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RESEARCH ARTICLE

Day-neutral jute plant: a hallmark for developing new jute genotype

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Abstract

Jute has more than 100 globally distributed species and is well known for its bast fibre biogenesis as well as its nutritional and medicinal properties. Unfortunately, year-round jute cultivation is highly limited due to its photosensitive character. Therefore, this study was carried out to analyse the flowering behaviour of selected cultivated jute species and their wild relatives to support the year-round supply of jute vegetables. A total of eight jute genotypes viz., Merha red, Merha green, Merha pink, Birol red, Birol green, Birol pink, BJRI deshi pat shak-1, and BINA pat shak-1 were examined, with the latter two selected as controls. In most cases, the six wild species had more surviving plants per unit area, better plant height, and more leaves and branches compared with controls. The highest stem base diameter, leaf area, leaf dry weight, and shoot dry weight were recorded in the control species. Days to 1st flowering, days to average flowering, and days to seed maturity were significantly earlier in wild species compared with the controls, indicating the existence of photo-insensitive characters. The desired vegetative and reproductive properties with high heritability and genetic variability can likely be transmitted from wild germplasm to cultivated jute species through crossing to produce a photo-insensitive jute variety.

Keywords

Jute; day-neutral; diversity analysis; flowering

Introduction

Jute (*Corchorus* spp.) is the second most important natural fibre-producing crop in the Indian sub-continent after cotton (1). More than 100 species of jute are being cultivated commercially worldwide (2). In Bangladesh, more than 698,000 ha of land are under jute cultivation, producing 7897100 MT of bast fibre (3). Bast fibre of jute is utilized for various purposes in the industry because of its uniqueness (4). In addition, jute leaves are used as herbal medicine for human health due to the presence of phytol and monogalactosyl-diacylglycerol (5). However, jute production is limited due to its season-binding nature and long and short-day length is required for vegetative growth and seed production, respectively (6).

Bangladesh Jute Research Institute (BJRI) has developed several new varieties with high yield, biotic, and stress-tolerant abilities (7). However, photoperiod-insensitive varieties of jute have not been developed yet due to several reasons, including inbreed's cross-incompatibility and protoplast fusion (8, 9). As a result, the whole year supply of fibre and leafy vegetables has been restricted. Additionally, the jute crop requires long periods (more than 5 months) for seed production in the summer season, and farmers keep land for this purpose, leading to very poor seed quality (10). A recent report showed that a jute genotype of *Corchorus capsularis* under the Tiliaceae family has been developed with a shorter life span (having early flowering ability); however, this genotype has not been released yet (4). Traditional breeding is not suitable for developing new varieties, so screening of germplasm might be helpful to overcome these problems.

Germplasm plays a significant role in developing new varieties of crops through traditional breeding in Bangladesh (11). Information on the genetic diversity of germplasm not only facilitates parent selection but also helps to determine the accurate patterns of genetic diversity leading to varietal development (12, 13). However, the germplasm of jute is decreasing in jute-growing areas, indicating the obstacles to jute breeding through the traditional variety development process (14, 15). So, the present study was designed to identify the jute germplasm having a short life cycle for developing a new jute genotype.

Materials and Methods

The experiment was conducted at the Jute Agriculture Experimental Station, Bangladesh Jute Research Institute, Manikganj, Bangladesh, from April to October 2021. The germplasm 'Merha red', 'Merha green', Merha pink, 'Birol red', Birol green, and Birol pink were collected from Rangpur and Dinajpur districts of Bangladesh; 'BJRI deshi pat shak-1' from Jute Agriculture Experimental Station, Bangladesh Jute Research Institute, Manikganj, and 'BINA pat shak-1' from Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh, were used. All tested genotypes belong to *C. capsularis* L., whereas BJRI deshi pat shak-1 and BINA pat shak-1 were used as controls (Figure 1). The altitude of the experimental field was 4 m in the Old Brahmaputra-Jamuna flood plain (AEZ-8) with silt loam soil, pH 6.7. The soil contained 1.5% organic matter, 0.09% total nitrogen, 3.0 microgram·g-1 available P, 0.08 meq.100– g K, and 11.00 mg·kg-1 available S. The soil was ploughed in two directions and smoothed. The soil received urea, triple superphosphate, muriate of potash, gypsum, and zinc sulfate @ 150, 25, 30, 45, and 11 kg·ha–1, respectively. During final land preparation, half of the urea and all other materials were applied. Seeds treated with Vitavax 200® (0.04%) were broadcast sown on 15 April, 2021 into 3 m × 2 m plots. Twenty days after seed sowing, the remaining urea was used as top dressing. All cultural operations were according to a standard procedure (13). After the emergence of seedlings, manual weeding was done at 14 days after sowing and soil moisture was maintained at field capacity by surface irrigation once a week. Plants were harvested on 15 May, 2021 for calculating vegetative yield attributes. Chlorophyll content was measured by using a SPAD meter (KONICA MINOLTA) and the relative water content (RWC) of the expanded leaf was calculated

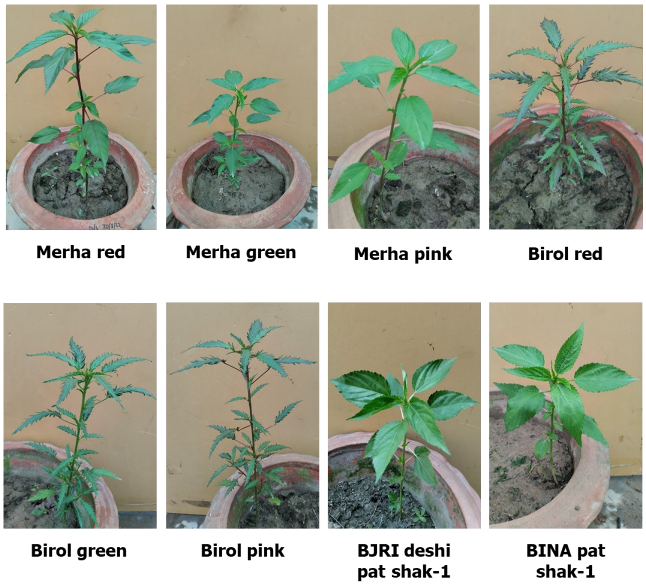

Fig.1.Photographs of different jute genotypes used in this research.

according to the formula of Barrs (16). Bitterness and taste were calculated by surveying 50 persons and scoring manually. A randomized complete block design (RCBD) was used for this experiment with three replications. A leaf area meter (LI-3100C, Li-Cor, Lincoln, NE) was used to determine the leaf area of jute leaf. For all genotypes, surviving numbers of plants were counted· m^{-2}. The data were subjected to ANOVA using the statistical software R. Treatment means were detached from LSD (Least significant difference). Different analysis like variance, path analysis, and correlation studies were conducted using STAR (ver. 2.0.1) and PB Tools (ver. 1.4), for both from Biometrics and Breeding Informatics, International Rice Research Institute, Los Banos, The Philippines.

Results and Discussion

Morpho-physiological attributes of different jute genotypes

The variations in different morpho-physiological characteristics occurred due to the variation in genetic inheritance of germplasm as well as the agro-climatic condition of the research area, which also influences the phenotypic appearance (17, 18). Data on different morpho-physiological attributes like plant survivability, plant height, base diameter, and leaf character of jute genotypes were collected, analysed and summarized in Table 1. Analysis found significant differences in morpho-physiological attributes among the studied genotypes. The highest plant survivability was found in Merha green, whereas the lowest survivability was found in BJRI deshi pat shak-1 (Table 1). In terms of plant height, the highest and lowest were found in Merha pink and Bina Shak-1, respectively. Merha pink and BJRI deshi pat shak-1 showed a higher plant base diameter compared to the other jute genotypes. The number of leaves as well as the leaf area plays an important role in the leaf yield. The number of leaves per plant was statistically different among the studied genotypes. The highest number of leaves was found in Birol green, and the lowest was recorded in BINA

Table 1. Morpho-physiological attributes of eight different jute genotypes

Genotype	Plant survivability	Plant height (cm)	Base diameter (mm)	Number of leaf	Leaf area (cm^2)
Merha red	300.67ab	42.267b	3.3867b	13.6 b	14.543 cd
Merha green	366.67a	36.667 bc	3.66b	12.667 b	15.653c
Merha pink	314.33ab	52.067a	4.8133a	14.733 ab	29.15 b
Birol red	290.67b	35.333 bc	3.8667 ab	13.733b	14.807 cd
Birol green	329.33ab	42.867 b	4.1133 ab	16.8 a	12.763cd
Birol pink	263.67bc	36.867 bc	3.5733b	14.533 ab	10.547d
BJRI deshi pat shak-1	137.67d	33.467c	4.78 a	13.2 b	38.253a
BINA pat shak-1	204cd	22.067d	4.22 ab	12.533b	35.213 ab
LSD(0.05)	7.835	7.9739	0.963	2.4344	4.5422
CV%	5.28	10.08	8.57	9.95	9.43

pat shak-1. However, the highest leaf area was recorded in BJRI deshi pat shak-1 and the lowest was recorded in Birol pink, which was statistically identical with Merha red, Merha green, Birol red, and BJRI deshi pat shak-1 (Table 1).

For jute, plant heights as well as basal diameter are the main morpho-physiological characteristics for the determination of fibre yield, and those two characters have a positive relationship with fibre yield (19, 20). The results of the present study indicate that variation in different morpho-physiological attributes occurred due to the variation in the genetic makeup of the germplasm (11).

Vegetative yield attributes of different jute genotypes

The fresh and dry weight of leaves are the important characteristics that significantly influence the vegetative yield of a plant. In addition, leaf area indicates the biomass production capacity of a plant, which has a significant positive impact on the plant height (1, 14). Leaf fresh weight was statistically different among the studied genotypes. Leaf fresh weight was highest and lowest in BJRI deshi pat shak-1 and Merha green, respectively (Table 2). Similarly, shoot fresh and dry weight was also higher in BJRI deshi pat shak-1. The lowest fresh shoot weight was found in both the Merha green and Birol pink genotypes. Analysis also revealed lowest dry shoot weight in the Birol red jute genotype. These results suggest the jute genotype BJRI deshi pat shak-1 had the highest yielding capacity, whereas Merha green had the lowest yielding ability compared to the rest of the jute genotypes. These results suggest that BJRI deshi pat shak-1 has a higher genetic makeup, leading to express phenotype of leaf and stem characteristics compared to the rest of the jute genotypes. It has been reported that the phenotype of any organism is regulated by its genotypic makeup as well as environmental factors (21).

Phenological characters of different jute genotypes

Jute is a photosensitive crop that has a critical photoperiod (12.5 hrs) for completing its life cycle and grows well at more than 25°C with a humidity range of 70% to 90%; however, it can vary based on the genotype as well as on the environmental parameters (22). Days to first flowering is an important phenological characteristic of jute that indicates the life cycle of a plant. Days to first flowering were statistically different among the studied genotypes. The maximum number of days to first flowering was recorded in BINA pat shak-1, and the lowest was recorded in both the Merha red and Merha green genotypes. This result indicated that both the Merha red and Merha green genotypes gave the seed with fewer days compared to the other genotypes (Table 3). Additionally, Merha genotypes (red, green, and pink) took less time for average days to flower than the other genotypes used in this research. Moreover, days to seed maturity were lower in Merha genotypes (red, green, and pink). On the other hand, BINA pat shak-1 took longest time from first flowering to seed maturity. These results indicated that Merha genotypes can be used for vegetables with a shorter crop life cycle. Data on the number of branches per plant was recorded and analysed. Analysis found a higher branch in the Merha green jute genotype (Table 3). This result also suggests not only higher vegetable production but also higher seed production, which might help as the source of seed for the next jute cultivation season. It has been reported that the flowering of jute has a positive relationship with seed maturity, leading to bad quality of seed (23). Similar result was also found in the current study. In addition, environmental factors like temperature, soil moisture content enhances the flowering (24, 25).

Seed yield and yield attributes of different jute genotypes

Yield is a complex character, and it depends on many factors that simply and relatively depend on the inheritance (26). It is also reported that yield is not only the genotype or variety selection criteria because yield is inherited and influenced by genetic as well as environmental factors (27, 28). Data on different seed yield contributing characters like the number of pods per plant,

Table 2. Vegetative yield attributes of different jute genotypes as vegetables

Genotype	Leaf fresh weight per plan (g)	Leaf dry weight per plant (g)	Shoot fresh weight (g)	Shoot dry weight (g)
Merha red	2.2 cde	0.268 cd	6.2667 bcd	0.7767 bc
Merha green	1.95d	0.2 d	4.5667 d	0.62 bcd
Merha pink	2.89 bcd	0.3833 bc	8.4333 ab	0.7833 b
Birol red	2.02 cde	0.2433 cd	5.6 cd	0.5267 d
Birol green	3.0467 bc	0.3233 bcd	7.3667 abc	0.6033 cd
Birol pink	1.82 de	0.2167 d	4.9667 d	0.6233 bcd
BJRI deshi pat shak-1	4.82 a	0.7233 a	9.3333 a	0.9833 a
BINA pat shak-1	3.5967 b	0.4367 b	7.5333 abc	0.6467 bcd
LSD	1.0992	0.1564	2.2597	0.1773
CV	8.09	9.56	9.09	4.56

Table 3. Phenological characters of different jute genotypes

Genotype	Days to 1st flowering	Days to average flowering	Days to seed maturity	Number of branch per plant
Merha red	38.67e	44.33 f	93.67 f	7.2 ab
Merha green	39.67e	44.67 f	98.33 e	9.8667 a
Merha pink	42 d	47 e	98.67 e	6.7333 ab
Birol red	45.67c	49.67cC	119.33 c	5.4667 b
Birol green	46 c	47.67 de	103 d	7.9333 ab
Birol pink	45.67c	48.67 cd	102 d	7.1333 ab
BJRI deshi pat shak-1	60.33b	64.33 b	151.33 b	4.0667 b
BINA pat shak-1	107a	113.67 a	184.67 a	6.8667 ab
LSD	1.4106	1.1856	2.1953	4.3263
CV	1.52	1.18	1.05	5.76

the number of seeds per pod, etc., of jute genotypes were summarized in Table 4. The number of pods per plant varied significantly among the different studied genotypes. Analysis found a higher number of pods per plant in Merha green, BJRI deshi pat shak-1, and BINA pat shak-1. However, analysis found a higher number of seeds per pod in the Birol red genotype and a lower number of seeds in BINA pat shak-1 (Table 4). These results indicate negative relationship between the number of pods and the number of seeds in each pod. Analysis also revealed that the seed weight was higher in BJRI deshi pat shak-1 compared to the rest of the jute genotypes (Table 4) indicating that seed size of BJRI deshi pat shak-1 is comparatively larger than the other genotypes. Data also found that seed yield per plant was statistically the same in all the jute genotypes except the Birol red genotype. However, total seed yield was found to be higher in Merha green than the remaining jute genotypes (Table 4). These results clearly indicate that Merha green might play an important role in seed production.

Quality attributes of different jute genotypes

Generally, the leaves of deshi jute (*Corchorus capsularis*) are bitter in taste, whereas those of tossa jute (*Corchorus olitorius*) are sweet (29). The taste of jute leaf varies in jute genotypes as well as with the age of the leaf (30). In the current research, the bitterness and taste of different jute genotypes were measured and analysed. On the bitterness scale (0-10), Birol pink genotype and BJRI deshi pat shak-1 showed the highest and lowest bitterness, respectively (Figure 2). In terms of taste, Merha green showed the highest taste compared to the other jute genotypes, whereas Merha pink showed the lowest taste. Additionally, the Merha green genotype showed the second-lowest bitterness in taste, which suggests that Merha green can be used as a leafy vegetable for the early summer season when other leafy vegetables are very limited.

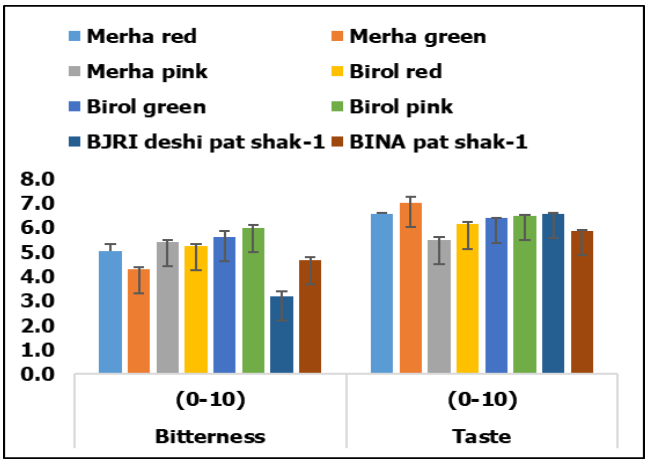

Fig. 2. Quality attributes of different jute genotypes

Physiological attributes of different jute genotypes

Chlorophyll content is one of the important factors for indicating plant health as well as helping to predict productivity (31, 32). In addition, relative water concentration of leaves reveals the water-containing status of the plant (33). Chlorophyll concentration and relative water concentration (RWC) of leaves from different jute genotypes were measured to understand the health status of each jute genotype. Analysis found that the higher chlorophyll content (SPAD value) in the Merha red genotype and the lowest SPAD value were observed in the Birol pink genotype (Figure 3). In addition, the BJRI deshi pat shak-1 genotype showed the second highest chlorophyll content. In case of relative water content, the Merha pink and Birol pink jute genotypes showed higher water content than the other genotypes (Figure 3). On the other hand, the Birol red genotype showed the lowest relative water content compared to the remaining genotypes. These results suggest that genotypes with higher chlorophyll content cannot contain the higher percent of relative water content (RWC%), and these two characters are highly dependent on genotype inheridity.

Table 4. Seed yield and yield attributes of different jute genotypes

Genotype	Number of pod per plant	Number of seed per pod	1000-seed weight (g)	Seed yield per plant (g)	Seed yield (kg/ha)
Merha red	44.4 b	25.333 b	2.4560 cd	1.8900 a	52.667 b
Merha green	97.82 a	28.667 ab	2.3257 e	1.9600 a	79.667 a
Merha pink	42.33 b	30.333 ab	2.3693 de	1.3433 a	39.667 b
Birol red	28.07 b	32.333 a	2.4623 c	0.4000 b	4.333 f
Birol green	57.53 b	28.667 ab	2.3807 cde	1.7067 a	12.667 e
Birol pink	58.93 b	27.333 ab	2.4650 c	1.6867 a	11.667 ef
BJRI deshi pat shak-1	132 a	29.333 ab	3.4647a	1.4500 a	24.667 cd
BINA pat shak-1	125.67 a	18.667 c	3.1383 b	1.3000 a	16.667 de
LSD	38.092	5.9983	0.0925	0.7444	8.0262
CV	9.66	8.42	2.01	8.97	6.82

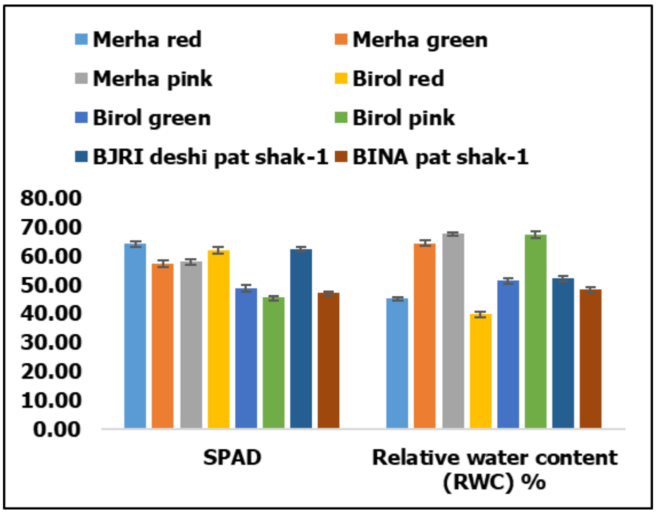

Fig 3. Physiological attributes of different jute genotypes.

Genetic parameters of leaf yield and yield-related traits in jute genotypes

The genetic parameters of leaf and seed yield-related attributes were analysed and summarized in Table 5. Analysis found a higher magnitude of genotypic variance than environmental variance in all traits. Analysis also revealed a higher phenotypic coefficient of variation (PCV) than the genotypic coefficient of variation (GCV) in all traits used in this research; however, the nominal difference observed between PCV and GCV in almost all traits used in this study indicates that genetic factors mostly influenced the expression of these traits (Table 5). However, plant population, branching per plant, and seed yield showed environmental effects in their phenotypic expression. Several traits like leaf area, first flowering, average flowering, seed maturity, and seed yield showed higher heritability than the other traits. This result indicates that traits with high heritability and high genetic advance would be more logical for selecting new jute genotypes. It has been reported that high heritability and genetic gain help to select the best genotypes as well as indicate the presence of additive genes, suggesting opportunities for crop improvement (1, 34).

Path coefficient analysis

Path coefficient analysis indicates the association between two features through direct and indirect effects (35, 36). In the present research, seed yield was considered an effect, and other traits were treated as causes for path coefficient analysis. Average flowering time had a direct positive effect on seed yield and an indirect positive effect on first flowering and thousand seed weight, whereas an indirect negative effect was found in plant height and seed maturity (Table 6). The report showed that average flowering time had a positive and significant effect on plant height along with seed yield (37).

Genotypic (G) and phenotypic (P) correlation coefficients analysis

The correlation among different traits was calculated and analyzed. Results found that in most cases, genotypic correlation coefficients were higher than their related phenotypic correlation coefficients (Table 7). This result strongly suggests that the association is predominantly regulated by genetic factors. Average flowering time was negatively correlated with plant population, plant height, number of leaves in each plant, branch per plant, seed per plant, and seed yield. However, plant height and seed in each pod were statistically and negatively significant with the average flowering time. On the other hand, first flowering time and seed maturity showed a positive and significant relationship with the average time of flowering. These results clearly indicate that an increase in plant population and plant height delayed the average time of flowering, whereas first flowering decreased the average time of flowering. In addition, increasing the average flowering time may lead to a decrease in number of seeds in each pod.

Table 5. Genetic parameters for leaf yield and yield-related traits in jute genotypes.

Trait	Mean	σ2P[a]	σ2g	σ2e	PCV	GCV	ECV	h2b	GA
PP	275.88	6589.367	4811.767	592.5333	29.42399	25.14387	8.823404	73.0232	991223.9
PH	37.7	88.627	67.894	6.911	24.97133	21.85618	6.973151	76.60645	13986.16
BD	4.0517	0.487527	0.185107	0.100807	17.23304	10.61876	7.836233	37.96852	38.13197
NL	13.975	3.210713	1.278333	0.644127	12.8218	8.090405	5.742934	39.81462	263.3367
LA	20.866	112.202	105.474	2.242667	50.76461	49.21908	7.177004	94.00367	21727.64
LFWPP	2.7188	1.511683	1.117703	0.131327	45.22235	38.88535	13.32905	73.93766	230.2469
LDWPP	0.3493	0.034897	0.026927	0.002657	53.48024	46.9778	14.75604	77.16114	5.546893
SFW	6.7583	3.96774	2.30268	0.55502	29.47366	22.45326	11.02343	58.03505	474.3521
SDW	0.6954	0.027897	0.017647	0.003417	24.01826	19.10278	8.405559	63.25726	3.635213
FF	53.125	519.0667	518.4167	0.216667	42.88571	42.85885	0.876188	99.87478	44.79416
AF	57.5	555.4167	554.9567	0.153333	40.98657	40.9696	0.681005	99.91718	46.35278
SM	118.88	1056.03	1054.46	0.523333	27.33565	27.31532	0.608528	99.85133	63.87613
BPP	6.9083	6.943573	0.840473	2.034367	38.14348	13.27061	20.64636	12.10433	0.629607
PPP	73.344	1898.883	1425.743	157.7133	59.41342	51.48208	17.1226	75.08325	64.4346
SPP	27.583	24.98807	13.25597	3.9107	18.12278	13.1997	7.169449	53.04919	5.294353
TSW	2.6328	0.18234	0.17955	0.00093	16.21896	16.0944	1.158307	98.46989	0.827823
SYPP	1.4671	0.364693	0.184003	0.06023	41.16273	29.23837	16.7281	50.45426	0.627149
Y	29	629.3633	588.3633	13.66667	86.50729	83.64208	12.74774	93.48548	46.18648

Note: PP= Plant population; PH= Plant height; BD= Base diameter; NL= Number of leaf; LA= Leaf area; LFWPP= Leaf fresh weight per plant; LDWPP= Leaf dry weight per plant; SFW= Shoot fresh weight; SDW= Shoot dry weight; FF= Days to first flowering; AF= Days to average flowering; SM= Days to seed maturity; BPP= Branches per plant; PPP= Pod per plant; SPP= Seed per pod; TSW= Thousand seed weight; SYPP= Seed yield per plant; Y= Yield (kg/ha).

Table 6. Path coefficient analysis

	PP	PH	BD	NL	LA	LFWPP	LDWPP	SFW	SDW	FF	AF	SM	BPP	PPP	SPP	TSW	SYPP	Correlation with Y
PP	**1.42**	0.99	0.79	0.11	-2.01	0.75	1.69	-0.13	0.56	-1.61	-1.76	7.12	0.12	0.05	0.11	-7.86	-0.12	0.26
PH	0.75	**1.87**	-0.66	0.41	-0.75	0.12	0.55	0.06	-0.17	-2.12	-2.37	7.6	0.04	0.05	0.53	-5.50	-0.17	0.41
BD	-0.44	0.48	**-2.56**	0.26	2.10	-0.88	-1.24	0.27	-0.43	0.66	0.71	-3.29	-0.08	-0.02	0.24	3.83	0.15	0.30
NL	0.14	0.67	-0.58	**1.16**	-0.78	-0.10	0.25	0.04	0.30	-0.91	-1.08	3.72	-0.05	0.04	0.32	-3.43	0.09	0.27
LA	-0.9	-0.45	-1.71	-0.29	**3.14**	-0.96	-2.00	0.268	-0.89	1.67	1.90	-7.23	-0.10	-0.06	-0.16	7.66	0.136	0.02
LFWPP	-0.82	-0.18	-1.74	0.09	2.32	**-1.29**	-2.23	0.32	-0.68	1.45	1.59	-6.38	-0.11	-0.05	-0.16	7.56	0.16	0.19
LDWPP	-0.95	-0.41	-1.25	-0.11	2.48	-1.14	**-2.53**	0.27	-0.85	1.21	1.35	-6.17	-0.11	-0.06	-0.05	8.15	0.08	0.11
SFW	-0.46	0.31	-1.74	0.12	2.10	-1.06	-1.74	**0.40**	-0.89	0.91	0.98	-4.14	-0.11	-0.02	-0.20	5.30	0.20	0.01
SDW	-0.49	0.20	-0.69	-0.22	1.76	-0.55	-1.34	0.22	**-1.60**	0.12	0.13	-1.80	-0.06	-0.03	-0.11	5.01	-0.19	0.45
FF	-0.75	-1.31	-0.56	-0.34	1.72	-0.62	-1.01	0.12	-0.06	**3.03**	3.39	-10.0	-0.03	-0.06	-0.71	6.77	0.120	0.33
AF	-0.73	-1.31	-0.53	-0.37	1.76	-0.61	-1.01	0.11	-0.06	3.03	**3.39**	-10.0	-0.04	-0.06	-0.73	6.77	0.12	0.291
SM	-0.95	-1.35	-0.79	-0.40	2.13	-0.77	-1.47	0.15	-0.27	2.85	3.19	**-10.64**	-0.08	-0.07	-0.54	8.44	0.20	0.39
BPP	0.65	0.31	0.79	-0.24	-1.22	0.53	1.01	-0.16	0.38	-0.42	-0.50	3.19	**0.27**	-0.01	-0.03	-3.83	-0.45	0.39
PPP	-0.65	0.88	-0.6	-0.50	1.82	-0.68	-1.44	0.10	-0.48	1.85	2.07	-7.23	0.04	**-0.11**	-0.32	7.27	-0.23	0.14
SPP	0.14	0.90	-0.56	0.33	-0.47	0.19	0.12	-0.07	0.16	-1.94	-2.24	5.21	-0.01	0.03	**1.11**	-3.04	0.02	0.16
TSW	-1.13	-1.05	-1.00	-0.40	2.45	-1.00	-2.10	0.21	-0.81	2.09	2.34	-9.15	-0.10	-0.08	-0.34	**9.82**	0.08	0.20
SYPP	0.22	0.41	0.48	-0.13	-0.53	0.25	0.27	-0.10	0.38	0.45	-0.54	2.66	0.15	-0.03	-0.03	-0.98	**-0.80**	0.61

Note: PP= Plant population; PH= Plant height; BD= Base diameter; NL= Number of leaf; LA= Leaf area; LFWPP= Leaf fresh weight per plant; LDWPP= Leaf dry weight per plant; SFW= Shoot fresh weight; SDW= Shoot dry weight; FF= Days to first flowering; AF= Days to average flowering; SM= Days to seed maturity; BPP= Branches per plant; PPP= Pod per plant; SPP= Seed per pod; TSW= Thousand seed weight; SYPP= Seed yield per plant; Y= Yield (kg/ha).

Table 7. Genotypic (G) and phenotypic (P) correlation coefficients of leaf yield and yield-related traits in jute genotypes.

		PP	PH	BD	NL	LA	LFWPP	LDWPP	SFW	SDW	FF	AF	SM	BPP	PPP	SPP	TSW	SYPP
PH	P	0.55																
	G	0.62																
BD	P	-0.46	0.26															
	G	-0.62	-0.02															
NL	P	0.37	0.65	0.04														
	G	0.45	0.68	0.12														
LA	P	-0.71*	-0.21	0.859**	-0.44													
	G	-0.77*	-0.27	0.99**	0.48													
LFWPP	P	-0.80*	-0.22	0.80*	-0.03	0.83**												
	G	-0.93**	0.34	0.90**	-0.144	0.89**												
LDWPP	P	-0.82*	-0.20	0.81*	-0.19	0.89**	0.96**											
	G	-0.92**	0.25	0.99**	0.20	0.96**	0.99**											
SFW	P	-0.59	0.11	0.954**	0.12	0.83**	0.921**	0.88**										
	G	-0.76*	0.02	0.99**	0.09	0.93**	0.99**	0.99**										
SDW	P	-0.64	0.09	0.792*	-0.17	0.82*	0.77*	0.88**	0.775*									
	G	-0.70*	0.19	0.83**	0.22	0.81*	0.86**	0.98	0.84**									
FF	P	-0.61	-0.78*	0.20	-0.45	0.53	0.51	0.41	0.33	0.096685								
	G	-0.65	-0.83**	0.36	0.50	0.56	0.57	0.46	0.39	0.03								
AF	P	-0.60	-0.78*	0.20	-0.49	0.54	0.50	0.41	0.33	0.10	0.99							
	G	-0.64	-0.82**	0.36	-0.55	0.57	0.55	0.45	0.38	0.048	0.99**							
SM	P	-0.78*	-0.81*	0.320	-0.55	0.67	0.66	0.61	0.45	0.28	0.93**	0.93**						
	G	-0.83**	-0.86**	0.52	-0.59	0.70*	0.72*	0.66	0.51	0.21	0.94**	0.93**						
BPP	P	0.79*	0.15	-0.56	0.10	-0.57	-068	-0.70*	-0.61	-0.55	-0.22	-0.21	-0.47					
	G	0.99**	0.23	-0.99**	0.75	-0.99**	-0.99**	-0.99**	-0.99**	-0.99**	-0.44	-0.40	-0.87**					
PPP	P	-0.62	-0.65	0.24	-0.59	0.63	0.57	0.63	0.34	0.53	0.64	0.64	0.71*	-0.09				
	G	-0.72*	-0.79*	0.44	-0.628	0.70*	0.63	0.70	0.43	0.52	0.70	0.70	0.77*	-0.61				
SPP	P	0.36	0.69	0.04	0.35	-0.28	-0.25	-0.15	-0.09	0.06	-0.89**	-0.89**	-0.71*	-0.15	-0.61			
	G	0.45	0.67	0.047	0.49	-0.25	-0.26	-0.13	0.01	0.09	-0.90**	-0.90**	-0.67	-0.50	-0.68			
TSW	P	-0.94**	-0.62	0.50	-0.48	0.80*	0.85**	0.88**	0.62	0.67	0.68	0.67	0.865**	-0.66	0.80*	-0.43		
	G	-0.99**	-0.67	0.64	-0.53	0.82*	0.90**	0.91**	0.70*	0.67	0.69	0.69	0.86**	-0.99**	0.84**	-0.44		
SYPP	P	0.199	0.13	-0.12	0.13	-0.09	-0.06	-0.02	-0.08	0.20	-0.12	-0.12	-0.25	0.61	0.39	-0.23	-0.08	
	G	0.35	0.22	-0.38	0.23	-0.185	-0.06	-0.09	0.03	0.32	-0.23	-0.22	-0.39	0.71*	0.22	-0.57	-0.17	
Y	P	0.27	0.38	0.32	-0.27	0.33	-0.05	0.09	0.12	0.41	-0.22	-0.18	-0.24	0.40	0.26	0.08	-0.10	0.52
	G	0.26	0.41	-0.30	-0.27	-0.02	-0.19	-0.11	-0.01	0.45	-0.33	-0.292	-0.39	0.39	-0.14	-0.16	-0.20	0.618

Note: PP= Plant population; PH= Plant height; BD= Base diameter; NL= Number of leaf; LA= Leaf area; LFWPP= Leaf fresh weight per plant; LDWPP= Leaf dry weight per plant; SFW= Shoot fresh weight; SDW= Shoot dry weight; FF= Days to first flowering; AF= Days to average flowering; SM= Days to seed maturity; BPP= Branches per plant; PPP= Pod per plant; SPP= Seed per pod; TSW= Thousand seed weight; SYPP= Seed yield per plant; Y= Yield (kg/ha).

Conclusion

The studied jute genotype showed good morphological traits, i.e., surviving plants per unit area, better plant height, more number of leaves and branches, as well as early flowering habits and seed maturity habits. However, lower or less significant differences were in stem base diameter, leaf area, leaf dry weight, and shoot dry weight. These cultivated genotype can be improved with the wild germplasms having photo-insensitive behaviour through crossing or transferring the interested genes through genetic engineering.

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Authors' contributions

MZT designed and performed the study, derived the models and genetic analysis. MZT, MAS and SNI analyzed data statistically and wrote the manuscript. MAH and MSAF supervised the experiment. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest : Authors do not have any conflict of interests to declare.

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