YIELD AND QUALITY OF JUTE SEED AS INFLUENCED BY VARIETY AND STAGE OF POD MATURITY IN LATE SOWN CONDITION

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CERTIFICATE

This is to certify that the thesis entitled ***"YIELD AND QUALITY OF JUTE SEED AS INFLUENCED BY VARIETY AND STAGE OF POD MATURITY IN LATE SOWN CONDITION"*** *submitted to the* ***Institute of Seed Technology****, Sher-E-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE (MS)*** *in* ***Seed Technology****, embodies the results of a piece of bona fide research work carried out by* ***SHARMIN FATEMA,*** *Registration. No.* ***12-04744*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Place: Dhaka, Bangladesh

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DEDICATED TO MY BELOVED PARENTS
WHO FIRST ENCOURAGED MY
INTEREST IN THIS KIND OF THING

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ABSTRACT

The research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from August, 2017 to December, 2017 to study the yield and quality of jute seed as influenced by variety and stage of pod maturity in late sown condition. Two factors viz. Factor A, three jute varieties; V_1 (O-9897), V_2 (BJRI Tossa Pat-5) and V_3 (BJRI Tossa Pat-6) and Factor B, three stages of pod maturity; M_1 (About 40% pods of the plant become brown), M_2 (About 60% pods of the plant become brown) and M_3 (About 80% pods of the plants become brown) were considered for the experiment. The experiment consisting of 9 treatment combinations and laid out in Randomized Complete Block Design (RCBD) with three replications. The result revealed that variety V_1 (O-9897) showed the highest seed yield (937.33 kgha^{-1}) which might be attributed to the highest number of pods plant^{-1} (22.57), number of seeds pod^{-1} (176.27) and weight of seeds pod^{-1} (0.37g). This variety also produced the tallest plant (163.52 cm) and number of branches plant^{-1} (2.61). Among the harvesting at different pod maturity stages, crop harvested at 60% pod maturity stage (M_2) showed the maximum seed yield (962.40 kgha^{-1}) which might perhaps the highest number of pods plant^{-1} (23.22), pod length (6.46 cm), pod diameter (5.66 mm), number of seeds pod^{-1} (180.02), weight of seeds pod^{-1} (0.39 g) and weight of 1000 seed (1.99 g) in this treatment. Interaction of V_1M_2 (Variety O-9897 with 60% pod maturity stage) gave the highest seed yield (1040.80 kgha^{-1}) along with the highest number of pods plant^{-1} (24.97), pod diameter (5.87 mm) and number of seeds pod^{-1} (185.50). Considering seed quality, variety V_2 (BJRI Tossa Pat-5), pod maturity stage M_2 (About 60% pods become brown) and interaction of V_2M_2 (BJRI Tossa Pat-5 with 60% pods become brown) gave the best quality of seed in jute. This interaction gave the highest germination (97.0%), seedling length (4.02 cm), seed vigor index (10.26) and oven dry weight of seedling (51.28 mg).

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
^{0}C	=	Degree Celsius
BJRI	=	Bangladesh Jute Research Institute
cm	=	Centimeter
CV%	=	Percentage of co-efficient of variance
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	And others
G	=	Gypsum
G	=	Gram (g)
ha^{-1}	=	Per hectare
Hr	=	Hour
kg	=	Kilogram
LSD	=	Least Significant Difference
Max	=	Maximum
mg	=	Milligram
Min	=	Minimum
mm	=	Millimeter
MP	=	Muriate of Potash
No.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
SAU	=	Sher-e-Bangla Agricultural University
T	=	Ton
TSP	=	Triple Super Phosphate
viz.	=	Videlicet (namely)
Wt.	=	Weight

CHAPTER I

INTRODUCTION

Jute (*Corchorus capsularis* L. and *Corchorus olitorius* L.) is one of the most important cash crops of Bangladesh. Jute is mostly grown in the Indo-Bangladesh region and in some countries of Southeast Asia. It has been reported that about 97% of world's jute is produced in Bangladesh and in India (FAO STAT, 2017). Production is concentrated mostly in Bangladesh, as well as India's states of Assam, Bihar, and West Bengal. In respect of production, Bangladesh ranks first (16.14 lac metric ton annually) among the jute growing countries of the world (BBS, 2018). In Bangladesh, approximate 40-45 lac farmers are directly or indirectly engaged in jute farming. About 4 crore people are related to jute cultivation, jute processing, jute and jute related goods business (FAO, 2014). It plays an important role for earning about 5-6% foreign exchange through exporting jute and jute goods. The land and climatic condition of Bangladesh are congenial for production of high-quality jute. In Bangladesh, total land for cultivation was 85,85,207.4 ha and about 7.50 lac hectares of land are under jute cultivation, where produced 16.14 lac metric tons jute (DAE, 2018).

Jute is a natural fibre belongs to Tiliaceae family and it has two species namely, *Corchorus olitarius* L. (Tossa Jute) and *Corchorus capsularis* L. (White Jute). The *olitorius* species is grown comparatively in high land and capsularis jute is grown in relatively in low land. Jute does not cause any health hazards and environment pollution. Traditionally jute has been used as a raw material for manufacturing yarns and twines, hessian, burlap and bulk packaging. Jute is also used in making different kind of artistic handicrafts which are also getting popularity day by day at home and abroad. Jute has been closely attached with our cultures, society and economy in Bangladesh for centuries.

Jute is predominantly grown for fibre rather than seed production. Farmers of Bangladesh conventionally grow seed and fibre simultaneously from the same plant of jute. They usually grow seeds by keeping a part of their fibre crops planted in March-April. Remnant part of the fibre crop due to prolonged stay in the field is usually affected by hailstorm, diseases, insect pests and natural calamities, becomes physiologically weak and produces low yield of poor-quality seeds. Besides, fibre quality on seed maturity becomes degraded and sells at a low price. This results in a chronic problem in the cultivation practice of jute crop. In recent time, the agro-ecological condition of the country has abruptly changed and jute seed production as a part of fibre crop is no longer remunerative. Farmers are also very reluctant to grow jute seed. So, the country has been facing acute shortage of quality jute seed every year, (Islam, 2009).

Quality seeds of an improved variety itself provide 20 percent additional yield of the crop (Hossain *et al*., 2008). Again, use of quality seeds of improved variety alone contributes 223.54 kg of extra fibre per hectare i.e. an increase of about 17 percent in fibre (Rahman *et al*., 1989). For jute cultivation, farmer requires 5000-5500 tons of seed annually (Hossain et al., 1994a). Many jute farmers use to produce jute crops by their own seeds to meet their requirements but such seeds are of poor in quality. There exist great scarcities of quality seed as only 13% quality jute seeds are supplied by different national seed agencies (Quader and Ali, 1974). To overcome jute seed problems and to ensure supply of required quality seeds, Bangladesh Jute Research Institute has been advocating late or off-season seed production for higher seed yield and economic return, which to be sown in the month of August and September and harvested in December and January (Hossain *et al*., 1994b). In traditional jute production system, water management includes application of irrigation is needed and draining out the excess water from the jute field. Jute growers are habituated to follow the technology or practice which has been developed through experiences and tradition and they are reluctant to change their practices (Azad, 1989). But according to modern cultivation system, for seed production, they are cultivated in rainy season. In that case, no irrigation is needed for their growth and development. Again, it will stand only 4 months in the field instead of 7-8 months which will help to produce other crops without wasting of land.

Jute is a photo-period sensitive and short-day plant. The critical photo-period is being 12 hours for *Corchorus capsularis L.* and 12.5 hours for *Corchorus olitorius* L. plants (Ali, 1961). Due to photo-sensitivity, jute plants sown or planted subjected to short days (less than the critical photo-period) giving stunted growth and introducing premature flowers (Johansen *et al*., 1985).

There evolved some less photo-sensitive varieties of both *C. capsularis* L. and *C. olitorius* L. species which have flexibility in sowing time and can easily be accommodated in three cropping seasons. Among the less photo-sensitive varieties, O-9897 of *C. olitorius L.*, ranks at the top for its higher yield and better quality fibre. Farmers also prefer this variety for its early sowing characteristics. This variety exclusively produces better fibre yield but produces very poor seed yield when planted in March-April as fibre crop (Hossain *et al*., 1994c). During the devastating flood of 1988, almost all of the jute seed crops were damaged. To recover that cataclysmic effect, jute seeds were planted in the month of September where, O-9897 provided excellent results. Earlier evidences also offered favorable opinions that late planting technique produce higher seed yield (Hossain *et al*., 1994c and Khan *et al*. 1997). Choudhury and Ali (1963) suggestively stated that one of the devices to increase seed yield of jute was to check vegetative growth by late sowing. They further stated that jute crop should be planted in June or later so that plants remain stunted, induce early flowers and produce higher seed yield. Evidences also indicated that jute seeds could be sown even in the month of December for producing seeds of the following crop season (Chang, 1960 and Kirby, 1963). Farmers will pay due attention to the research findings about which they have some experiences and seem to be more economical.

Seed maturity is an important factor which contributes to seed yield. Seeds attain maturity through accumulation of dry matter and proper development of other essential seed parts. Seed attains physiological maturity when maximum dry matter is accumulated. Drying of seeds in the standing crop causes through respiration utilizing energy, but wet seed respires much faster than dry one. When this drying period is prolonged, an extensive amount of energy is used causing reduced seed viability. Besides, during seed maturation period, high wind and beating rain test the strength of plant roots and stalks; diseases of various sorts have ample time to become established and field infection of storage insects occur in some crops (Hossain, 1999).

Above facts and findings thus indicated that photo-periodic effect rather brought beneficial effect to late-planted jute seed crop. Appropriate methods have been developed to produce jute seeds.

Therefore, present review was undertaken to evaluate the yield and quality of jute seed as influenced by variety and stage of seed maturity in late sown condition with following objectives:

- To know the varietal performance of producing quality seed in late sowing condition;
- To find out the effect of stage of pod maturity on the yield and quality of late season jute seed crop, and
- To assess the interaction between variety and stage of pod maturity on seed yield and quality of *Corchorus olitorius L.* jute in late season.

CHAPTER II

REVIEW OF LITERATURE

Jute specially *Chorchorus olitorious* L. (*Phaseolus vulgaris* L.) is a popular fibre crop of the world. The relevant literatures available on yield and seed quality of different jute varieties as influenced by variety and stage of seed maturity in late sown condition were reviewed under following heads:

2.1 Effect of variety of jute seed in late sowing seed production method

Choudhury and Ali (1962) observed that plants having more vegetative growth produced more fibre but less seeds; therefore, checking of vegetative growth by late sowing was the improved device to increase the seed yields. They further suggested that to produce higher yield of better-quality seeds of jute crop should be grown in June, so that the plants remain stunted in growth, induce early flowering and produce higher yield of seeds.

Joseph *et.al.* (1984) carried out field trials at Barrackpur, West Bengal with *C. capsularis* cv. JRC 212 and *C. olitorious* cv. JRO 632 and reported that, seed yield plant^{-1} was positively correlated with plant height, basal stem diameter, number of branches plant^{-1}, seed weight and pod number which made the greatest contribution to the yield.

Hossain *et.al.* (1991) carried an experiment to investigate effect of seedling transplantation of late sown jute crop on seed yield with four cultivars (CVL-1, D-154, O-4 and O-9897) in 1990 at Manikgonj, Rangpur, Faridpur, Comilla and Kishorgonj regional station of BJRI. Seedling were transplanted on September 1, 15 and 30 to the monsoon seed bed. The interaction effect between dates of transplanting and varieties of jute indicated that all the four varieties transplanted on September 1 and 15 produced higher seed yields. Variety O-9897 produced the highest seed yield (546 kgha^{-1}) over the other varieties.

Hossain *et.al*. (1994a) conducted an experiment at Rangpur Station of BJRI with four varieties viz. CVL-1, D-154, O-4 and O-9897 during 1992 to assess the feasibility of growing late jute seed crop through transplanting on three different transplanting dates.

They also found that the variety O-9897 gave significantly the highest seed yield (630 kgha^{-1}) when seedling was transplanted on 1st September.

Hossain *et.al*. (1993) conducted an experiment at Manikgonj and Rangpur in 1992 with four genotypes of jute viz. Chitla, OM-1, O-9897 and O-4 to study the feasibility of growing sole jute seed crop in late season with different dates of sowing (August 15 and 30 and September 15). From the result it was observed that all the genotypes gave higher yield in August 15 sowing at both stations. Irrespective of dates of sowing, Variety O-9897 gave higher yield at Manikgonj (980 kgha^{-1}).

Rahman *et.al.* (1992) carried out an experiment at Faridpur and Kishorgonj with O-9897 jute cultivar at four ciltivar at four sowing dates (August 15 & 30 and September 15 & 30). Result revealed that August 15 sowing produced significantly the highest seed yield and gradually decreased with delayed sowing from August 15.

Khan and Islam (1993) carried out an experiment at Kishoregonj regional station of BJRI to find out the best time of sowing for late season seed crop of jute (var. O-9897). Result indicated that August 30 sowing produced significantly the highest seed yield (1086 kgha^{-1}) followed by August 15 sowing (1033 kgha^{-1}). The sowing of October 15 produced the lowest seed yield (400 kgha^{-1}).

Hossain *et.al.* (1994b) demarcated the last time of sowing of late jute seed crop for different agro-climatic regions of Bangladesh. According to his works, sowing of late jute seed crop should not be done beyond the 1st week of September at Rangpur, middle of September at Jessore and end of September at Faridpur, Manikgonj and Chandina (Comilla) regions.

Islam *et.al.* (1994) conducted an experiment where the highest plant height, base diameter, the weight of dry plant, number of branches per plant, seeds per pod and seed yield were obtained from the direct seeding method in case of variety O-9897.

Hossain *et.al.* (1994c) reported that the higher seed yield of jute seed produced in the late planting season. The author considered the planting time of jute in the late season, the corresponding temperature of their flowering period and yield, thus demarcated the last planting time of jute and stated that seed should not be planted beyond the first week of September at Rangpur, middle of September at Jessore and end of September at Faridpur, Manikgonj and Kishoregonj; and 5 October at Comilla regions of Bangladesh.

Haque (1995) conducted an experiment with *C. capsularis* and *C. olitorious* varieties to show the varietal suitability on seed production under late planting technique. The author reported that there were significant variations in seed yield among different varieties of jute sown as late seed crop. Among *C. olitorious* cv. O-9897, O-4 and Chaitali produced 1044, 891 and 811 kg seeds ha^{-1} respectively. Among *C. capsularis* varieties CVE-3 showed the highest seed yield potential ($509kg^{-1}$) followed by D-154 ($473kg^{-1}$) and CVL-1 (416 $kgha^{-1}$). Although, differences in seed yield among *C. capsularis* varieties were statistically significant, all the studied varieties of *C. capsularis* gave significantly lower seed yield than those of *C. olitorious* varieties.

Hossain (1999) conducted research on varietal suitability for late planting technique on seed yield productivity with *C. olitorious* (var. O-4, O-9897 and chaitali), *C. capsularis* (var. D-154, CVL-1 and CVE-3), *Hibiscus sabdariffa* (var. HS-24) and *H. cannabinus* (var. HC-2). It was concluded that, all the varieties of *C. capsularis* (var. D-154, CVL-1 and CVE-3), *C. olitorious* (var. O-4, O-9897 and Chaitali) and *H. cannabinus* (var. HC-2) can be sown as late season seed crop. But, *H. sabdariffa* (var. HS-24) should be grown as conventional practices for seed production.

Sohel *et.al.* (2002 and 2003) reported that jute seed obtained from top cutting method gave significantly higher percentage of germination and shoot length indicating its superiority over the conventional method. The variety O-9897 gave higher percentage of germination, speed of germination, root length and dry weight of root and shoot indicating its superiority attributes among the varieties. The interaction effect of planting method and variety of different attributes differed significantly.

Islam (2005) reported that the top-cutting method gave the highest seed yield of 738 $kgha^{-1}$ in *C. capsularis* L. and 913 $kgha^{-1}$ in *C. olitorious* L. compared to that of conventional method of 477 $kgha^{-1}$ in *C. capsularis* L and 529 $kgha^{-1}$ in *C. olitorious* L. and their differences were highly significant. Late sowing method gave statistically similar yield of 715 $kgha^{-1}$ in *C. capsularis* and 869 $kgha^{-1}$ in *C. olitorious* to top cutting. Irrespective of planting method, the varieties CVL-1 and CVE-3 of C. capsularis and O-9897 and OM-1 of *C. olitorious* produced statistically similar yield. The interaction effect of seed maturity stage and variety were significant for pod plant^{-1}, seed pod^{-1}, seed weight plant^{-1}, 1000 seed weight and seed yield except branch plant^{-1}. All the varieties under top cutting and late sowing methods produced much higher seed yieds compared to their corresponding yields under conventional method of seed production technique.

Hossain and Wahab (1992) found that improved seeds of *C. olitorius* under optimum management condition produced 32% higher yields respectively compared to local seeds under farmers management condition.

Talukder and Ali (1977) observed that germination capacity of jute seeds correlated with jute seed variety. In late sown condition, seedling grow more rapidly in case of improved variety than that of local seed.

2.2 Effect of stage of pod maturity in late sowing seed production method of jute

Delouche (1971) stated that as the seed continued to decrease in moisture content decreased during or after maturation, they came more and more under the influence of field environment. The factors that had the most detrimental effect on seed quality were temperature (too high or too low), relative humidity (high) and precipitation (frequent). These could act singly or in combinations to cause a substantial reduction in seed quality before the seeds were even harvested. Besides, field conditions were seldom favorable in the storage. Delouche and Baskin (1973a) further stated that frequent and prolonged precipitation, high humidity and temperature of the humid tropics could result in rapid and severe deterioration of seeds before they were harvested and also during storage. Delouche *et al.* (1973b) also stated that seeds attained functional maturity at the time when maximum dry weight was accumulated. For many kinds of seeds, this occurred when moisture content was too high for mechanical harvest. For example, wheat, barley and oat seeds contained about 40% moisture at the time of maturity, corn about 35% and rice from 32-35% and soybean about 28-30%. The seeds remained on the plants in field until they dried down sufficiently i.e., the harvest maturity.

Evidence further indicates that conditions before and during harvest including post-harvest drying may affect loss of seed viability (Austin, 1972; Johanson *et al*., 1984; Roberts, 1972), but only extreme environmental condition before harvest is likely to affect seed viability to any marked extent (Austin, 1972). Delouche (1976) again stated as an established fact that the period between physiological maturity and harvest maturity was critical and important in terms of seed quality. Justice and Bass (1978) stated that much of the research relating to maturity had been oriented towards production and harvest goals without continuing into storage studies. Such studies had marginal relevance to the relationship of seed maturity and life span in storage. Since, healthy and matured plump seeds stored better than the immature seeds.

Matthews (1979) reported that major causes of low seed vigour of wheat and barley in the United Kingdom was the prolonged period of ripening during wet harvest time, which was not usual in New-Zealand. Talukder and Ali (1979) harvested *C. olitorious* seeds from 20-60 days after anthesis and that of *C. capsularis* from 20-50 days each with five-day interval. Results showed that 1000-seed weight and percentage germination increased successively with the rise in maturity level. *C. capsularis* seeds met ISTA standard of 80% germination even when harvested as early as 30 days after anthesis, but *C. olitorious* seeds provided only 71% germination harvested on 50 days after anthesis. However, *C. olitorious* gave above 90% germination that harvested on 55 or above days after anthesis. Information available from very extensive 10 stages of harvest environment conducted by Jeytic (1980) indicated that harvest should be carried out in the second half of the wax ripeness stage at grain moisture content from 25-30% and should be completed by 11-15 days depending on the cultivar.

Hossain and Wahhab (1981) reported that *C. capsularis* seeds harvested at 12 days earlier (matured green stage) than the full brown stage gave seed germination 84%, thus released the land earlier assuring higher yield of the follow-up crops. *Borghi et al.* (1984) harvested wheat between 20 and 30 June (normal harvest date 8 July) with grain moisture content of 19-39% and dried the grains quickly to 12% moisture within 24 hours. The grain quality was as good as that from normal harvest. Besides, that authors stated that harvesting cereals 11-14 days early was a practical proposition, allowed a second crop in the sequence, gave straw with a better forage value and gave the possibility of planting cultivar with a longer growth cycle that normally produced higher yield.

Agrawal (1986) stated that it was of great importance to harvest a seed crop at the time which allowed both the maximum yield and the best quality seeds. He also said that harvesting was the last field operation in seed production. Several studies related to seed maturity level indicate that the optimum time to harvest was when the seeds were fully matured; weather damage had just begun and seeds were easy to harvest and the clean resulting minimum harvest losses. The author further stated that harvesting at an early stage made combining difficulties and relative losses due to threshing and cleansing were greater. Similarly harvested at a late stage might result in increased weather damage to seeds and losses due to shattering of seeds and lodging of plants in the field. Therefore, the optimum harvest time is somewhere between these two extremes. Singh (1987) reported that large and medium size seeds normally occurred due to higher and low levels of seed maturity in sorghum. However, both large and medium size seeds gave similar results for their germination.

Khan and Biswas (1989) reported that incidence of disease pathogens increased with the rise in seed maturity of jute. During the harvest period in October-November, weather became misty, which influenced the spread of disease organisms and secondary infection by the fungal spores. The moist condition of the dried pod surface favored the growth of fungal organisms. Since all the pods of a single plant did not matured at a time and the crop was left in the field to get all the pods matured and dried completely, dried pods become densely infected. Thus, to prevent jute seeds from primary source of infection, the authors suggested harvesting just after the semi-dry stage of pods, when about 50% pods became dry and 50% remained semi-dry.

Quader and Ali (1974) studied seed quality of jute that was harvested at different stages of maturity. Results showed that both number of seed and its weight increased in the pods that were harvested at advanced stages of maturity. Besides, mature pods after being dried for about a week after harvest showed pronounced effect on the germination percentage of seeds.

Wahhab (1977) harvested early planted jute seed crop after 171, 178, 183 and 187 days of field duration and reported that seed germination and 1000-seed weight did not differ, although, pod shattering percentage increased with delay in harvest.

Wahub and Talukder (1978) and Wahhab and Talukder (1992) further reported that *capsularis* jute seeds collected at stages of maturity including green matured stages of pods had no adverse effect on quality and quantity of seeds.

Hossain et al. (1979) in an interaction study of stage of seed maturity and types of harvest (whole plant, top cutting and fruit picking) reported that seeds harvested by whole plants and top cutting did not differ in quality due to stage of maturity. However, for seeds harvested by fruit picking, the early-harvested seeds gave lower seed yield and lower percentage of seed germination.

Hossain and Wahhab (1981) stated that percentage of germination in jute seed increased gradually with the increase of stage of seed maturity and variation was significant at each level, but all the seeds collected at green matured stage through full brown stage gave germination above 80%. However, Khandakar *et al*. (1984) reported that jute seed did not reach full maturity as long as pods remain green; browning of pods was the indication of seed maturity in *C. capsularis* jute. The crop harvested at full brown stage of pods gave the lowest seed moisture content, higher 1000-seed weight and the maximum seed viability. In another study,

Khandakar *et al.* (1985) stated that *C. capsularis* and *C. olitorious* crops planted on the first and third week of April and harvested after 187 and 178 days of field duration attained optimum physiological maturity of seed as indicated by maximum accumulation of dry matter, the lowest seed moisture content and the highest seed viability. The authors further stated that *C. capsularies* seeds attained optimal physiological maturity when about 60% pods received brown color and that of *C. olitorious* pods when about 70% and the seed yield was maximum as well.

Hossain (1999) stated that harvesting jute seed crop at early stages made relatively low losses due to threshing and produced many unfilled seeds. Besides, mature seeds retained viability better than the immature seeds at storage. The author further added that harvesting at a late stage might result in increased weather damage and losses due to shattering of seeds. Therefore, the author suggested that jute seeds should be harvested between the intermittent time of pre-mature and complete maturity when the weather damage just began, thus the optimal harvest time was when about 50 % pods attained brown color.

CHAPTER III

MATERIALS AND METHODS

In this chapter a short description of the location of the experimental plot, climatic condition of the area where the plot was situated, materials used for experimental treatments, design of the experiment, method of cultivation, method of data collection, statistical analysis have been presented.

3.1 Experimental Site

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 to study the yield and quality of jute seed as influenced by variety and stage of pod maturity in late sown condition during the period from August, 2017 to December, 2017. It is situated at $23°74^{/}$ North latitude and $90°35^{/}$ East longitude (Anon., 1989). The land was 86 m above the sea level. It belongs to Madhupur Tract (AEZ 28). For better understanding about experimental site it is shown in the Map of AEZ of Bangladesh in Appendix- I. The land topography was medium high and soil texture was silty clay with pH 6.1. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-II.

3.2 Climate

Experimental area belongs to subtropical climatic zone which is characterized by heavy rainfall, high temperature and relatively long day period during “Kharif-1” season (April-September) and scarce rainfall, low humidity, low temperature and short-day period during “Rabi” season (October-March). This climate is also characterized by distinct season, viz. the monsoon extending from May to October, the winter or dry season from November to February and pre-monsoon period or hot season from March to April (Edris *et al*. 1979). The meteorological data in respect of temperature, total rainfall (mm) and relative humidity for the entire experimental period have been shown in Appendix III.

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract in Agroecological Zone (AEZ)-28 (UNDP, 1988). It was medium high land and the soil series was

Tejgaon (FAO, 1988). The soil was having a texture of sandy loam with pH and CEC were 5.8 and 2.64 meq/100 g soil, respectively. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing laboratory, SRDI, Khamarbari, Dhaka and details of the recorded soil characteristics were presented in Appendix II.

3.4 Planting Materials

The seeds of different Tossa jute varieties were collected from Bangladesh Jute Research Institute (BJRI), Dhaka.

3.5 Treatments of the experiment

Factor A – Variety (3)

1. V_1 = O-9897
2. V_2 = O-795 (BJRI Tossa Pat-5)
3. V_3 = O-3820 (BJRI Tossa Pat-6)

Factor B – Stage of seed maturity (3)

1. M_1 = About 40% pods of the plant become brown
2. M_2 = About 60% pods of the plant become brown
3. M_3 = About 80% pods of the plant become brown

There were 9 (3×3) treatment combinations given below:

V_1M_1, V_1M_2, V_1M_3, V_2M_1, V_2M_2, V_2M_3, V_3M_1, V_3M_2 and V_3M_3.

3.6 Design and layout of the experiment:

The two-factor experiment was laid out in the Randomized Complete Block Design RCBD (factorial) with three replications. The land size was (26m × 12m) or 312m^2. Each block consisted of 9-unit plots. The size of each unit plot was (3m × 2m) or 6 m^2. The distance maintained between two replications and two plots were 1 m and 0.75 m, respectively. Line to line distance is 30 cm. There was 10 line in each plot. The layout of the experiment is shown in Figure 1.

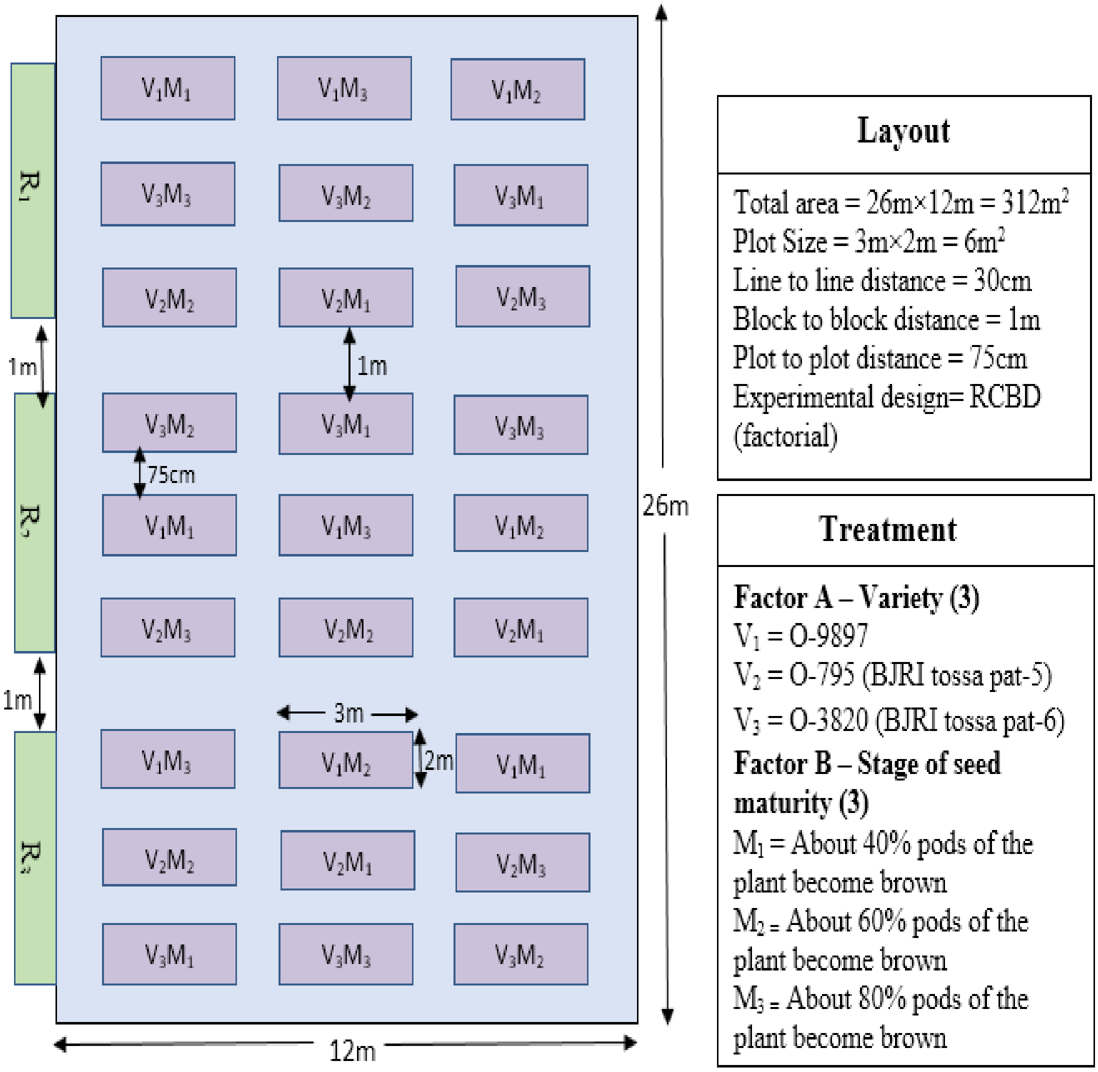


Figure 1: Layout of the experimental field

3.7 Land preparation

The experimental area was first ploughed by a power tiller and the soil was exposed to sun for 5 days. Then the land was thoroughly prepared by ploughing and cross ploughing. The weeds and stubbles were removed from the field. Then the land was divided into 27-unit plots keeping plot and block to block spacing. The treatments were assigned in plot at random. During land preparation, carbofuran @ 16 kg ha^{-1} was mixed with the soil uniformly for controlling soil borne insects.

3.8 Fertilization

The recommended fertilizer dose used for jute was 170-85-60-85-28 kg ha^{-1} of Urea, TSP, MP, Gypsum and Zinc Sulphate, respectively. Fertilization (basal dose) was completed on 10 August, 2017. Urea, TSP, MP, Gypsum and Zinc Sulphate were applied before final land preparation. One third portion of total Urea, full amount of TSP, MP, Gypsum, Zinc Sulphate were applied as basal dose. Next 1/3 Urea was applied after 30 days of sowing and the rest of the urea was applied after 45 days.

3.9 Sowing of seeds

Seeds were sown in line on 10 August, 2017 in each plot. There was 10 line in each plot. Line to line distance was maintained at 30 cm.

3.10 Intercultural operations

3.10.1 Irrigation and drainage system

No irrigation was done because of rainy season. Drainage system was done at 13 August among the plots to drain out excessive water which was harmful to jute plants. It also responsible for pest and disease attack.

3.10.2 Gap filling

Gap filling was done on 1 September, 2017 which was 20 days after sowing.

3.10.3 Weeding

Two weeding was done during their establishment. One weeding was done on 28 August, 2017 and another weeding was done on 16 September, 2017.

3.10.4 Thinning

During plant growth period one thinning was done on 1 September, 2017 which was 20 days after sowing.

3.10.5 Plant protection measures

At the early stage of growth, some plants were attacked by insect's pests (mainly aphid) and Malathion 57 EC was sprayed twice at the rate of 2 ml $liter^{-1}$ at an interval of 15 days. Insecticides was sprayed on 25 September, 2017 and 9 October, 2017 through the sowing line.

3.11 Harvesting

The crops were harvested at 40%, 60% and 80% pod maturity stage as per treatment. 10 sample plants were collected from each plot for taking yield attributes data. For taking seed yield data, plants of central 1.0 m^2 area were collected from each plot avoiding border plant. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading these on the threshing floor. The seeds were separated, cleaned and dried in the sun for 5 consecutive days for achieving safe moisture of seed.

3.12 Data collection

The data were recorded on the following parameters

a. Plant height (cm)

b. Branches plant^{-1} (no.)

c. Pods plant^{-1} (no.)

d. Seeds pod^{-1} (no.)

e. Pod length (cm)

f. Weight of seed pod^{-1} (g)

g. 1000 seed weight (g)

h. Pod diameter (mm)

i. Seed yield (kg ha^{-1})

The plot wise sun-dried seeds were used for quality assessment. The seeds were set for standard germination test and the following data were taken----

a. Seedling length (cm)

b. Vigor index

c. Germination percentage

d. Dry weight of seedling (mg)

e. Electrical conductivity (dSm^{-1})

3.13 Procedure of recording data

It was done on the basis of following parameter-

3.13.1 Plant height

The height of ten randomly collected plants from each plot was measured from ground level to the tip of the plant and the mean value of plant height was recorded in cm.

3.13.2 Branches plant^{-1}

The number of branches plant^{-1} was counted from ten randomly sampled plants. It was done by counting total number of branches of the 10 sampled plants then the average data were recorded.

3.13.3 Pods plant^{-1}

Number of pods plant^{-1} was counted from the 10 selected plant sample and then the average pod number was calculated.

3.13.4 Seeds Pod^{-1}

Ten pods were selected from each plot and the seed number were counted carefully. The average number of seeds of 10 pods was calculated.

3.13.5 Pod length (cm)

Length of pod was measured by meter scale from twenty pods and then average pod length was calculated.

3.13.6 Weight of seed pod^{-1} (g)

From each plot, 10 pods were selected and seeds were separated from the pods. The weight of the seed from each pod was measured by an electrical balance. The average value of the seeds of 10 pods was calculated to have seeds pods^{-1}. It was recorded in gram.

3.13.7 1000 seed weight (g)

1000 seed from each plot was counted and measured by an electrical balance. It was recorded in gram.

3.13.8 Pod diameter (mm)

Ten pods from each plot was taken and the diameter was measured by using slide calipers. It was recorded in millimeter. The average value was calculated.

3.13.9 Seed yield (kgha^{-1})

Seed yield was measured from the plants of central 1.0 m^2 area. The weight was finally converted to kg ha^{-1}.

3.13.10 Seedling length (cm)

The length of five seedlings from each treatment was recorded at 10 DAS and the average value was calculated. Measurement was done using a meter scale and unit was expressed in centimeter (cm).

3.13.11 Vigor index

Seed vigor index (SVI) was measured by the following formula (Islam, 2009):

$$\text{Seed Vigor Index} = \frac{\text{Number of seeds germinated (first count)}}{\text{Number of days to first count}} + \cdots \ldots \ldots \ldots + \frac{\text{Number of seeds germinated (last count)}}{\text{Number of days to last count}}$$

3.13.12 Germination percentage (%)

Seeds obtained from each treatment were placed in petridish which were full of sand. There was 25 seeds in each petridish. The number of sprouted and germinated seeds was counted daily commencing. Germination was recorded at 24 hrs interval and continued up to 5th days. More than 2 mm long plumule and radicle was considered as germinated seed.

The germination rate was calculated using the following formula (Islam, 2009):

$$\text{Rate of germination (\%)} = \frac{\text{Total number of germinated seeds}}{\text{Total seed placed for germination}} \times 100$$

3.13.13 Dry weight of seedling

Ten seedlings from each petridish were collected randomly at 10 days after sowing. Samples were put into envelop separately and placed in oven maintained at 70°C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the sample was taken and recorded in milligram (mg).

3.13.14 Electrical conductivity (dSm^{-1})

Electrical conductivity test provides a quick decision about the seed quality. It is concern to deterioration process of seeds degradation of cell membranes and leakage out of the cells and also reduction of respiratory and biosynthetic activities (Delouche *et.al.* 1973). The 2g seeds of each sample were taken in a conical flask containing 50ml de-ionized water and were incubated at 20°C for 24 hours as per Ali *et.al.* (2004) and Islam (2009). At the end of 24-hour soak period, water of the beaker containing seeds was decanted in order to separate the seeds. The electrical conductivity of the decanted water containing seed leachate was measured with EC meter (Model-CM-30ET). Four replicates of measurements were made for each sample of seed. It was recorded in dSm^{-1}.

3.14 Statistical analysis

The recorded data on different parameters were statistically analyzed using MSTAT-C computer software program. The analysis of variance for the characters under study were performed by 'F' variance test. The differences between the pairs of treatment means were compared using least significant difference (LSD) test (Gomez and Gomez, 1984). The probability level used was 0.05 in all cases.

CHAPTER IV

RESULTS AND DISCUSSION

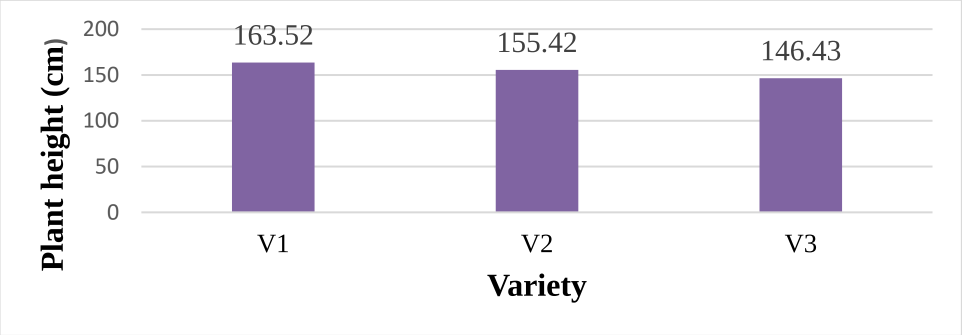
The experiment was conducted to study the yield and quality of jute seed as influenced by variety and stage of seed maturity in late sown condition. A summary of the analysis of variances of all the characters studied together with their sources of variation and corresponding degrees of freedom have been shown in Appendix IV-IX. Data on phenological characters, yield attributes, yield and quality parameter of different jute variety, their stage of seed maturity and their interaction were recorded. The results have been presented and discussed with the help of tables and graphs and possible interpretations given under the following headings:

4.1 Plant characters

4.1.1 Plant height (cm)

Effect of variety

Plant height is an important morphological character, which is very essential parameter for plant growth and development. Plant height was significantly influenced by variety (Fig. 2 and Appendix IV). The tallest plant (163.52 cm) was recorded from the crops of V_1 (O-9897) variety. The shortest plant (146.43 cm) was recorded from V_3 (O-3820). Probably the genetic makeup of varieties was responsible for the variation in plant height. This result is in agreement with findings of Neogi *et.al.* (2010). They reported that variety had significant influence on plant height.

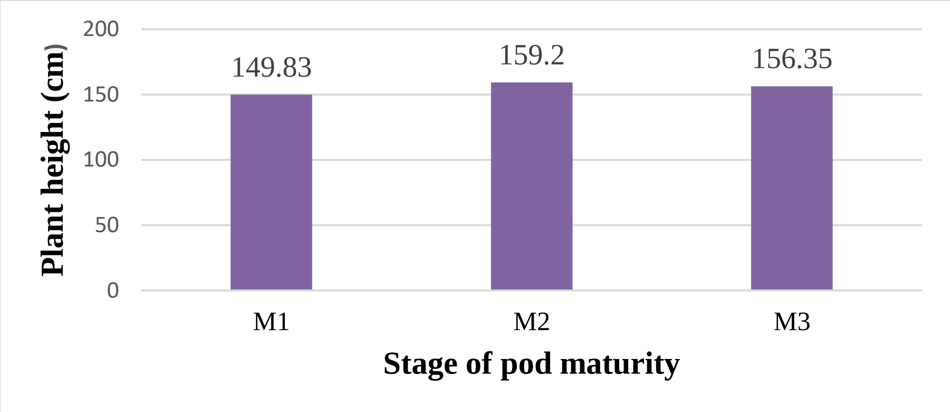


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 2: Effect of variety on plant height of jute seed crop in late sown condition ($LSD_{0.05}$ = 11.013)

Effect of stage of pod maturity

Pod maturity stage exhibited a non-significant influence on plant height of jute in late sown condition (Figure 3 and Appendix IV). In case of seed maturity, the tallest plant (159.20 cm) was found in M_2 treatment whereas the shortest one (149.83 cm) was found in M_1 treatment. M_3 showed intermediate level.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 3: Effect of stage of pod maturity on plant height of jute seed crop in late sown condition ($LSD_{0.05}$ = 11.013^{NS})

Interaction effect of variety and stage of pod maturity

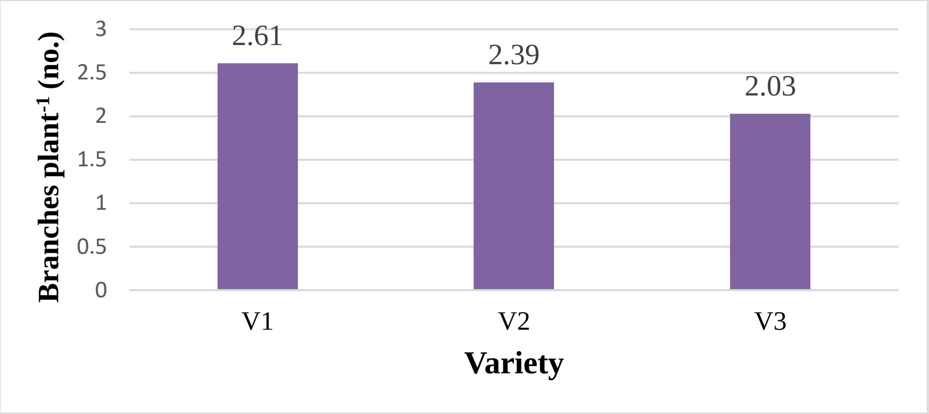
The significant variation was found due to interaction effect of variety and stage of pod maturity on plant height of jute at late sown condition (Table 1 and Appendix IV). The tallest plant (166.15 cm) was found from treatment combination of V_1M_3 which was statistically similar with all the interactions except V_3M_1 (136.13 cm). The lowest plant height (136.13 cm) was found in V_3M_1 treatment which was statistically similar with V_2M_1 (153.10 cm), V_2M_3 (151.67 cm), V_3M_2 (151.93 cm) and V_3M_3 (151.23 cm).

4.1.2 Number of branches plant^{-1}

Effect of variety

Different variety of jute revealed a significant influence on number of branches plant^{-1} at late sown condition. (Fig. 4 and Appendix V). The maximum number of branches plant^{-1} (2.61) was recorded from V_1 which was statistically similar with V_2 (2.39), whereas the minimum number of branches plant^{-1} (2.03) was found from V_3 treatment.

Variations in number of branches plant^{-1} among the varieties may perhaps the genetic characters of the varieties.

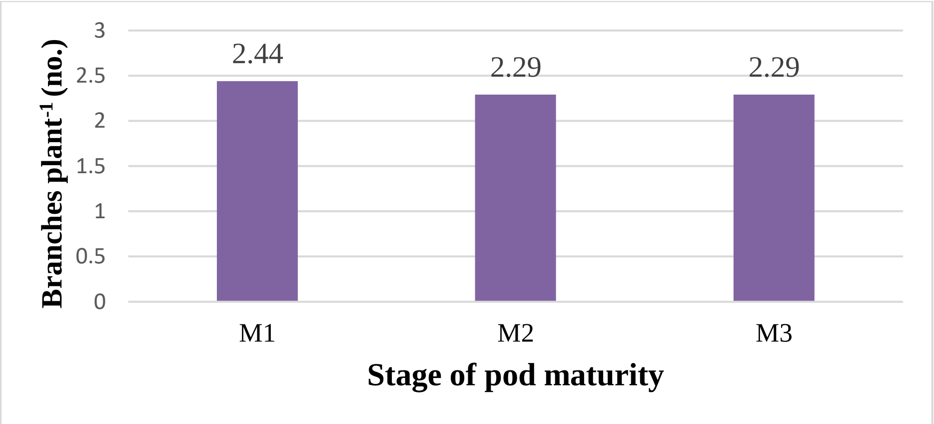


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 4: Effect of variety on number of branches plant^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.288)

Effect of stage of pod maturity

There exhibited a non-significant difference among the stage of pod maturity in late sown condition of jute (Figure 5 and Appendix V). Maximum number of branches plant^{-1} (2.44) was found in M_1 treatment which was followed by M_2 (2.29) and M_3 (2.29) treatments.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 5: Effect of stage of pod maturity on number of branches plant^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.288^{NS})

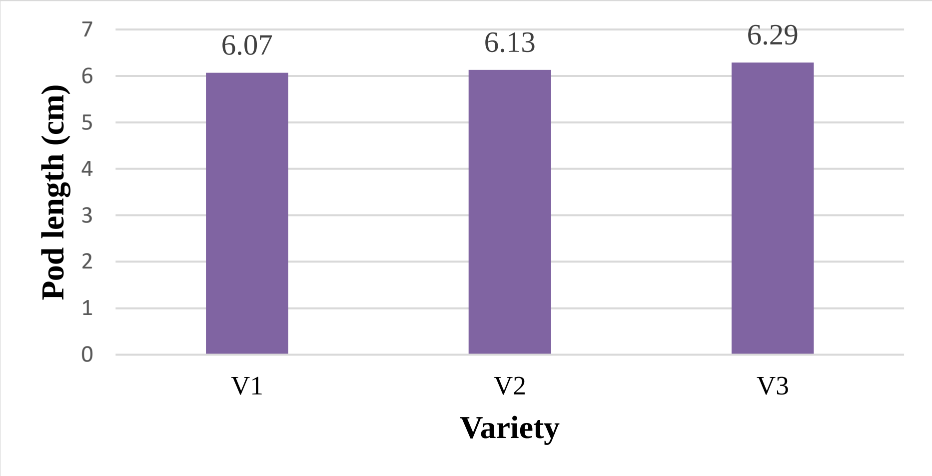
Interaction effect of variety and stage of pod maturity

Interaction effect of variety and stage of pod maturity demonstrated a significant influence at late sown condition of jute (Table 1 and Appendix V). The highest number of branches plant^{-1} (3.08) was recorded from V_1M_1 treatment combination, while the minimum value (1.76) was recorded from V_3M_1 treatment which was statistically similar with V_1M_2 (2.22) and V_3M_3 (2.03) treatment combinations.

4.1.3 Pod length (cm)

Effect of variety

Different jute variety showed non-significant influence on pod length of jute at late sown condition (Figure 6 and Appendix VI). However, the highest pod length was found from V_3 (6.29cm) and that was lowest from V_1 (6.07cm).

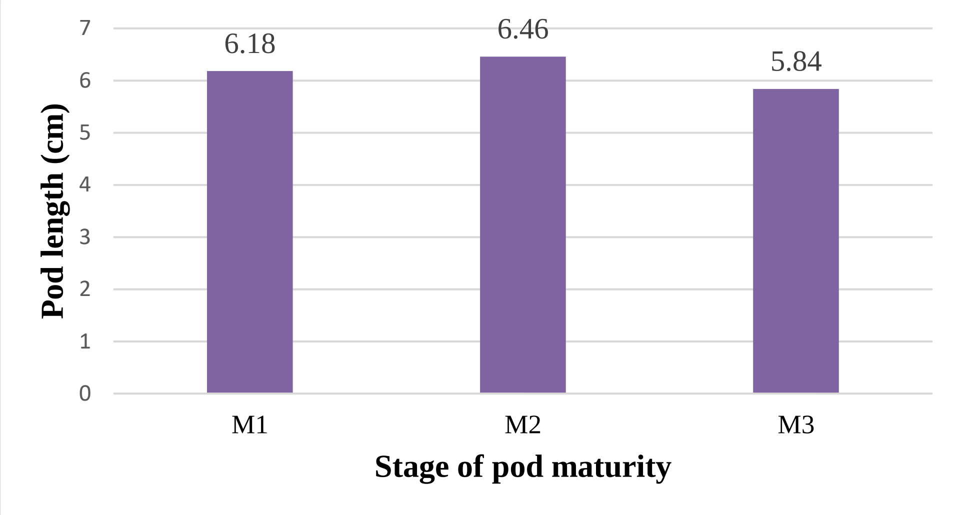


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 6: Effect of variety on pod length of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.322^{NS})

Effect of stage of pod maturity

Considerable variation was found in terms of pod length affected by different levels of pod maturity (Figure 7 and Appendix VI). The figure indicated that the highest length of pod (6.46 cm) was recorded from the treatment M_2 which was statistically identical with the treatment of M_1 (6.18 cm) and the lowest length of pod (5.84 cm) was recorded from the treatment M_3.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 7: Effect of stage of pod maturity on pod length of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.322)

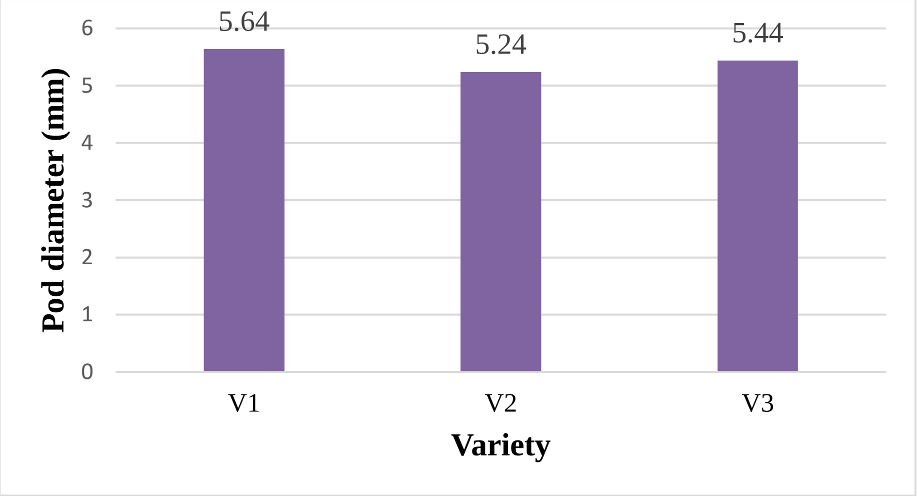
Interaction effect of variety and stage of pod maturity

Significant variation was recorded due to interaction effect of varieties and stage of pod maturity on pod length of late sown jute (Table 1 and Appendix VI). The result revealed that the highest pod length (6.90 cm) was recorded from the treatment combination of V_3M_2 which was statistically similar with the treatment combination V_2M_2 (6.38 cm). The treatment combination, V_3M_3 gave the lowest pod length (5.79 cm) which was statistically similar with the treatment combination of V_1M_3 (5.82 cm), V_1M_1 (6.29 cm), V_1M_2 (6.12 cm), V_2M_1 (6.07 cm), V_2M_3 (5.93 cm) and V_3M_1 (6.18 cm).

4.1.4 Pod diameter (mm)

Effect of variety

Pod diameter is a crucial parameter and an important part of crop plant because of its physiological role in photosynthetic activities. Pod diameter is directly related to the yield of jute variety. Effect of variety on pod diameter was found to be statistically non-significant at late sown condition (Fig. 8 and Appendix VII). However, the highest pod diameter (5.64 mm) was recorded from variety V_1 whereas the lowest (5.24 mm) was found from variety, V_2.

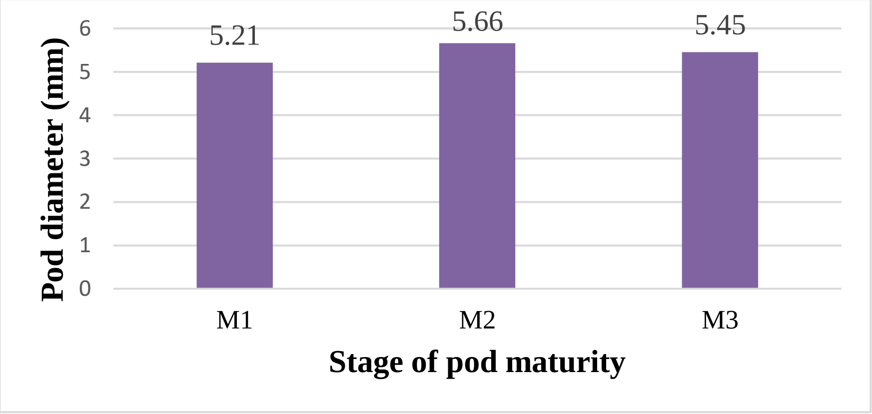


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 8: Effect of variety on pod diameter of jute seed crop in late sown condition ($LSD_{0.05} = 0.428^{NS}$)

Effect of stage of pod maturity

Effect of stage of pod maturity on pod diameter was observed statistically significant at late sown condition (Fig. 9 and Appendix VII). The highest pod diameter (5.66 mm) was recorded from M_2 treatment, while the lowest pod diameter (5.21 mm) was measured from M_1 treatment, which was also statistically similar with M_3 (5.45 mm) treatment



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 9: Effect of stage of pod maturity on pod diameter of jute seed crop in late sown condition ($LSD_{0.05} = 0.428$)

Interaction effect of variety and stage of pod maturity

Interaction effect of variety and stage of pod maturity had significant differences on pod diameter at late sown condition (Table 1 and Appendix VII). The result revealed that the maximum pod diameter (5.87 mm) was recorded from V_1M_2 treatment combination which was statistically similar with all the treatment combination except V_2M_1. The lowest pod diameter (5.04 mm) was recorded from V_2M_1 treatment combination which was statistically similar with V_1M_1, V_2M_2, V_2M_3, V_3M_1, V_3M_2 and V_3M_3 where the pod diameter were 5.26 mm, 5.54 mm, 5.15 mm, 5.33 mm, 5.59 mm and 5.42 mm, respectively. Greater pod diameter is very important as it determines seed size which regulates yield and quality of jute seed (AOSA, 1981).

Table 1. Plant characters of jute as influenced by variety and stage of pod maturity in late sown condition

Treatment	Plant height (cm)	Branches plant^{-1} (no.)	Pod length (cm)	Pod diameter (mm)
V_1M_1	160.27 a	3.08 a	6.29 bc	5.26 ab
V_1M_2	164.16 a	2.22 bcd	6.12 bc	5.87 a
V_1M_3	166.15 a	2.53 b	5.82 c	5.79 a
V_2 M_1	153.10 ab	2.48 bc	6.07 bc	5.04 b
V_2 M_2	161.50 a	2.36 bc	6.38 ab	5.54 ab
V_2 M_3	151.67 ab	2.32 bc	5.93 bc	5.15 ab
V_3 M_1	136.13 b	1.76 d	6.18 bc	5.33 ab
V_3 M_2	151.93 ab	2.30 bc	6.90 a	5.59 ab
V_3 M_3	151.23 ab	2.03 cd	5.79 c	5.42 ab
LSD $_{(0.05)}$	**19.075**	**0.499**	**0.558**	**0.742**
CV (%)	**7.10**	**12.30**	**5.23**	**7.88**

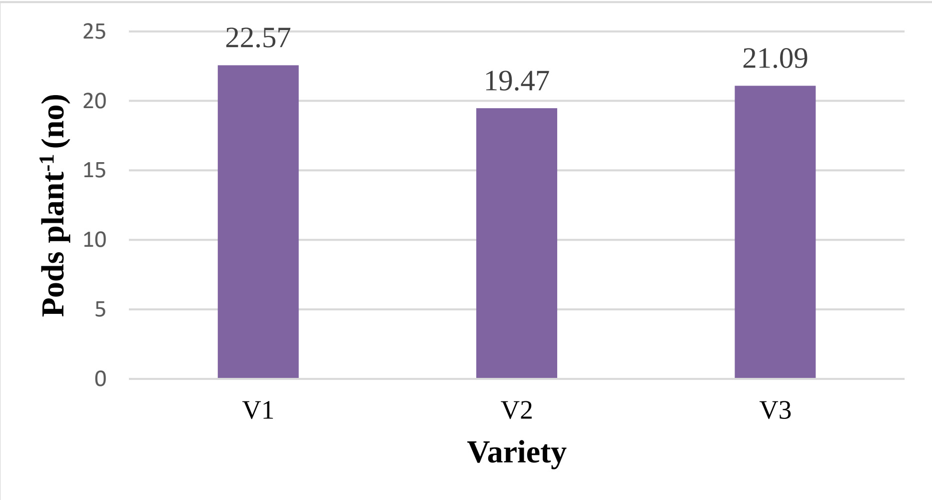
Here, V_1 = O-9897, V_2 = O-795 (BJRI Tossa Pat-5), V_3 = O-3820 (BJRI Tossa Pat-6) M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

4.2 Seed yield and yield contributing characters

4.2.1 Pods plant^{-1}

Effect of variety

Number of pods plant^{-1} was significantly affected due to varietal performance of jute under the present study (Figure 10 and Appendix VIII). Results indicated that the maximum number of pods plant^{-1} (22.57) was recorded from variety V_1 whereas the minimum number of pods plant^{-1} (19.47) was found from variety, V_2. The findings of the present study also accord with those of other authors (Talukder and Hossain,1989) who reported that number of branches of jute is the main reason of increasing number of pods plant^{-1} of jute.

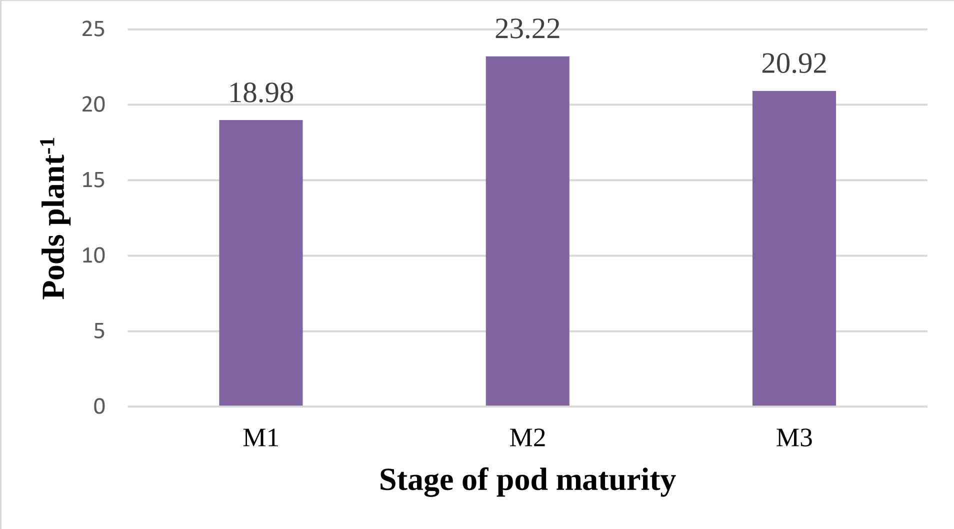


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 10: Effect of variety on number of pods plant^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.967)

Effect of stage of seed maturity

Number of pods plant^{-1} affected significantly due to different levels of pod maturity stage of jute in late sown condition (Figure 11 and Appendix VIII). Results indicated that the highest number of pods plant^{-1} (23.22) was recorded from the treatment M_2 which is statistically similar to M_3 (20.92) and the lowest number of pods plant^{-1} (18.98) was recorded from the treatment, M_1.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 11: Effect of stage of pod maturity on number of pods plant^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.967)

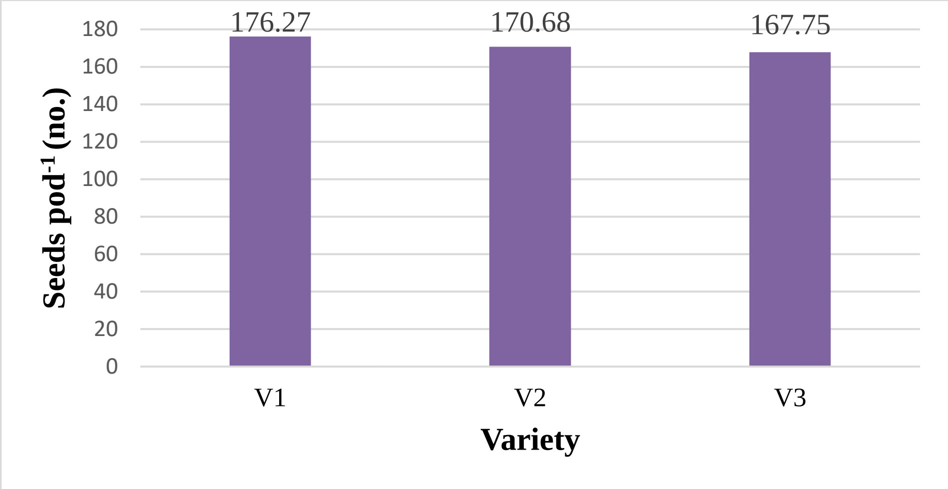
Interaction effect of variety and stage of pod maturity

Significant variation was recorded due to interaction effect of varieties and pod maturity stage on number of pods plant^{-1} (Table 2 and Appendix VIII). It was found from the table that the highest number of pods plant^{-1} (24.97) was recorded from the treatment combination, V_1M_2. The treatment combination, V_2M_1 gave the lowest number of pods plant^{-1} (17.15).

4.2.2 Seeds pod^{-1}

Effect of variety

The effect of variety on seeds pod^{-1} was significant due to jute varieties (Figure 12 and Appendix IX). It was found that the highest number of seeds per pod (176.27 cm) was recorded from variety, V_1 which was statistically similar with the treatment V_2 (170.68) and the lowest number of seeds pod^{-1} (167.75) was found from variety, V_3.

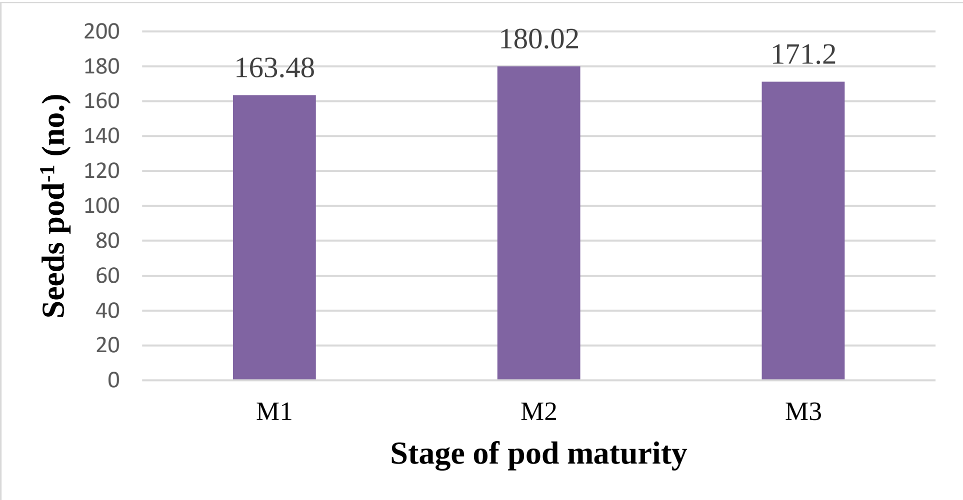


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 12: Effect of variety on number of seeds pod^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 6.42)

Effect of stage of pod maturity

Seeds pod^{-1} of jute differed significantly due to different stage of pod maturity (Figure 13 and Appendix IX). The maximum number of seeds pod^{-1} (180.02) was recorded from M_2, while the minimum number of seeds pod^{-1} (163.48) was counted from M_1.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 13: Effect of stage of pod maturity on number of seeds pod^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 6.42)

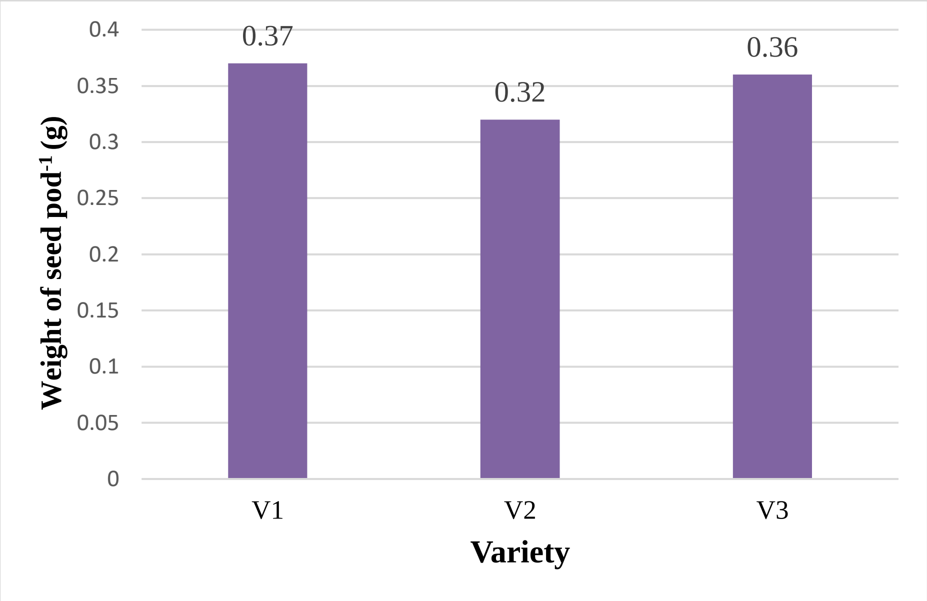
Interaction effect of variety and stage of pod maturity

The significant variation was found due to interaction effect of varieties and stage of pod maturity on number of seeds per pod of jute (Table 2 and Appendix IX). The maximum number of seeds pod^{-1} (185.50) was recorded from the treatment combination V_1M_2 which was statistically similar with the treatment combination V_1M_3, V_2M_2 and V_3M_2 where the number of seeds pod^{-1} were 174.91, 176.40 and 178.17, respectively. The minimum number of seeds per pod (156.53) was recorded from the treatment condition V_3M_1 which was statistically similar with the treatment combination V_2M_1 where the number of seeds pod^{-1} was 165.51.

4.2.3 Weight of seed pod^{-1} (g)

Effect of variety

Significant effect was observed on weight of seed pod^{-1} due varietal difference of jute (Figure 14 and Appendix X). The figure indicated that the highest weight of seed pod^{-1} (0.37g) was achieved from the variety V_1 which was statistically similar to the treatment V_3 (0.36g). The lowest weight of seed pod^{-1} (0.32g) was found from variety, V_2.

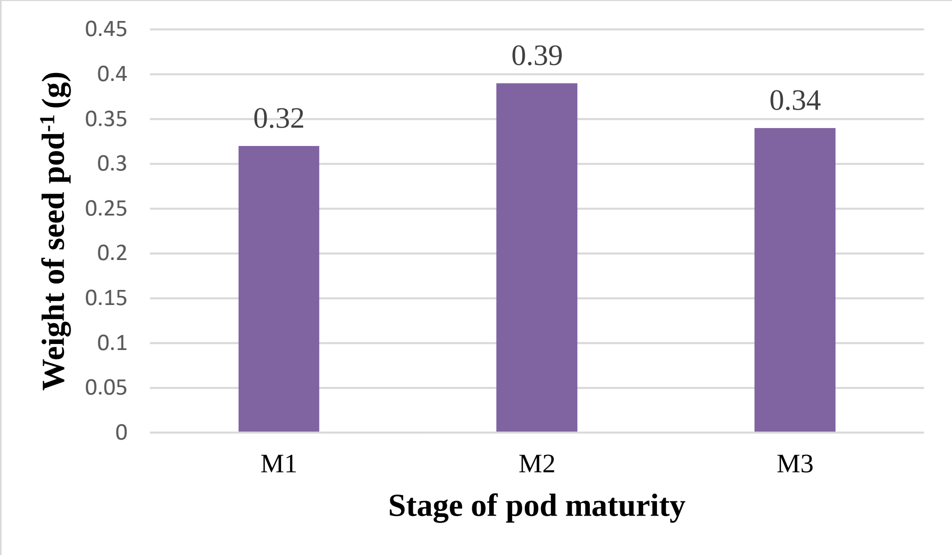


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 14: Effect of variety on weight of seed pod^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.011)

Effect of stage of pod maturity

Weight of seed pod^{-1} exerted significant difference due to stage of pod maturity of jute in late sown condition (Figure 15 and Appendix X). Results indicated that the maximum weight of seed pod^{-1} (0.32 g) was recorded from the treatment M_2 and the minimum weight of seed pod^{-1} (0.32 g) was recorded from the treatment M_1.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 15: Effect of stage of pod maturity on weight of seed pod^{-1} of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.011)

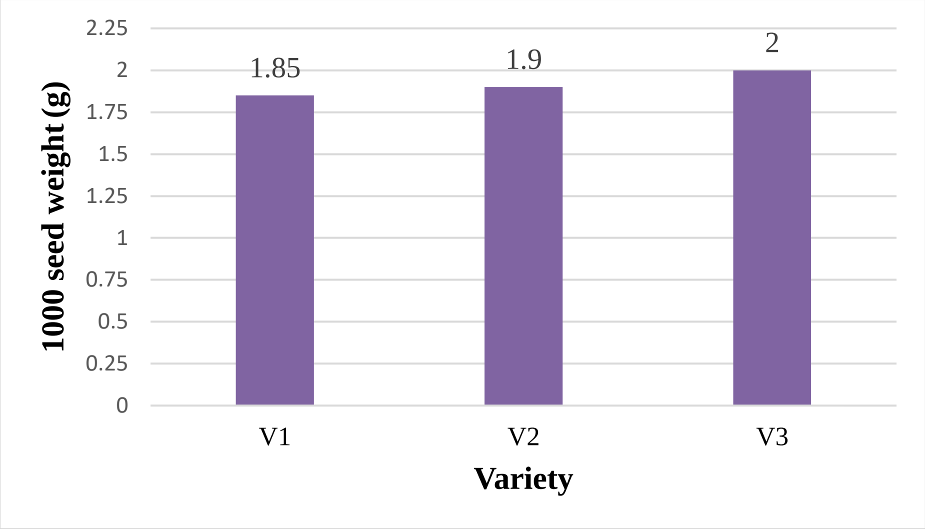
Interaction effect of variety and stage of pod maturity

Significant variation was recorded due to interaction effect of varieties and pod maturity stage on weight of seed pod^{-1} (Table 2 and Appendix X). The result revealed that the highest weight of seed pod^{-1}(0.43 g) was recorded from the treatment combination V_3M_2 which was statistically similar to the treatment combination V_1M_2 (0.41 g). The treatment combination, V_2M_1 gave the lowest number of seed pod^{-1} (0.30 g) which was statistically similar to the treatment combination V_2M_3 (0.32 g) and V_3M_1 (0.32 g).

4.2.4 Weight of 1000 seed (g)

Effect of variety

Weight of 1000 seed was significantly influenced by varietal performance of jute in late sown condition (Figure 16 and Appendix XI). The highest weight of 1000 seed (2.00 g) was achieved from the variety V_3 whereas and the lowest weight of 1000 seed (1.85 g) was found from variety, V_1 which was statistically similar to the variety V_2 (1.90 g).

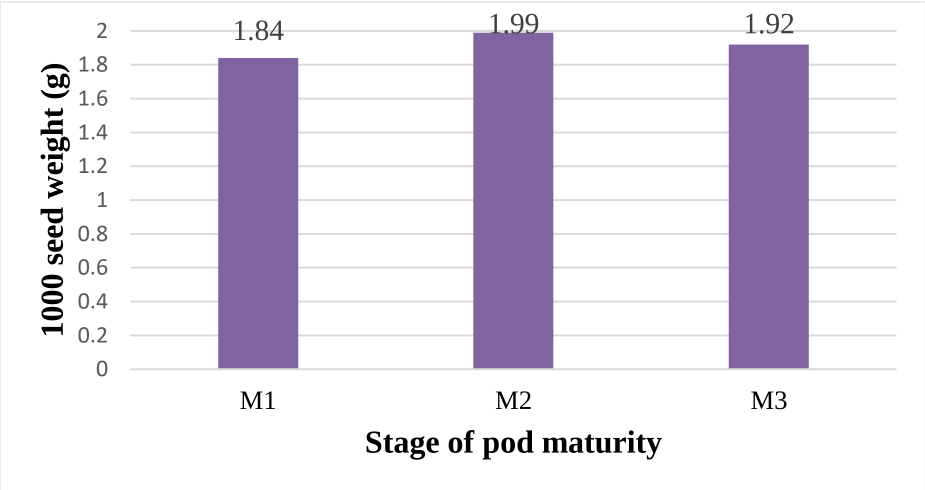


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 16: Effect of variety on 1000 seed weight of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.0821)

Effect of stage of pod maturity

There observed a significant variation on thousand seed weight due to different stage of pod maturity at late sown condition (Figure 17 and Appendix XI). Results revealed that the 1000 seed weight (1.99 g) was recorded from the treatment M_2 which was statistically similar to the treatment M_3 (1.92 g). The lowest 1000 seed weight (1.84 g) was recorded from the treatment M_1 which was statistically similar to the treatment M_3 (1.92 g).



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 17: Effect of stage of pod maturity on 1000 seed weight of jute seed crop in late sown condition ($LSD_{0.05}$ = 0.0821)

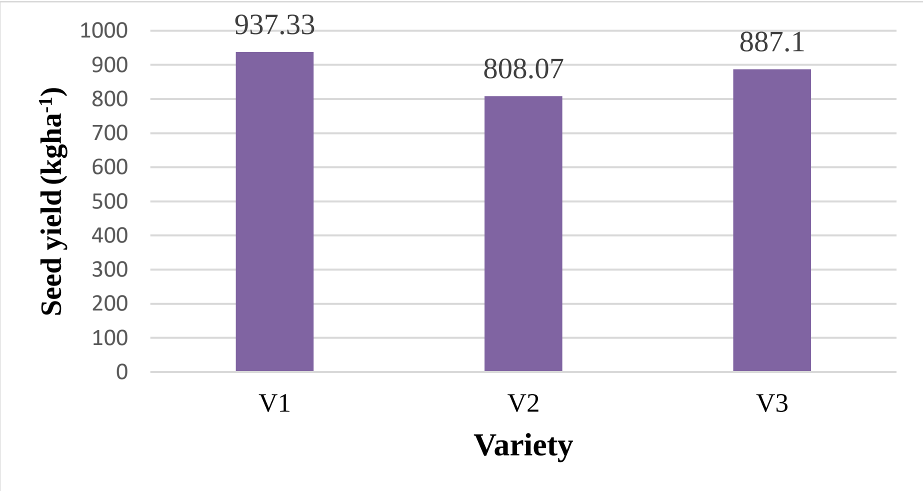
Interaction effect of variety and stage of pod maturity

Interaction effect of varieties and stage of pod maturity exhibited significant variation on 1000 seed weight in late sown jute (Table 2 and Appendix XI). It was revealed that the highest 1000 seed weight (2.15 g) was found from the treatment combination, V_3M_2. The treatment combination, V_1M_1 gave the lowest 1000 seed weight (1.79 g) which was statistically similar to the treatment combination of V_1M_2, V_1M_3, V_2M_1, V_2M_3 and V_3M_3 where the 1000 seed weight was 1.84 g, 1.92 g, 1.80 g, 1.92 g and 1.93 g, respectively.

4.2.5 Seed yield (kg ha^{-1})

Effect of variety

Seed yield (kg ha^{-1}) was significantly influenced by varietal difference in late sown jute (Figure 18 and Appendix XII). It was recorded that the highest seed yield (937.33 kg ha^{-1}) was achieved from the variety V_1 whereas the lowest seed yield (808.07 kg ha^{-1}) was found from variety, V_2. The result revealed that variety V_1 out yield over variety V_2 and V_3 by producing higher seed yield.

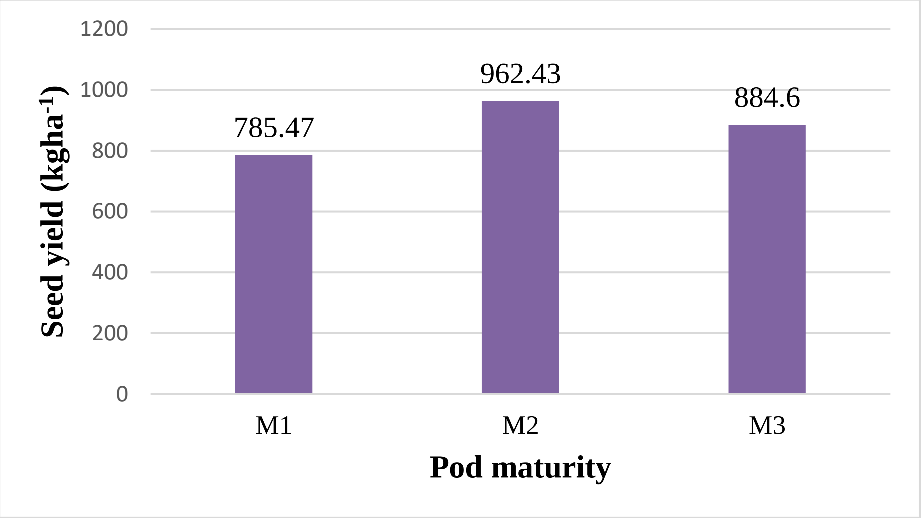


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 18: Effect of variety on seed yield of jute seed crop in late sown condition ($LSD_{0.05}$ = 45.27)

Effect of stage of pod maturity

Significant variation was found in terms of seed yield ha^{-1} due to different pod maturity stage in late sown condition of jute (Figure 19 and Appendix XII). Results indicated that the highest seed yield (962.43 kg ha^{-1}) was recorded from the treatment M_2 and the lowest seed yield (785.47 kg ha^{-1}) was recorded from the treatment M_1. It can be found from the result that crop harvested at 60% pod maturity stage (M_2) was superior in producing higher seed yield over crop harvested at 40% and 80% pod maturity stage. At 40% pod maturity stage, possibility of getting premature or unfilled seed is higher which causes low seed yield. On the contrary, at 80% pod maturity stage, shattering of seed is occurred due to over maturity which contributes low seed yield of jute seed in late sown condition. This finding is in agreement with the result of Hossain (1999).



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 19: Effect of stage of seed maturity on seed yield of jute seed crop in late sown condition ($LSD_{0.05}$ = 45.27)

Interaction effect of variety and stage of pod maturity

Seed yield was recorded due to interaction effect of varieties and pod maturity stage (Table 2 and Appendix XII). It was found from the result that the highest seed yield (1040.80 kg ha^{-1}) was recorded from the treatment combination V_1M_2 which was statistically similar to the treatment combination V_3M_2 (1010.90 kg ha^{-1}). The treatment combination, V_2M_1 gave the lowest seed yield (745.40 kg ha^{-1}).

Table 2. Seed yield and yield contributing characters of jute as influenced by variety and stage of pod maturity in late sown condition of jute

Treatment	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	Weight of seed pod^{-1} (g)	1000 seed weight (g)	Seed yield (kg ha^{-1})
V_1M_1	20.46 de	168.39 bc	0.35 b	1.79 d	840.70 cd
V_1M_2	24.97 a	185.50 a	0.41 a	1.84 cd	1040.80 a
V_1M_3	22.27 bc	174.91 a-c	0.37 b	1.92 b-d	930.50 b
V_2 M_1	17.15 f	165.51 cd	0.30 c	1.80 cd	745.40 e
V_2 M_2	21.73 b-d	176.40 a-c	0.35 b	1.99 b	835.60 cd
V_2 M_3	19.53 e	170.12 bc	0.32 c	1.92 b-d	843.20 cd
V_3 M_1	19.33 e	156.53 d	0.32 c	1.94 bc	770.30 de
V_3 M_2	22.97 b	178.17 ab	0.43 a	2.15 a	1010.90 a
V_3 M_3	20.97 c-e	168.56 bc	0.35 b	1.93 b-d	880.10 bc
LSD (0.05)	**1.67**	**11.13**	**0.0203**	**0.1423**	**78.40**
CV (%)	**9.23**	**3.75**	**3.30**	**4.28**	**5.08**

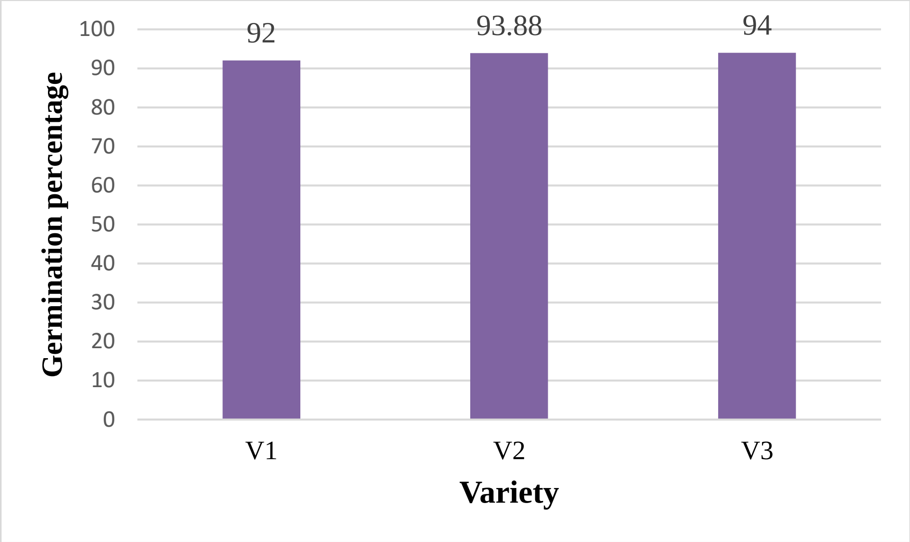
Here, V_1 = O-9897, V_2 = O-795 (BJRI Tossa Pat-5), V_3 = O-3820 (BJRI Tossa Pat-6)
M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

4.3 Quality attributes

4.3.1 Germination percentage (%)

Effect of variety

Seed germination was influenced by different varieties (Figure 20 and Appendix XIII). It was found that the highest percent of seed germination (94.00) was found from the seeds produced from V_3 variety which was statistically similar to the variety V_2 where germination percentage was 93.88. The lowest percent seed germination (92.00) was found from the variety, V_1.

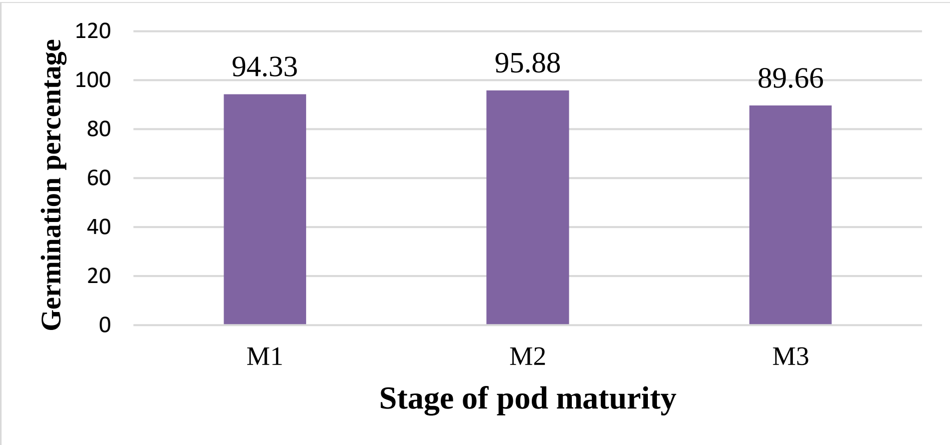


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 20: Effect of variety on germination percentage of jute seed in late sown condition ($LSD_{0.05}$ = 1.725)

Effect of stage of pod maturity

Effect of stage of pod maturity exerted significant variation on seed germination of jute in late sown condition (Figure 21 and Appendix XIII). Results indicated that the highest percent of seed germination (95.88) was recorded from seeds of treatment M_2 which was similar to the treatment M_1 whereas, the lowest percent of seed germination (89.66) was recorded from the seeds of treatment M_3. The present result confirmed with those of Bhattacharjee *et.al.* (2000) who observed the germination of 55-65% matured jute seed at maximum level. This is agreement with Islam (2019)



M_1 = When about 40% pods of the plant are brown, M_2 = When about 60% pods of the plant are brown, M_3 = When about 80% pods of the plant are brown

Figure 21: Effect of stage of pod maturity on germination percentage of jute seed in late sown condition ($LSD_{0.05}$ = 1.725)

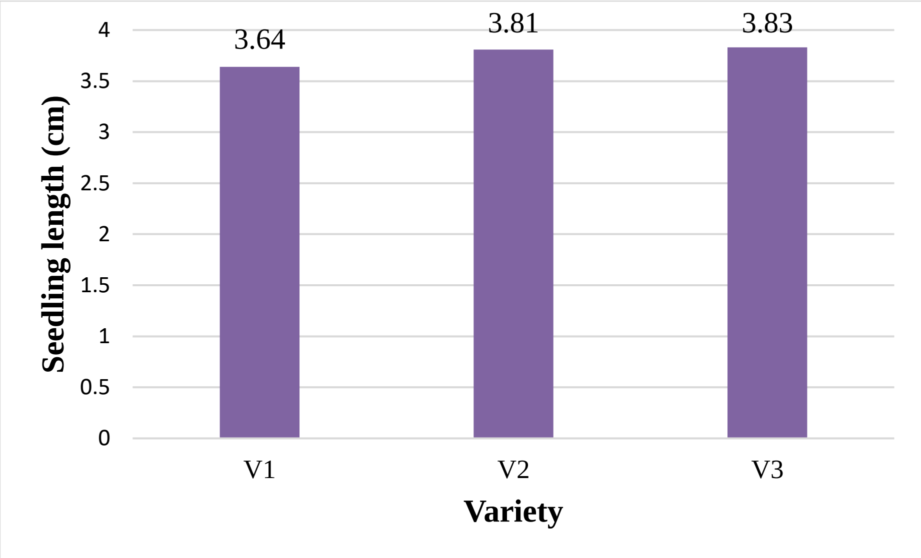
Interaction effect of variety and stage of pod maturity

Significant variation was recorded on percent of seed germination due to interaction effect of varieties and pod maturity stage in late sown condition (Table 3 and Appendix XIII). It was found that the highest percent of seed germination (97.00) was recorded from the seeds of treatment combination V_2M_2 which was statistically to V_2M_1 (96.00%), V_3M_2 (96.00%), V_1M_2 (94.66%) and V_3M_1 (94.66%). The lowest percent of seed germination (88.66) was found from the seeds of treatment combination V_2M_3 which was statistically similar to the treatment combination of V_1M_3 (89.00%) and V_3M_3 (91.33%).

4.3.2 Seedling length

Effect of variety

Seedling length was non-significantly affected by the different varieties of jute seed in late sown condition (Figure 22 and Appendix XIV). However, numerically the highest seedling length (3.83cm) was found from variety, V_3 and the lowest value (3.64cm) was recorded from V_2 variety.

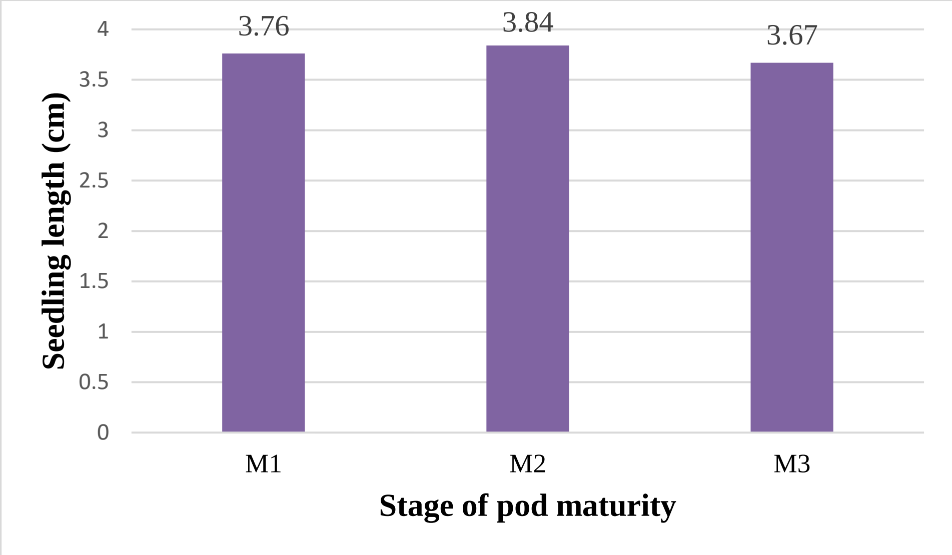


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 22: Effect of variety on seedling length of jute seed in late sown condition ($LSD_{0.05}$ = 0.2089^{NS})

Effect of stage of pod maturity

Seedling length did not differ significantly due to stages of pod maturity of jute in late sown condition (Figure 23 and Appendix XIV). The maximum seedling length (3.84cm) was recorded from the seeds achieved from M_2 and that of the lowest was recorded from M_3 (3.67cm).



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 23: Effect of stage of seed maturity on seedling length of jute seed in late sown condition ($LSD_{0.05}$ = 0.2089^{NS})

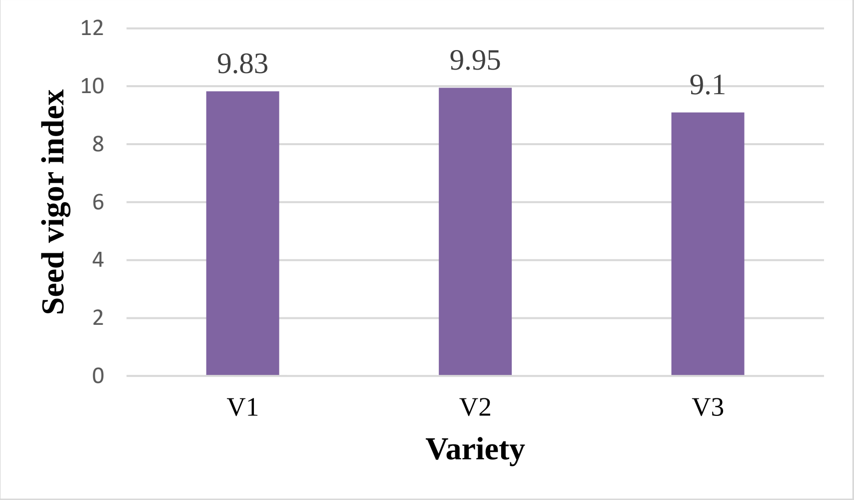
Interaction effect of variety and stage of pod maturity

The significant variation was found due to interaction effect of varieties and pod maturity stage in late sown condition of jute (Table 3 and Appendix XIV). The maximum seedling length (4.02 cm) was recorded from the seeds achieved from the treatment combination of V_1M_3 which was statistically similar to the treatment combination V_1M_1 (3.96 cm), V_2M_1 (3.68 cm), V_2M_3 (3.72 cm), V_3M_1 (3.93 cm), V_3M_2 (3.85 cm) and V_3M_3 (3.71 cm). Reversely, the minimum seedling length (3.58 cm) was found from seeds that were obtained from the treatment combination of V_1M_3 which was statistically similar to all the treatments except V_2M_2 (4.02 cm).

4.3.3 Seed vigor index

Effect of variety

Seed vigor index is an important factor for successful crop production. Under the present study, seed vigor index influenced significantly by different variety (Figure 24 and Appendix XV). The maximum seed vigor index (9.95) was recorded from V_2 which was identical to the variety V_1 (9.83) whereas the minimum seed vigor index (9.10) was found from the seeds produced by variety, V_3.

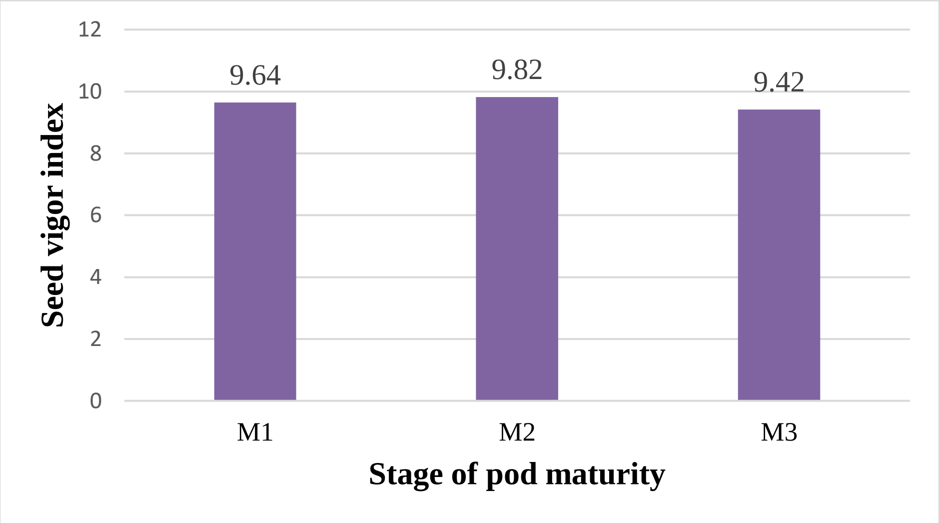


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 24: Effect of variety on seed vigor index of jute seed in late sown condition ($LSD_{0.05}$ = 0.3685)

Effect of stage of pod maturity

Vigor index of jute seed affected significantly by the different pod maturity stage of jute in late sown condition (Figure 25 and Appendix XV). The maximum seed vigor index (9.82) was recorded from the seeds achieved from treatment M_2 which was statistically similar to the treatment M_1 (9.64). The minimum seed vigor index (9.42) was measured from the seeds obtained from treatment M_3.



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 25: Effect of stage of seed maturity on seed vigor index of jute seed in late sown condition ($LSD_{0.05}$ = 0.3685)

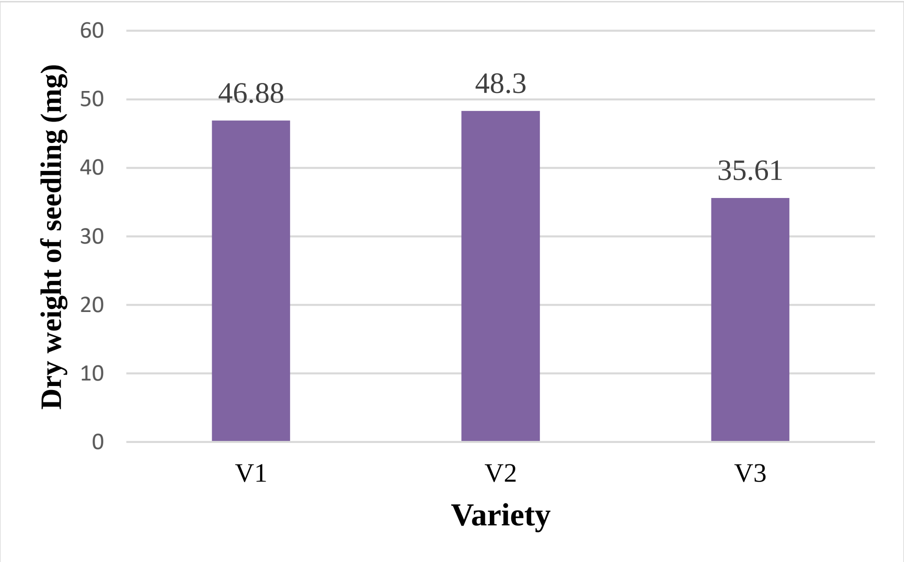
Interaction effect of variety and stage of pod maturity

The seeds obtained from the different treatment combination of varieties and seed maturity stage in late sown condition showed significant variation on seed vigor index of jute (Table 3 and Appendix XV). The maximum seed vigor index (10.26) was recorded from seeds achieved from the treatment combination, V_2M_2 which was statistically similar to the treatment combination V_1M_2 (10.03), V_2M_1 (9.92), V_1M_1 (9.76), V_1M_3 (9.70) and V_2M_3 (9.66) whereas the minimum seed vigor index (8.90) was achieved from the seeds obtained from the treatment combination V_3M_3 which was statistically similar to V_3M_1 (9.23) and V_3M_2 (9.16) treatment combination. This is in agreement with Islam (2019).

4.3.4 Dry weight of seedling

Effect of variety

Dry weight of seedling was affected significantly due to jute varieties (Figure 26 and Appendix XVI). The maximum dry weight of seedling (48.30 mg) was recorded from V_2 variety which was statistically similar to the variety V_1 where the value of dry weight of seedling was 46.88 mg. The minimum dry weight of seedling (35.61 mg) was found from the seeds produced by variety, V_3.

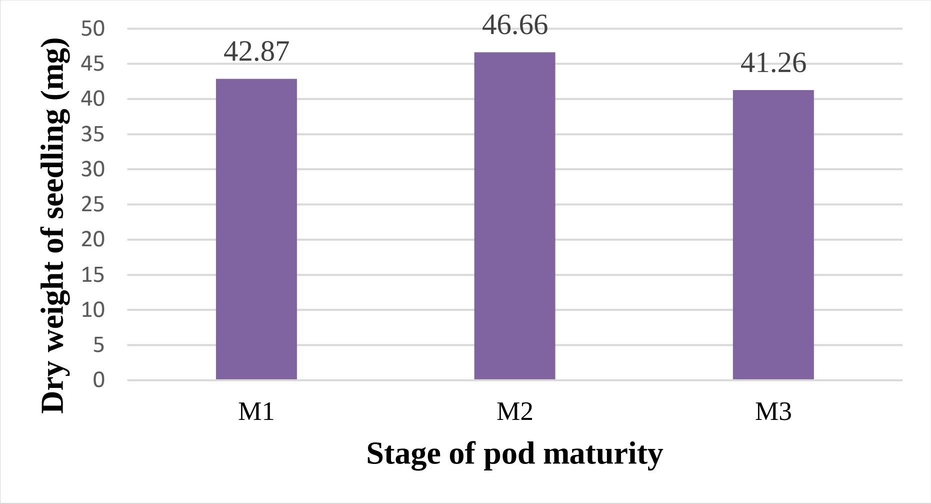


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 26: Effect of variety on dry weight of seedling of jute seed in late sown condition ($LSD_{0.05}$ = 3.53)

Effect of stage of pod maturity

Dry weight of seedling of jute exerted significant difference due to pod maturity stage in late sown condition (Figure 27 and Appendix XVI). The maximum dry weight of seedling (4.66 mg) was recorded from the seeds obtained from M_2 seed maturity stage, while the minimum dry weight of seedling (41.26 mg) was recorded from the seeds of M_3 treatment which was statistically similar to the treatment M_1 (42.87 mg).



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 27: Effect of stage of pod maturity on dry weight of seedling of jute seed in late sown condition ($LSD_{0.05}$ = 3.53)

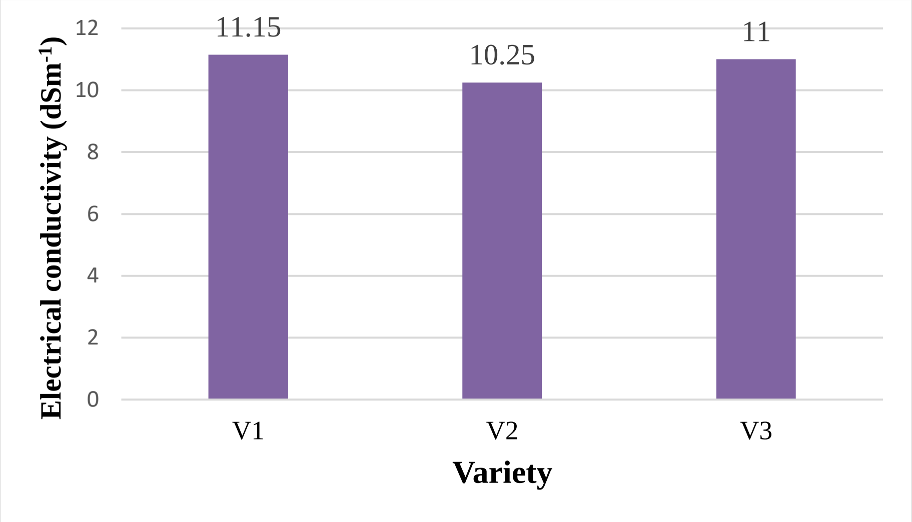
Interaction effect of variety and stage of pod maturity

Interaction effect of variety and stage of pod maturity had significant variation in dry weight of seedling of jute in late sown condition (Table 3 and Appendix XVI). The maximum dry weight of seedling (51.28 mg) was recorded from seeds obtained from the treatment combination, V_2M_2 which was statistically similar to V_1M_1 (45.46 mg), V_1M_2 (50.32 mg), V_2M_1 (48.03 mg) and V_2M_3 (45.59 mg) whereas the minimum dry weight of seedling (33.34 mg) was recorded from the seeds obtained from the treatment combination, V_3M_1 (35.12 mg) and V_3M_3 (33.34 mg).

4.3.5 Electrical conductivity

Effect of variety

Electrical conductivity test had also been applied to detect the difference among the seeds of jute variety in late sown condition. Effect of variety on electrical conductivity was found to be statistically non- significant (Fig. 28 and Appendix XVII). The highest electrical conductivity (11.15 dSm^{-1}) was recorded from variety, V_1 which was followed by the variety V_3 (11.00 dSm^{-1}) and V_2 (10.25 dSm^{-1}).

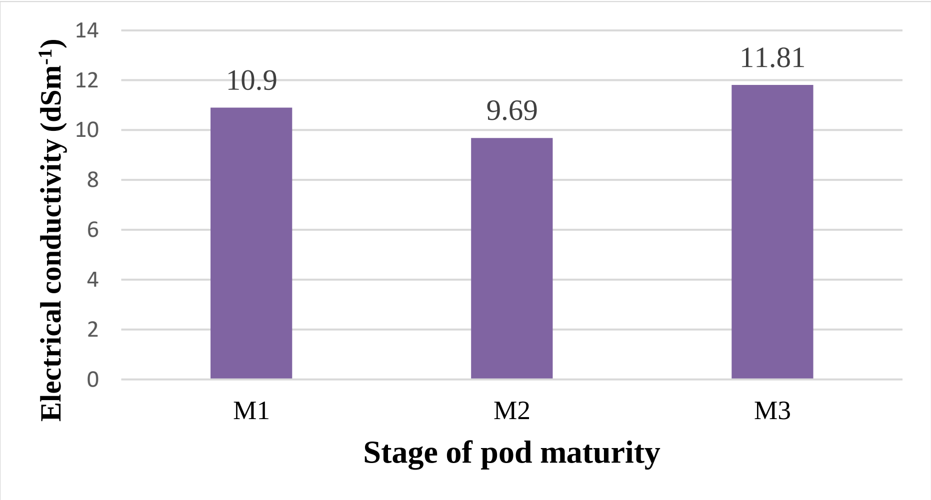


V_1 = O-9897, V_2 = BJRI Tossa Pat-5, V_3 = BJRI Tossa Pat-6

Figure 28: Effect of variety on electrical conductivity of jute seed in late sown condition ($LSD_{0.05}$ = 1.468^{NS})

Effect of stage of pod maturity

Effect of stage of pod maturity on electrical conductivity of jute seed was observed statistically significant at different pod maturity stages in late sown condition (Fig. 29 and Appendix XVII). The highest electrical conductivity was recorded (11.81 dSm^{-1}) from M_3 treatment, which was statistically similar to the treatment M_1 (10.90 dSm^{-1}) while the lowest electrical conductivity (9.69 dSm^{-1}) was measured from M_2 treatment, which was also statistically similar to the treatment M_1 (10.90 dSm^{-1}).



M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

Figure 29: Effect of stage of pod maturity on electrical conductivity of jute seed in late sown condition ($LSD_{0.05}$ = (1.468)

Interaction effect of variety and stage of pod maturity

Interaction effect of variety and pod maturity stage at late sown condition had significant differences on electrical conductivity of jute seed (Table 3 and Appendix XVII). The highest electrical conductivity (12.37mg) was recorded from V_3M_3 treatment combination which was statistically similar to V_1M_1, V_1M_2, V_1M_3, V_2M_1, V_2M_3 and V_3M_1 when electrical conductivity was 11.60 dSm^{-1}, 9.86 dSm^{-1}, 12.00 dSm^{-1}, 10.07 dSm^{-1}, 11.07 dSm^{-1} and 11.03 dSm^{-1}, respectively. The lowest electrical conductivity was recorded from V_3M_2 treatment combination which was statistically similar to V_2M_2, V_1M_1, V_1M_2, V_1M_3, V_2M_1, V_2M_3 and V_3M_1 when electrical conductivity were 9.63 dSm^{-1}, 11.60 dSm^{-1}, 9.86 dSm^{-1}, 12.00 dSm^{-1}, 10.07 dSm^{-1}, 11.07 dSm^{-1} and 11.03 dSm^{-1}, respectively.

Table 3. Quality attributes of jute seed as influenced by variety and stage of pod maturity in late sown condition

Treatment	Germination percentage	Seedling length (cm)	Vigor index (%)	Oven dry weight of seedling (mg)	Electrical conductivity (ds m^{-1})
V_1M_1	92.33 bc	3.69 ab	9.76 ab	45.46 ab	11.60 ab
V_1M_2	94.66 ab	3.65 b	10.03 a	50.32 ab	9.86 ab
V_1M_3	89.00 d	3.58 b	9.70 ab	44.86 b	12.00 ab
V_2 M_1	96.00 a	3.68 ab	9.92 a	48.03 ab	10.07 ab
V_2 M_2	97.00 a	4.02 a	10.26 a	51.28 a	9.63 b
V_2 M_3	88.66 d	3.72 ab	9.66 ab	45.59 ab	11.07 ab
V_3 M_1	94.66 ab	3.93 ab	9.23 bc	35.12 c	11.03 ab
V_3 M_2	96.00 a	3.85 ab	9.16 bc	38.38 c	9.60 b
V_3 M_3	91.33 cd	3.71 ab	8.90 c	33.34 c	12.37 a
LSD $_{(0.05)}$	**2.988**	**0.3618**	**0.6328**	**6.10**	**2.543**
CV (%)	**1.85**	**5.56**	**3.83**	**8.10**	**13.60**

Here, V_1 = O-9897, V_2 = O-795 (BJRI Tossa Pat-5), V_3 = O-3820 (BJRI Tossa Pat-6)

M_1 = About 40% pods of the plant become brown, M_2 = About 60% pods of the plant become brown, M_3 = About 80% pods of the plant become brown

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

A field experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from August 2017 to December 2017 to determine the yield and quality of jute seed as influenced by variety and stage of pod maturity in late sown condition. Harvest of different pods completed within December, 2017 but seed processing and yield results were obtained in January, 2018. The experiment consisted of two factors viz. three jute varieties and stage of pod maturity. Three varieties namely V_1 (O-9897), V_2 (BJRI Tossa Pat-5) and V_3 (BJRI Tossa Pat-6); and three stage of pod maturity as M_1 (when about 40% pods of the plants are brown), M_2 (when about 60% pods of the plants are brown) and M_3 (when about 80% pods of the plants are brown) were used under the present study. The experiment consisting of 9 treatment combinations those were laid out in a Randomized complete Block Design RCBD (factorial) with three replications. The size of each unit plot was 6 m^2 (3m×2m). The plants were randomly selected from each plot to record data on the growth parameters, yield attributes and yield of plants. Seed quality test was also done from seeds of different treatments. The collected data were statistically analyzed and the results of this experiment have been summarized. In most cases variety of jute, different seed maturity stage and their combination showed significant influence on yield contributing parameters, yield and seed quality attributes.

Both significant and non-significant variation were recorded in case of pheonological character of jute seed. It was found that the highest plant height (163 cm) and maximum number of branch plant^{-1} (2.61) were recorded from the variety V_1 (O-9897). The lowest plant height (146.43 cm) and minimum number of branch plant^{-1} (2.03) were found from the variety V_3 (BJRI Tossa Pat-6). But non-significant variation was found from pod length and pod diameter in terms of variety. The highest pod length (6.46 cm) and the highest pod diameter (5.66 mm) were found from M_2 stage (60% pods of the plants were brown). Likewise, the lowest pod length (5.84 cm) was found from M_3 stage (80% pods of the plants were brown) and the lowest pod diameter (5.66 mm) was found from M_1 stage (40% pods of the plants were brown). Non-significant variation was found from plant height and branch plant^{-1}. In case of the combination of both variety and pod maturity stage in late sown condition, the highest plant height (166.15 cm) was found from the treatment combination, V_1M_3, maximum number of branch plant^{-1} (3.08) was found from V_1M_1 treatment, the highest pod length (6.90 cm) was recorded from the treatment combination, V_3 M_2 and the highest pod diameter (5.87 mm) was found from V_1M_2 treatment. Likewise, the lowest plant height (136.13 cm) and the lowest number of branch plant^{-1} (1.76) were found from the treatment combination, V_3M_1. The lowest pod length (5.79 cm) was found from V_3M_3 treatment and the lowest pod diameter (5.04 mm) was found from V_2M_1 treatment.

In case of yield attributes and yield contributing parameter, significant variation was found in each parameter. Among the variety, the highest number of pod plant^{-1} (22.57), the highest number of seed pod^{-1} (176.27), the highest weight of seed pod^{-1} (0.37g) and the highest seed yield (937.33 kgha^{-1}) were found from V_1 (O-9897) variety. Maximum weight of thousand seed (2.00 g) was found from V_3 (BJRI Tossa Pat-6) variety. The lowest number of pod plant^{-1} (19.47), minimum weight of seed pod^{-1} (0.32 g) and the lowest seed yield (808.07 kgha^{-1}) was found from the variety V_2 (BJRI Tossa Pat-5). Minimum number of seed pod^{-1} (167.75) was found from V_3 (BJRI Tossa Pat-6) variety and minimum weight of thousand seed (1.85 g) was found from V_1 (O-9897) variety. Among the maturity stage, the highest number of pod plant^{-1} (23.22), the highest number of seed pod^{-1} (180.02), the highest weight of seed pod^{-1} (0.39 g), maximum weight of thousand seed (1.99 g) and maximum seed yield (962.43 kgha^{-1}) were found from M_2 (when 60% pods of the plant are brown) stage. The lowest number of pod plant^{-1} (18.98), the lowest number of seed pod^{-1} (163.48), the lowest weight of seed pod^{-1} (0.32 g), minimum weight of thousand seed (1.84 g) and minimum seed yield (785.47 kgha^{-1}) was found from M_1 (when 40% pods of the plant are brown) stage. Data were collected among the combined effect of variety and stage of seed maturity in late sown condition. The highest number of pod plant^{-1} (24.97), the highest number of seed pod^{-1} (185.50) and the highest seed yield (1040.80 kgha^{-1}) were found from the treatment combination, V_1M_2 and the highest weight of seed pod^{-1} (0.43 g) and maximum thousand seed weight (2.15 g) was found from the combination, V_3M_2. The lowest number of pod plant^{-1} (19.33) and the lowest number of seed pod^{-1} (156.53) were found from the treatment combination, V_3M_1. Again, minimum weight of seed pod^{-1} (0.30 g) and minimum seed yield (745.40

kgha^{-1}) were obtained from V_2M_1 treatment combination and minimum weight of thousand seed (1.79 g) was found from treatment combination, V_1M_1.

Seed yield and seed quality obtained from different treatments had significant and non-significant effect on quality parameter of jute seed in late sown condition. In terms of varietal performance, the highest seed germination (94.00%) was found from V_3 (BJRI Tossa Pat-6) variety. The highest vigor index (9.95) and the highest oven dry weight of seedling (48.30 mg) were found from the variety V_2 (BJRI Tossa Pat-5). The lowest seed germination (92.00%) was found from the variety V_1 (O-9897) where the lowest vigor index (9.10) and minimum dry weight of seedling (35.61mg) were found from the variety V_3 (BJRI Tossa Pat-6). Non-significant variation was found between seedling length and electrical conductivity in terms of variety. Considering stage of pod maturity, seeds obtained from the treatment, M_2 (60% brown colored pod), showed the highest seed germination (95.88%), the highest seedling length (3.84cm), the highest vigor index (9.82) and maximum oven dry weight of seedling (46.66 mg). M_3 stage (80% brown colored pod) showed the lowest seed germination (89.66%), the lowest seedling length (3.67 cm), the lowest vigor index (9.42) and minimum oven dry weight of seedling. The highest electrical conductivity (11.81 dSm^{-1}) was found from the M_3 (80% brown colored pod) stage where the lowest electrical conductivity (9.69 dSm^{-1}) was found from M_2 stage. In case of seeds produced from different combined treatment of variety and stage of pod maturity, the highest seed germination (97%), the highest seedling length (4.02 cm), the highest vigor index (10.26) and highest oven dry weight of seedling (51.28 mg) was identified from the treatment combination, V_2M_2 where the highest electrical conductivity (12.37 dSm^{-1}) was found from V_3M_3 treatment combination. The lowest vigor index (8.90) and the lowest oven dry weight of seedling (33.34 mg) was identified from the treatment combination, V_3M_3. The lowest seed germination (88.66%) was found from V_2M_3, the lowest seedling length (3.58 cm) was found from V_1M_3 and lowest electrical conductivity was found from V_3M_2 treatment.

5.2 Conclusion

From the above findings the following conclusion could be made:

- V_1 (O-9897) variety showed the best performance in respect of yield contributing parameters and yield in late sown condition.

- V_2 (BJRI Tossa Pat-5) variety showed the best performance in respect of quality contributing parameters in late sown condition.
- Pod maturity stage M_2 (when 60% pods of the plants were brown) gave the best results regarding yield, yield contributing parameters and seed quality in late sowing.
- Variety V_1 (O-9897) along with M_2 (60% pod maturity stage) showed the best results considering yield contributing parameters and yield at late sown condition.
- Variety V_2 (BJRI Tossa Pat-5) along with M_2 (60% pod maturity stage) showed the best results regarding seed quality at late sown condition.

5.3 Recommendation

This was a single year and single location experiment. So, for wider validity of the result, the following recommendation could be made:

- Further study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
- Other cultivars or varieties may be studied in the further program with more treatments.

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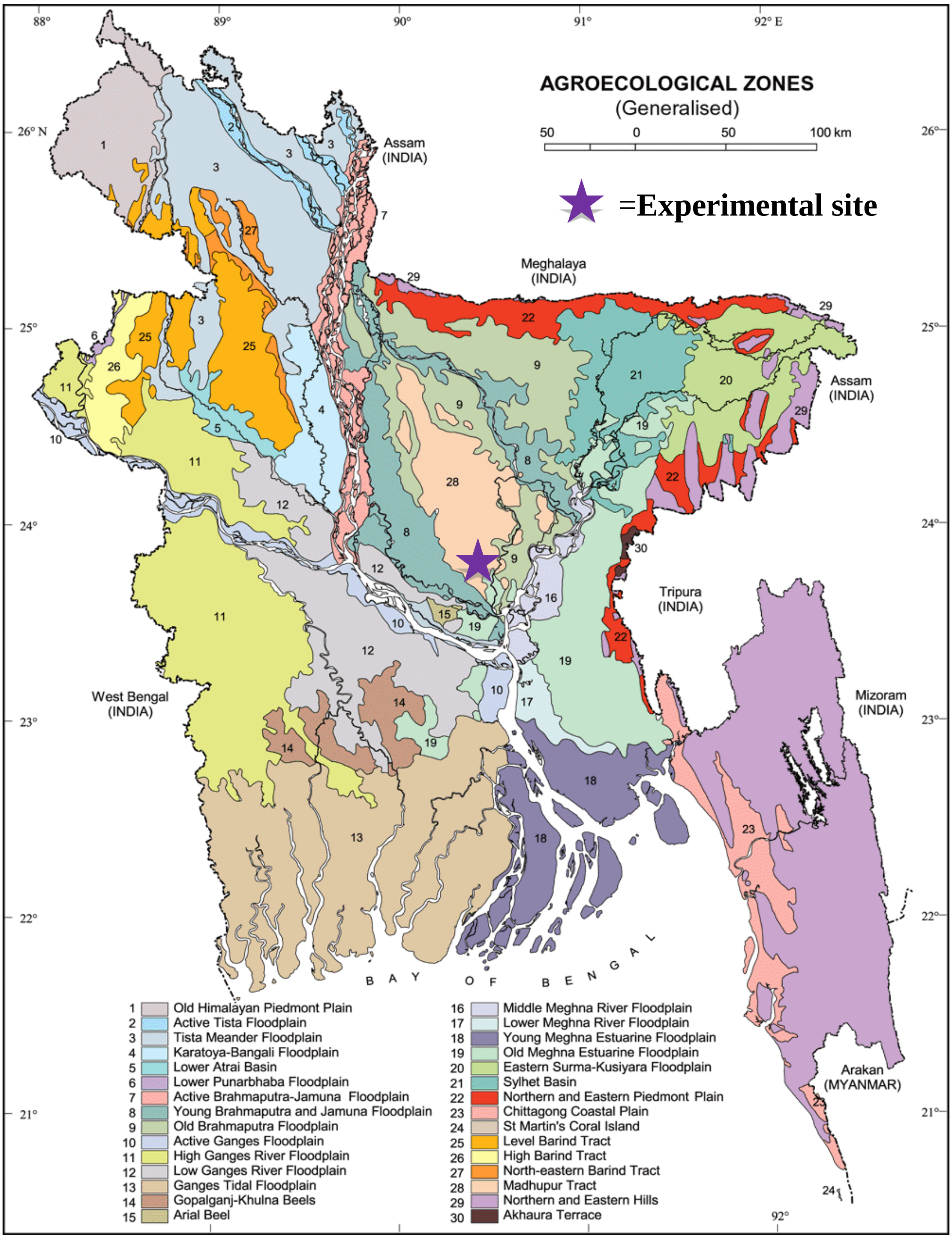
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological zones of Bangladesh



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of soil of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood leveled
Drainage	Well drained
Cropping pattern	Not applicable

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	27
Silt	43
Clay	30
Textural class	Silty Clay Loam (ISSS)
Chemical characteristics	
Soil characters	**Value**
pH	5.8
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.01
Available S (ppm)	45
CEC meq/100g soil	2.64

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix III. Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from July 2017 to December 2017.

Month	Air temperature (°C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
July,17	31.8	26.3	83	375.5
August,17	32.1	26.4	82	292.9
September,17	32	25.9	83	340.0
October,17	29.18	18.26	78	174.5
November,17	25.82	16.04	73	31.1
December,17	22.4	13.5	73	12.1

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka

Appendix IV. Mean Square Values of the data on plant height (cm) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of plant height (cm)
Replication	2	138.954
Factor A (Variety)	2	657.744**
Factor B (Seed maturity)	2	207.351^{NS}
Interaction (A×B)	4	71.603*
Error	16	121.442

**: Significant at 1% level of significance *: Significant at 5% level of significance
^{NS}: Non-significant

Appendix V. Mean Square Values of the data on number of branch plant^{-1} of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of branches plant^{-1} (no.)
Replication	2	0.34224
Factor A (Variety)	2	0.76756**
Factor B (Seed maturity)	2	0.0665^{NS}
Interaction (A×B)	4	0.37054*
Error	16	0.08327

**: Significant at 1% level of significance *: Significant at 5% level of significance
^{NS}: Non-significant

Appendix VI. Mean Square Values of the data on pod length (cm) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of pod length (cm)
Replication	2	0.29449
Factor A (Variety)	2	0.11218^{NS}
Factor B (Seed maturity)	2	0.86669**
Interaction (A×B)	4	0.20497*
Error	16	0.1041

**: Significant at 1% level of significance   *: Significant at 5% level of significance
^{NS}: Non-significant

Appendix VII. Mean Square Values of the data on pod diameter (mm) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of pod diameter (mm)
Replication	2	0.10588
Factor A (Variety)	2	0.36003^{NS}
Factor B (Seed maturity)	2	0.47204*
Interaction (A×B)	4	0.05894*
Error	16	0.18406

*: Significant at 5% level of significance
^{NS}: Non-significant

Appendix VIII. Mean Square Values of the data on number of pod plant^{-1} of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of pods plant^{-1} (no.)
Replication	2	19.5431
Factor A (Variety)	2	21.6525**
Factor B (Seed maturity)	2	40.565**
Interaction (A×B)	4	0.275*
Error	16	0.9376

**: Significant at 1% level of significance   *: Significant at 5% level of significance

Appendix IX. Mean Square Values of the data on number of seed pod^{-1} of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of seed pod^{-1} (no.)
Replication	2	174.063
Factor A (Variety)	2	108.317*
Factor B (Seed maturity)	2	612.166**
Interaction (A×B)	4	24.674*
Error	16	41.941

**: Significant at 1% level of significance   *: Significant at 5% level of significance

Appendix X. Mean Square Values of the data on weight of seed pod^{-1} (g) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of weight of seed pod^{-1} (g)
Replication	2	0.0027
Factor A (Variety)	2	0.00723**
Factor B (Seed maturity)	2	0.01263**
Interaction (A×B)	4	0.00088**
Error	16	0.00014

**: Significant at 1% level of significance

Appendix XI. Mean Square Values of the data on 1000 seed weight (g) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of 1000 seed weight (g)
Replication	2	0.00225
Factor A (Variety)	2	0.05694**
Factor B (Seed maturity)	2	0.04769**
Interaction (A×B)	4	0.01797*
Error	16	0.00676

**: Significant at 1% level of significance   *: Significant at 5% level of significance

Appendix XII. Mean Square Values of the data on seed yield (kgha^{-1}) of jute seed crop as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of seed yield (kgha^{-1})
Replication	2	50904
Factor A (Variety)	2	253000**
Factor B (Seed maturity)	2	445606**
Interaction (A×B)	4	39531**
Error	16	12487

**: Significant at 1% level of significance

Appendix XIII. Mean Square Values of the data on seed germination percentage of jute seed as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of seed germination percentage
Replication	2	43.8148
Factor A (Variety)	2	11.3704**
Factor B (Seed maturity)	2	94.3704**
Interaction (A×B)	4	4.7037*
Error	16	2.9815

**: Significant at 1% level of significance *: Significant at 5% level of significance

Appendix XIV. Mean Square Values of the data on seedling length (cm) of jute as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of seedling length (cm)
Replication	2	0.21714
Factor A (Variety)	2	0.0981^{NS}
Factor B (Seed maturity)	2	0.06523*
Interaction (A×B)	4	0.04318*
Error	16	0.04369

*: Significant at 5% level of significance
^{NS}: Non-significant

Appendix XV. Mean Square Values of the data on vigor index of jute seed as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of vigor index
Replication	2	1.4606
Factor A (Variety)	2	1.91406**
Factor B (Seed maturity)	2	0.36095*
Interaction (A×B)	4	0.04895*
Error	16	0.13594

**: Significant at 1% level of significance *: Significant at 5% level of significance

Appendix XVI. Mean Square Values of the data on dry weight of seedling (mg) of jute as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of dry weight of seedling (mg)
Replication	2	84.122
Factor A (Variety)	2	375.244**
Factor B (Seed maturity)	2	66.31**
Interaction (A×B)	4	1.246*
Error	16	12.483

**: Significant at 1% level of significance *: Significant at 5% level of significance

Appendix XVII. Mean Square Values of the data on electrical conductivity (dSm^{-1}) of jute as influenced by interaction effect of variety and stage of pod maturity in late sown condition.

Source of variation	Degrees of freedom	Mean square of electrical conductivity (dSm^{-1})
Replication	2	0.3308
Factor A (Variety)	2	2.0771^{NS}
Factor B (Seed maturity)	2	10.1216**
Interaction (A×B)	4	0.5632*
Error	16	2.1587

**: Significant at 1% level of significance *: Significant at 5% level of significance
^{NS}: Non-significant
