed a few suitable varieties at its Regional Research Station, Barrackpore, Kolkata-700121. These have been evaluated under different date of sowing along with popular checks. Attempt has also been made to create a sowing window for the benefit of the millions of resource poor farmers.

MATERIALS AND METHODS

Materials

NJ 7050: Developed at Nuziveedu Seeds Limited from a cross in between JRO 878 and JRO 524. Pedigree method of selection was followed under appropriate selection environment. It was nominated for AINP-JAF (ICAR) trial for multilocation testing. Four years evaluation (IET, AVT-I, AVT-II & Adaptive) have also been completed. Stem colour of this variety is coppery red. Due to its strong resistance to pre-mature flowering and suitability for early sowing, the genotype has been shared with ICAR-CRIJAF for their crop improvement programme.

NJ 7055: Developed at Nuziveedu Seeds Limited from a cross involving Sudan Green/JRO 524/JRO 632. Pedigree method of selection was done under appropriate selection environment. Three years trial (IET, AVT-I, AVT-II) under AINP-JAF(ICAR) has been completed. Stem colour of this variety is green. This genotype has also been shared with ICAR-CRIJAF for crop improvement programme.

NJ 7005 (Raja): Developed at Nuziveedu Seeds Limited from a cross involving JRO 524/JRO 632//JRO 8432. Four years trial (IET, AVT-I, AVT-II & Adaptive) under AINP-JAF (ICAR) along with resistance to pre-mature flowering under 4th March sowing has also been completed.

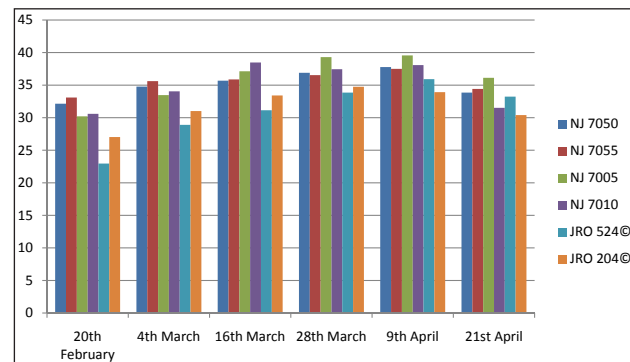


Fig. 1: Showing fibre yields of varieties under different date of sowing

NJ 7010 (Rani): Developed at Nuziveedu Seeds Limited following mutation breeding using Ethyl Methene Sulphonate in the variety JRO 524. After four years evaluation (IET, AVT-I, AVT-II & Adaptive) under AINP-JAF(ICAR) it has been Released and Notified in 2018 by Central Variety Release Committee.

JRO 524 (Navin): Developed at ICAR-CRIJAF from a cross Sudan Green /JRO 632 and Released & Notified in 1978. The variety is still very popular among farmers and was used as check in the present study.

JRO 204 (Suren): Developed at ICAR-CRIJAF from a cross involving IND/SU/053 X KEN/DS/060 and Released & Notified in 2007. It is getting popularity as a better variety over JRO 524 as regard to its resistance to pre-mature flowering and was used as 2nd check under present study.

DNA profile with fingerprints of the materials

DNA isolation

Genomic DNA of these jute accessions was extracted from 30-day-old seedlings using a modified cetyltrimethyl ammonium bromide method (Haque *et al.* 2004) and diluted to 50ng/ μ L with double distilled H₂O. All samples were stored at -20°C for further analysis.

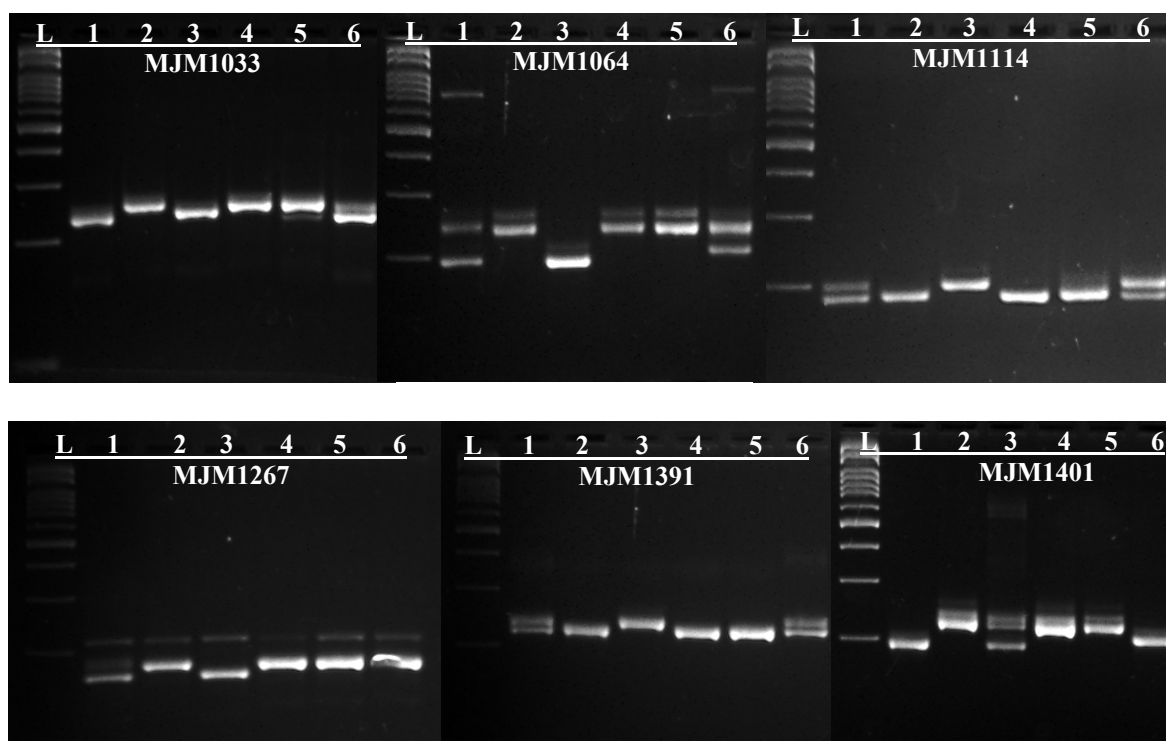


Fig. 2: Representative SSRs amplification profile of 6 jute lines amplified with MJM1033, MJM1064, MJM1114, MJM1267, MJM1391 and MJM1401. L= 100bp ladder, 1=JRO524, 2 = JRO204, 3 = NJ7005, 4 = NJ7010, 5 = NJ7055 and 6 = NJ7050

PCR analysis

A total of 66 SSR primers (Mir *et al.* 2008, 2009) were used for screening six genotypes of jute. Of these, 23 SSR primers produced clear polymorphic bands in this study. PCR reactions were performed in 15µL reaction volumes containing approximately 30 ng of jute template DNA, 1X PCR buffer [(750 mM Tris-HCl (pH 8.8 at 25°C), 200 mM (NH₄)₂SO₄ 0.1% (v/v)], 1.5 mM MgC₁₂, 0.1 mM dNTPs, 0.5 µM of each primer and 0.3 unit of *Taq* DNA polymerase. The reaction mixture was subjected to PCR amplification in a Thermocycler (Eppendorf; Germany) using a PCR program of: preheating for 4 min at 94 °C; 30 cycles, each for 30 s at 94 °C (denaturation), 30 s at the annealing temperature of a particular primer pair (ranges were 56–60°C), and 30 s at 72°C for 1 min (extension) and a final extension at 72°C for 5 min followed by cooling at 10°C for an indefinite time. The PCR products were mixed with bromophenol blue gel loading dye and were analyzed by electrophoresis on 2.5% (w/v) agarose gel. The gels were stained in 0.5 mg/ml ethidium bromide and were documented using gel documentation system. This was followed by scoring of bands with the help of 100 bp DNA size standard (Fermentas, Lithuania, USA).

Data analysis

Amplified DNA fragments were scored as 1 (present) or 0 (absent). Polymorphism information content (PIC) was estimated by using PIC calculator by SJK Jan 2002. Genetic similarity coefficients (GSC) comparing all pairs of the 6 jute accessions were calculated by the unweighted pair group of arithmetic means (UPGMA) method with NTsys pc2 [F.J. Rohlf *et al.* 2002].

Methods

Experiments were conducted at Regional Research Station, Nuziveedu Seeds Limited, Barrackpore (22°46'N, 88°24'E & 7.5 m above MSL), North 24 Parganas, West Bengal, India during Feb, 2016 to Sept, 2017. Seeds were sown in six splits at 12 days interval in each of two consecutive years starting from 20th February to 21st April. Complete Block Design with three replications were followed. Each plot size was 15 sqm (6 × 2.5 meter). Plants were grown in lines following recommended spacing of 25 × 5-7 cm (Ghorai, 2008). For cultivation of crop including control of weeds, pests, diseases and fibre retting standard package of practices were followed (Saha *et al.* 2008; Mukesh Kumar *et al.* 2013;

Ramasubramanyam, T and Ghosh, S.K. 2008; Roy *et al.* 2008 and Majumdar *et al.* 2008).

Percentage of plants with flowers, branches and pods (effective pods with more than 3 cm length) were counted at 60 & 90 day after sowing (DAS). Plant height, base diameter and fibre yield /plot were recorded at 120 DAS. For assessment of premature flowering resistance Kumar *et al.* 2008 and Begum and Kumar, 2011 were followed. During harvesting two border rows (length wise) were removed and data were collected from net plot size of 12.0 sqm only. Before recording plot yield sundried fibre bundles were taken into hot-air ovens for four hours at 60°C temperatures for uniform drying.

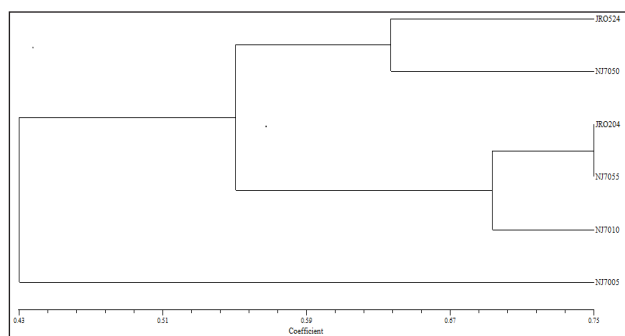


Fig. 3: Genetic diversity of 6 jute accessions based on 23 SSRs data. Dendrogram constructed from cluster analysis using jaccard's similarity coefficient based on UPGMA and SAHN algorithm

RESULTS AND DISCUSSION

Pre-mature flowering: *Corchorus olitorius* (tossa jute) being a short day plant (SDP) and the critical photoperiod of which being 12.5 hours (Sengupta & Sen, 1944), it favors short light periods for its flowering. Therefore, if seed is sown in early or mid-March when photoperiod is far less than 12.5 hours, flowering is induced in the young seedlings. As an obvious effect of it, a 40-70 day old plant (based on date of sowing and genotype) start producing flower buds and branches. This commonly called *pre-mature flowering* in jute. It adversely affect not only cylindrical growth of the stem but also fiber yield and fibre quality. This is the single most important phenomenon which determine the date of seed sowing. The fact is feared by jute growers and to avoid it they start seed sowing in 4th week of March or even later, as the extent of risk of unwanted flowering and branches gradually

decreases along with increases of day length under timely or late sowing (end of March-end of April).

1st sowing (20th February)

Pre-mature flowering and plant height were highly influenced by this very early sowing and the varieties under study showed highly differential effects (Table 1,2 & 3). Only NJ 7050 & NJ 7055 had been able to produce tall cylindrical stems without formation of significant number of flowers or branches. On other hand, both the popular varieties JRO 524 and JRO 204, used as check, had produced profuse flowers, branches and even pods. Under 20th February sowing the other two varieties namely NJ 7005 & NJ 7010 had also produced pre-mature flower and branches but not to that extent as recorded in check varieties JRO 524 or JRO 204.

As regard to plant height and fibre yield all the entries recorded negative co-relation with the percentage of flowering plants in the population. In this very early sowing schedule both NJ 7050 & NJ 7055 had recorded 18.92% and 22.43% higher (on an average) respectively, fibre yield than the best check variety JRO 204 and hence may be considered suitable for sowing (Table 3). The overall lower fibre yield under 20th February, as compared to other sowing schedules, may be attributed to prevailing low temperature and low humidity and less number of intermittent rainy days.

2nd Sowing (4th March): Under 2nd sowing too the varieties like NJ 7050 & NJ 7055 performed nicely as regard to resistance to pre-mature flowering & fibre yield (Table 1,2&3). Both the genotypes (NJ 7050 & NJ 7055) produced tall cylindrical stems and recorded 12.21% & 14.87% higher yield, respectively, as compared to the best check variety JRO 204. The genotypes like NJ 7005 & NJ 7010 had also recorded 7.87% and 9.80% respectively, higher fibre yield than the best check variety JRO 204 (Table 3). So, under 5th March sowing though all the four varieties (viz, NJ 7050, NJ 7055, NJ 7005 & NJ 7010) were found suitable but as per recorded fibre yield the first two varieties (viz., NJ 7050 & NJ 7055) were found most suitable.

3rd Sowing (16th March): Under 16th March sowing though all the new varieties were found resistant to pre-mature flowering but as regard to fibre yield only NJ 7005 & NJ 7010 were found significantly

Table 1: Evaluation of elite jute varieties against pre-mature flowering and fibre yield in pre-kharif, 201

Date of sowing	Varieties	At 60 days			At 90 days			At harvest (120 days)				
		Flower (%)	Branch (%)	Pod (%)	Flower (%)	Branch (%)	Pod (%)	Plant height (mt)	Base diameter (cm)	Yield/plot	Yield/ha (in qtl)	Superiority over best check(%)
20 th February	NJ 7050	0.0	0.0	0.0	1.5	0.9	0.0	3.75	1.46	3.630	30.25	19.28
	NJ 7055	0.0	0.0	0.0	0.3	0.2	0.0	3.69	1.45	3.720	31.00	22.26
	NJ 7005 (Raja)	11.1	10.9	0.0	16.0	15.0	0.6	3.22	1.35	3.385	28.21	11.24
	NJ 7010 (Rani)	9.0	0.6	0.0	10.6	8.5	3.0	3.75	1.59	3.417	28.48	12.32
	JRO 524 (Navin) ©	67.0	65.0	34.5	93.0	74.5	65.0	3.00	1.58	2.546	21.22	-16.32
	JRO 204 (Suren) ©	47.0	46.0	10.0	56.5	59.0	22.0	3.05	1.31	3.043	25.36	Best check
	Mean	22.40	20.4	7.4	29.7	26.2	15.1	3.41	1.46	3.290	37.42	—
	CD(P=0.05)	3.2	3.0	1.8	2.7	2.5	3.0	0.16	0.07	0.072	1.74	—
4 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.63	1.48	3.985	33.21	13.23
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.95	1.69	4.058	33.82	15.31
	NJ 7005 (Raja)	0.8	0.7	0.0	1.4	0.6	0.2	3.99	1.78	3.770	31.42	7.13
	NJ 7010 (Rani)	0.0	0.0	0.0	0.7	1.1	0.0	3.98	1.69	3.869	32.24	9.92
	JRO 524 (Navin) ©	70.0	64.0	29.0	78.0	71.0	55.0	3.28	1.48	3.305	27.54	-6.1
	JRO 204 (Suren) ©	29.0	27.0	9.0	46.0	39.0	23.0	3.00	1.59	3.520	29.33	Best check
	Mean	16.6	15.3	6.3	21.0	18.6	13.0	3.64	1.62	3.751	31.26	—
	CD(P=0.05)	3.2	3.4	1.6	2.3	2.3	1.8	0.17	0.05	0.086	1.69	—
16 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.96	1.63	4.204	35.03	6.22
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.97	1.64	4.272	35.60	7.95
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	4.09	1.65	4.393	36.61	11.01
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	4.02	1.64	4.600	38.33	14.25
	JRO 524 (Navin) ©	27.0	25.8	19.0	47.0	39.5	24.5	3.45	1.53	3.662	30.52	-7.45
	JRO 204 (Suren) ©	19.0	17.0	4.8	27.0	13.5	10.0	3.64	1.45	3.958	32.98	Best check
	Mean	7.7	7.1	4.0	12.3	8.8	5.8	3.86	1.59	4.181	34.85	—
	CD(P=0.05)	3.1	3.0	1.4	1.9	1.7	1.5	0.19	0.07	0.100	1.48	—
28 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.85	1.60	4.404	36.67	6.29
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.71	1.59	4.339	36.16	4.81
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	4.04	1.68	4.682	39.02	13.10
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.99	1.52	4.451	37.09	7.50
	JRO 524 (Navin) ©	9.0	6.0	5.0	20.5	18.5	13.0	3.61	1.60	4.058	33.82	-1.97
	JRO 204 (Suren) ©	0.2	0.1	0.0	5.7	4.0	0.2	3.76	1.62	4.140	34.50	Best check
	Mean	1.5	1.0	0.8	4.4	3.8	2.2	3.83	1.60	4.435	36.21	—
	CD(P=0.05)	—	—	—	—	—	—	0.26	0.07	0.090	1.71	—
9 th April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.84	1.62	4.600	38.33	5.15
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.92	1.64	4.555	37.96	4.11
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	4.02	1.66	4.819	40.16	10.14
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.98	1.58	4.635	38.63	5.95
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.80	1.60	4.375	36.46	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.63	1.56	4.162	34.68	-4.88
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.86	1.61	4.524	37.70	—
	CD(P=0.05)	—	—	—	—	—	—	0.13	0.05	0.084	1.45	—
21 st April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.78	1.62	4.208	35.07	2.45
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.83	1.60	4.273	35.61	4.03
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.88	1.65	4.466	37.22	8.74
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.69	1.58	3.883	32.36	-5.46
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.74	1.56	4.108	34.23	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.59	1.52	3.748	31.23	-8.76
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.75	1.58	4.114	34.29	—
	CD(P=0.05)	—	—	—	—	—	—	—	—	—	—	—

Table 2: Evaluation of elite jute varieties against pre-mature flowering and fibre yield in pre-kharif, 2017

Date of sowing	Varieties	At 60 days			At 90 days			At harvest (120 days)				
		Flower (%)	Branch (%)	Pod (%)	Flower (%)	Branch (%)	Pod (%)	Plant height (mt)	Base diameter (cm)	Yield/ plot	Yield/ ha (in qtl)	Superiority over best check (%)
20 th February	NJ 7050	0.0	0.0	0.0	0.9	0.5	0.0	3.61	1.54	4.084	34.03	18.57
	NJ 7055	0.0	0.0	0.0	1.1	0.3	0.0	3.81	1.63	4.223	35.19	22.61
	NJ 7005 (Raja)	13.9	11.7	0.0	17.0	11.0	0.8	3.80	1.53	3.865	32.21	12.23
	NJ 7010 (Rani)	6.0	5.4	0.0	15.0	8.5	2.0	3.39	1.35	3.924	32.70	13.94
	JRO 524 (Navin) ©	85.0	81.0	42.5	85.0	80.5	47.0	2.72	1.20	2.962	24.68	-14.01
	JRO 204 (Suren) ©	35.0	33.0	21.0	68.5	46.0	32.0	2.81	1.45	3.444	28.7	Best check
	Mean	23.3	21.9	10.6	31.3	24.3	13.6	3.36	1.45	3.750	31.25	—
	CD(P=0.05)	3.6	3.4	2.0	3.1	2.9	3.2	0.20	0.09	0.080	1.92	—
4 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	4.09	1.72	4.363	36.36	11.19
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.87	1.55	4.490	37.42	14.43
	NJ 7005 (Raja)	0.2	0.1	0.0	2.2	0.2	0.0	3.47	1.30	4.262	35.52	8.62
	NJ 7010 (Rani)	0.0	0.0	0.0	0.1	0.1	0.0	3.70	1.41	4.304	35.87	9.69
	JRO 524 (Navin) ©	47.0	46.5	19.0	70.0	63.0	37.0	3.10	1.38	3.632	30.27	-7.43
	JRO 204 (Suren) ©	20.0	19.5	16.0	39.0	34.0	17.0	3.56	1.43	3.924	32.70	Best check
	Mean	11.2	11.0	5.8	18.6	16.2	9.0	3.63	1.47	4.162	34.69	—
	CD(P=0.05)	2.6	2.8	2.0	2.9	2.7	2.6	0.23	0.09	0.094	1.83	—
16 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.64	1.41	4.362	36.35	7.45
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.73	1.46	4.340	36.17	6.92
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.95	1.57	4.519	37.66	11.32
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.90	1.54	4.637	38.64	14.22
	JRO 524 (Navin) ©	21.5	20.2	14.1	42.5	33.3	20.4	3.29	1.45	3.811	31.76	-6.11
	JRO 204 (Suren) ©	11.0	10.5	6.3	21.0	23.5	9.0	3.50	1.59	4.060	33.83	Best check
	Mean	5.4	5.1	3.4	10.6	9.5	4.9	3.67	1.50	4.288	35.73	—
	CD(P=0.05)	—	—	—	—	—	—	0.31	0.07	0.078	1.92	—
28 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.71	1.42	4.457	37.14	6.11
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.95	1.41	4.429	36.91	5.46
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.90	1.54	4.751	39.59	13.11
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.81	1.68	4.536	37.80	8.00
	JRO 524 (Navin) ©	5.2	8.3	4.2	24.5	12.5	4.3	3.48	1.42	4.066	33.88	-3.20
	JRO 204 (Suren) ©	0.0	0.0	0.0	4.2	2.1	0.0	3.60	1.46	4.200	35.00	Best check
	Mean	0.9	1.4	0.7	4.8	2.4	0.7	3.74	1.49	4.407	36.72	—
	CD(P=0.05)	—	—	—	—	—	—	0.27	0.08	0.092	1.49	—
9 th April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.72	1.50	4.466	37.22	5.23
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.78	1.44	4.446	37.05	4.75
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.96	1.54	4.678	38.98	10.21
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.82	1.42	4.504	37.53	6.11
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.66	1.46	4.245	35.37	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.85	1.45	3.980	33.17	-6.22
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.79	1.47	4.386	36.55	—
	CD(P=0.05)	—	—	—	—	—	—	0.22	0.06	0.078	1.22	—
21 st April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.60	1.46	3.918	32.65	1.30
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.65	1.54	3.988	33.23	3.1
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.70	1.53	4.206	35.05	8.75
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.57	1.42	3.679	30.66	-4.37
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.56	1.46	3.868	32.23	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.43	1.44	3.548	29.57	-8.25
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.59	1.47	3.868	32.23	—
	CD(P=0.05)	—	—	—	—	—	—	—	—	—	—	—

Table 3: Pool data (Pre-kharif, 2016 & 2017)

Date of sowing	Varieties	At 60 days			At 90 days			At harvest (120 days)				
		Flower (%)	Branch (%)	Pod (%)	Flower (%)	Branch (%)	Pod (%)	Plant height (mt)	Base diameter (cm)	Yield/plot	Yield/ha (in qtl)	Superiority over best check(%)
20 th February	NJ 7050	0.0	0.0	0.0	1.2	0.7	0.0	3.68	1.50	3.857	32.14	18.92
	NJ 7055	0.0	0.0	0.0	0.7	0.3	0.0	3.75	1.54	3.971	33.09	22.43
	NJ 7005 (Raja)	12.5	11.3	0.0	16.5	13.0	0.7	3.51	1.44	3.625	30.21	11.73
	NJ 7010 (Rani)	7.5	0.5	0.0	12.8	8.5	2.5	3.57	1.47	3.670	30.59	13.13
	JRO 524 (Navin) ©	76.0	73.0	38.5	89.0	77.5	56.0	2.86	1.39	2.754	22.95	-15.16
	JRO 204 (Suren) ©	41.0	39.5	15.5	62.5	52.5	27.0	2.93	1.38	3.244	27.03	Best check
	Mean	22.8	20.7	9.0	30.5	25.3	14.4	3.38	1.45	3.520	29.36	
	CD(P=0.05)	3.4	3.2	1.9	2.9	2.7	3.1	0.18	0.08	0.076	1.84	
4 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.86	1.60	4.174	34.78	12.21
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.91	1.62	4.274	35.62	14.87
	NJ 7005 (Raja)	0.5	0.4	0.0	1.8	0.4	0.1	3.73	1.54	4.016	33.47	7.87
	NJ 7010 (Rani)	0.0	0.0	0.0	0.4	1.6	0.0	3.84	1.55	4.086	34.05	9.80
	JRO 524 (Navin) ©	58.5	55.3	24.0	74.0	67.0	46.0	3.19	1.43	3.468	28.9	-6.76
	JRO 204 (Suren) ©	24.5	23.3	12.5	42.5	36.5	20.0	3.28	1.51	3.722	31.02	Best check
	Mean	13.9	13.2	6.1	19.8	17.4	11.0	3.64	1.54	3.956	32.96	
	CD(P=0.05)	2.9	3.1	1.8	2.6	2.5	2.2	0.20	0.07	0.090	1.76	
16 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.80	1.52	4.283	35.69	6.83
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.85	1.55	4.306	35.88	7.43
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	4.02	1.61	4.456	37.13	11.16
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.96	1.59	4.618	38.48	14.23
	JRO 524 (Navin) ©	24.3	23.0	16.5	44.8	36.4	22.5	3.37	1.49	3.736	31.14	-6.78
	JRO 204 (Suren) ©	15.0	15.0	5.5	24.0	18.5	9.5	3.57	1.52	4.009	33.41	Best check
	Mean	6.5	6.3	3.7	11.5	9.2	5.3	3.80	1.55	4.234	35.29	
	CD(P=0.05)	—	—	—	—	—	—	0.22	0.10	0.100	1.65	
28 th March	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.78	1.51	4.430	36.9	6.20
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.83	1.50	4.384	36.53	5.13
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.97	1.61	4.716	39.3	13.1
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.90	1.60	4.493	37.44	7.75
	JRO 524 (Navin) ©	7.1	7.2	4.5	22.5	15.5	8.7	3.58	1.51	4.062	33.85	-4.08
	JRO 204 (Suren) ©	0.1	0.05	0.0	5.0	3.0	0.1	3.68	1.54	4.170	34.75	Best check
	Mean	1.2	1.2	0.8	4.6	3.1	1.5	3.79	1.55	4.421	36.46	
	CD(P=0.05)	—	—	—	—	—	—	0.23	0.08	0.085	1.78	
9 th April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.78	1.56	4.533	37.77	5.19
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.85	1.54	4.500	37.5	4.43
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.99	1.60	4.748	39.57	10.17
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.90	1.50	4.569	38.08	6.03
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.73	1.53	4.310	35.92	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.74	1.51	4.071	33.92	-5.55
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.83	1.54	4.455	37.12	
	CD(P=0.05)	—	—	—	—	—	—	0.17	0.07	0.780	1.61	
21 st April	NJ 7050	0.0	0.0	0.0	0.0	0.0	0.0	3.69	1.54	4.063	33.86	1.87
	NJ 7055	0.0	0.0	0.0	0.0	0.0	0.0	3.75	1.57	4.130	34.42	3.56
	NJ 7005 (Raja)	0.0	0.0	0.0	0.0	0.0	0.0	3.79	1.59	4.336	36.13	8.74
	NJ 7010 (Rani)	0.0	0.0	0.0	0.0	0.0	0.0	3.63	1.50	3.781	31.51	-4.91
	JRO 524 (Navin) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.65	1.51	3.988	33.23	Best check
	JRO 204 (Suren) ©	0.0	0.0	0.0	0.0	0.0	0.0	3.51	1.48	3.648	30.40	-8.5
	Mean	0.0	0.0	0.0	0.0	0.0	0.0	3.67	1.53	3.991	33.26	
	CD(P=0.05)	—	—	—	—	—	—	0.21	0.06	0.102	1.59	

Table 4: Suitability of jute varieties under different sowing schedule

Variety/ Genotype	20 th February	4 th March	16 th March	28 th March	9 th April	21 st April
NJ 7050	Suitable	Most Suitable	Suitable	Suitable	Not Suitable	Not Suitable
NJ 7055	Suitable	Most Suitable	Suitable	Suitable	Not Suitable	Not Suitable
NJ 7005	Not-Suitable	Suitable	Most Suitable	Most Suitable	Most Suitable	Suitable
NJ 7010	Not-Suitable	Suitable	Most Suitable	Suitable	Suitable	Not Suitable
JRO 524©	Not-Suitable	Not Suitable	Not Suitable	Not Suitable	Suitable	Suitable
JRO 204©	Not-Suitable	Not Suitable	Not Suitable	Suitable	Suitable	Not Suitable

* Suitability was judged on basis of resistance to pre-mature flowering and comparative yield advantage

better than others including the best check (i.e. JRO 204). These two varieties recorded 11.16% & 14.26% higher yield than the best check and were found most suitable. Under this sowing schedule both the popular checks were found susceptible to pre-mature flowering though JRO 204 was found better over JRO 524 (Table 3).

4th Sowing (28th March): This seed sowing schedule was considered as the quite normal or timely sowing schedule. Here all the entries except the popular variety JRO 524, used as check, were found suitable for sowing. These entries didn't produce pre-mature flowers in significant numbers and recorded acceptable level of fibre yield (Table 1,2&3) and among the suitable entries NJ 7005 recorded the highest fibre yield (13.10% higher than the best check variety JRO 204) and hence considered as the most suitable variety under 28th March sowing (Table 3).

5th Sowing (9th April): This is also considered as quite normal or timely sowing schedule where all the six entries showed no unwanted pre-mature flowers or branches and recorded more or less acceptable level of fibre yield. Under this sowing schedule the popular variety JRO 524 was emerged out as the best check and the entry NJ 7005 was recorded as the most suitable variety for cultivation (Table 3).

6th Sowing (21st April): Under this late sowing none of the six entries had produced any pre-mature flowers though the over all fibre yield has been reduced as compared to normal or timely sowing schedule (i.e., 28th March & 9th April sowing). Here also the popular variety JRO 524 had emerged out as the better over the 2nd check variety JRO 204 and among the test entries NJ 7005 again recorded the highest fibre yield. Under 6th (i.e., late) sowing schedule the overall fibre yield of the varieties

recorded lower yield when compared with timely sowing(4th or 5th schedule). This may be attributed to availability of less number of shiny days especially at late crop stage due to on-set of monsoon. Not only this due to excessive rains the pests and soil moisture control were also hampered.

SSR analysis

Out of the 66 pairs of SSR primers, only 23 pairs produced polymorphic bands and therefore, these 23 pairs were selected for use in the analysis of the genetic diversity of jute. The polymorphism was seen by SSR efficiently distinguishing all genotypes of jute. A total of 60 alleles were identified among the 6 jute genotypes and number of alleles amplified by each primer varied from 2 - 5 (Table 5) with an average of 2.6 alleles per locus (with allele size 120bp – 350bp) which is lesser than that reported (4.6) by Akter *et al.* 2008 and (5.2) by Nag *et al.* 2018.

Table 5: Polymorphic SSR primers, number of alleles and polymorphic information content in 6 jute genotypes

SSR primers	No of polymorphic alleles	PIC
MJM1033	2	0.36
MJM1042	2	0.37
MJM1059	2	0.37
MJM1064	2	0.35
MJM1066	5	0.69
MJM1072	2	0.72
MJM1114	2	0.35
MJM1129	5	0.64
MJM1130	2	0.3
MJM1134	4	0.48
MJM1140	3	0.55
MJM1142	4	0.52

MJM1150	3	0.58
MJM1166	2	0.34
MJM1182	2	0.37
MJM1222	2	0.37
MJM1227	2	0.36
MJM1262	4	0.52
MJM1267	2	0.34
MJM1277	2	0.24
MJM1390	2	0.32
MJM1391	2	0.35
MJM1401	2	0.37
Total	60	na
Average	2.6	0.43

MJM = Meerut jute microsatellite; na = Not applicable.

Differences in the average number of alleles per locus may be from using different combinations of genotypes and different loci in the present study. The PIC value, a reflection of allelic diversity and frequency among the jute genotypes analyzed, ranged from 0.3 to 0.72, with an average of 0.43 (Table 5). The lowest PIC value 0.3 in the locus MJM1130 and highest PIC value (0.72) was observed in the MJM1072 locus, indicating that this was the most informative primer in this study.

Genetic diversity

To characterize the genetic diversity among these 6 jute accessions, Dendrogram was generated using NTSYS software based on the genetic similarity matrix derived from data generated through SSR markers. It was divided into two distinct clusters (similarity value 0.45), JRO524, NJ7050, JRO204, NJ7055 and NJ7010 in one cluster and NJ7005 in one cluster, which suggested that significant divergence existed in the jute genotypes (Fig. 3). The genetic similarity coefficient (GSC) ranged from 0.45 to 0.75.

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