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Research Article

YIELD AND QUALITY OF KENAF SEED AS INFLUENCED BY DE-TOPPING AND SPACING UNDER TRANSPLANTING METHOD

A.F. Mollah[1*], M.M. Rahman[2], M.Z. Tareq[1], M.M. Hasan[3] and A.B.M.Z. Hoque[4]

[1]Bangladesh Jute Research Institute, Regional Station, Rangpur, Bangladesh
[2]Department of Agronomy, BAU, Mymensingh, Bangladesh
[3]Adaptive Research Division, BRRI, Gazipur, Bangladesh
[4]Genetic Resource and Seed Division, BJRI, Dhaka, Bangladesh

*Corresponding author's email: mollahabulfazal@yahoo.com

Abstract

An experiment was conducted at the Bangladesh Jute Research Institute (BJRI), Regional Station, Kishoreganj, Bangladesh during July to December 2010 and 2011 to study the effect of spacing and time of de-topping on yield and quality of kenaf seed cv. HC-95 grown under transplanting method. The experiment comprised three plant spacing (viz., 40 cm × 15 cm, 30 cm × 15 cm and 20 cm × 15 cm) and five de-topping (viz., no de-topping, de-topping at transplanting, de-topping at 15, 30 and 45 days after transplanting (DAT) in a Randomized Complete Block Design (RCBD) with three replications. The highest yield of kenaf seed was obtained from planting at 30 cm × 15 cm spacing. The best quality seed in respect to germination and vigour was also obtained from transplanting at 30 cm × 15 cm spacing. The highest seed yield, germination and vigour of seed were obtained for de-topped at 30 DAT. The study concludes that late season kenaf produces highest seed yield with best quality when planted at 30 cm x 15 cm spacing and for de-topping at 30 DAT.

Key words: Kenaf; de-topping; plant spacing and yield; branching; germination; vigour

Introduction

Kenaf (*Hibiscus cannabinus* L.) is a fibre crop belonging to the family Malvaceae. At present, around 0.08- 0.09 million tons of kenaf is produced in the country from 0.04 million hectares of land (Mostofa, 2012) which required 480 tons of seed. Government and other seed producing organizations in the country are not able to meet up the requirement. Therefore, the shortage of supply of quality seed in planting time hinders the production and expansion of this crop. Hence, the production of quality kenaf seed in the country is very much essential to meet the increasing demand and expand this valuable crop. Kenaf is highly profitable crop in Bangladesh. It can give very high yield and cultivation is profitable than jute because it can be produced with lower cost and minimal management practices. The prices of jute and kenaf fibres are almost same, and as consequence, kenaf is expanded to huge areas in char and marginal land of the country. It has multiple uses and its demand is increasing. This can be used as good source of fibre, fuel and it has substantial impact in alleviating environmental degradation.

Kenaf is a new fibre crop in Bangladesh and the farmers are not acquainted with the seed production technology of this crop. Farmers of Bangladesh are conventionally growing seed and fibre from the same crop. For this, the crop is sown in March-April and the seed is harvested in November - December. The seed produced from this crop is of low quality and quantity. The research report on seed production technology is highly scarce. Kenaf is a short day plant like jute. Therefore, there is a possibility of producing kenaf seed by sowing the crop during July to September as like as late jute seed production technology. Late jute seed production is done using three different methods of planting such as direct seeding, seedling transplanting and top cutting. Transplanting methods could be followed in kenaf. The crop is planted at 30 cm × 10 cm for fibre production (Bukenya-Ziraba, 2004) but the optimal spacing for seed production has not yet been determined. Kenaf is an indeterminate crop, de-topping may have influence on branching and pod formation. Pinching is the removal of the apical bud to release the lower auxiliary buds from apical dominance in order to increase branching and stimulate auxiliary bud development, increases higher number of branches/plant, pods/plant and seeds/pod. The kenaf seedlings also produce more branches after de-topping. This practice consequently increases the number of flowers and fruits and produces higher seed yield (Islam and Iqbal, 1992). Adjustment of planting spacing in relation to de-topping practice could be a useful agronomic

management option influencing the yield and quality of kenaf seed. Information on de-topping is highly scanty in Asian countries. Therefore, the present study was undertaken with a view to finding out the effect of spacing and de-topping on yield and quality of kenaf seed under transplanting method.

Materials and Methods

An experiment was conducted at the Bangladesh Jute Research Institute (BJRI), Regional Station, Kishoreganj, Bangladesh during July to December 2010 and 2011 to the see the effect of spacing and de-topping on yield and quality of kenaf seed. The site is located at 24°38´North latitude and 90°13´ East longitudes and at an altitude of 18 m. The soil of the site belongs to Old Brahmaputra Floodplain Agro Ecological Zone, 'AEZ-9' (UNDP and FAO, 1988). The field was medium high land having well-drained silty loam soil with p^H 6.75. The experiment comprised five times of de-topping viz., no de-topping, de-topping at transplanting, de-topping at 15, 30 and 45 days after transplanting (DAT) and three plant spacing viz., 40 cm × 15 cm, 30 cm × 15 cm and 20 cm × 15 cm. The trial was laid out in a randomized complete block design with three replications. The unit plot size was 3 m × 2 m. Seed of kenaf variety HC-95 was used as test crop. The experimental plots were fertilized with urea, triple super phosphate (TSP), murate of potash (MoP) and gypsum @ 110-50-20-100 kg/ha, respectively. All fertilizers except urea were applied during final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). For seedling transplanting method, first kenaf seedling was raised in seedbed and 20 days old seedlings were transplanted in the main plots. Seedlings were planted on 15 July 2010 and 2011 in rows continuously at spacing as per experimental specification. Before plantation, uprooted seedlings were kept in shade. Lower leaves of the seedlings were removed leaving 2-3 leaves on the top. Weeding and other intercultural operations were done as and when necessary. The top of all the plants of a plot (treatment) were de-topped with a sharp knife at 15 days interval as per treatment design. Diathane M-45 was sprayed on the concerned plants just after de-topping to prevent any fungal infection.

The crop was hand harvested at maturity (i.e. when 80% of the capsules become brown in color). Threshing was done with a hammer after 2-3 days sun drying. Then seeds were sun dried on jute mat kept on cemented floor for 5-6 days to around 8% seed moisture content. After cleaning the seed was stored in thick polythene bags and kept in the laboratory until further use for quality tests. Prior to harvesting, ten plants from each plot were harvested to collect data on different crop characters such as number of pods/plant, seeds/pod, 1000-seed weight, seed yield/plant. Standard laboratory germination test, electrical conductivity and accelerated ageing tests were done to record on germination and vigour of seed. A brief description on different laboratory tests is given below.

Laboratory Germination Test

The test was conducted on top of the paper method. The germination percentage of seed was measured with the following formula:

$$Germination\ (\%) = \frac{Number\ of\ normal\ seedling}{Number\ of\ seed\ sown} \times 100$$

Vigour Index (VI)

The numbers of germinated seedlings were counted daily from the germination test up to 8 days. The seed vigour index (VI) was then calculated by following formula (AOSA, 1983):

$$Vigour\ Index\ (VI) = \frac{Number\ of\ germinated\ seed}{Days\ of\ first\ count} + - - - + \frac{Number\ of\ germinated\ seed}{Days\ of\ final\ count}$$

Electrical conductivity (EC) test

Randomly selected 50 seeds were taken in a 250 ml flasks containing 75 ml de-ionized water at 20°C (±1°C) for 24 hours. Electrical conductivity measured with EC meter (Model-YSI 3200). Value expressed in $\mu scm^{-1}g^{-1}$ (AOSA, 1983).

Accelerated ageing (AA) test

15 g seed in accelerated ageing chamber exposing to 41^0C temperature and 100% RH for 72 hours. Following the laboratory germination test (ISTA, 1999).

Statistical Analysis of data

The collected data on different yield related characters and seed quality parameters were subjected statistical analysis following ANOVA technique. Differences among treatment means were adjusted by Duncan's Multiple Range Test with the help of a computer based statistical package program MSTAT-C.

Results

Effect of De-Topping

Almost all the parameters were found statistically significant in terms of time of de-topping in 2010 and 2011 (Table 1-3). At planting time initial number of plant population/m^2 was 26.45 in both the years. In 2010, at time of harvest the highest plant population (21.54) was observed from de-topping at 45 DAT and the lowest (18.69) in no de-topping. In 2011, the highest plant population (23.43) was found in de-topping at 45 DAT. On the other hand, the lowest plant population (20.94) was found in de-topping at transplanting system. In 2010, the highest mortality percentage (29.42%) was observed from no de-topping system and the lowest mortality percent (17.91%) was

found from de-topping at 45 DAT. In 2011, the highest mortality percentage (18.72%) was observed from de-topping at transplanting system and the lowest mortality percent (10.61%) was found from de-topping at 45 DAT (Table1). In 2010, plants of no de-topping produced the highest plant height (184.10 cm) and the lowest plant height (175.4 cm) was obtained from the plants of de-topping at 45 DAT. In 2011, the tallest plant (179.20 cm) was obtained from no de-topping system. De-topping at 45 DAT contributed the shortest plant (169.30 cm). Plant base diameter was significantly influenced by de-topping in 2011 but not in 2010. The widest plant (9.03 mm) was recorded from plants of de-topping at 45 DAT and the narrowest plant (8.21 mm) was found in plant under de-topping at transplanting time. In 2010, the maximum number of branches/plant (3.59) was obtained from de-topping at 45 DAT and the lowest number of branches/plant (0.00) was received from plants of no de-topping (Table 2). In 2011, the maximum number of branches/plant (2.23) was found from de-topping at 45 DAT and the lowest number of branches/plant (0.00) was received from plants of no de-topping). In 2010, significantly the highest number of pods/plant (31.19) was obtained from de-topping at 45 DAT. No de-topping gave the lowest number of pods/plant (19.78). In 2011, significantly the highest number of pods/plant (27.12) was recorded from de-topping at 45 DAT. Table 2 also shows that the lowest number of pods/plant (19.14) was obtained from no de-topping. In 2010, number of seeds/pod was affected significantly due to top management systems. The highest number of seeds (16.93) was produced in plants from de-topping at transplanting and the lowest number of seeds/pod (16.48) was recorded from the plants of de-topping at 45 DAT. In case of 2011, significant variation was not found in number of seeds/pod due to top management systems (Table 2). In 2010 and 2011, significantly the highest seed yield/plant (9.73g and 9.81 g) was obtained from the plants of de-topping at 30 DAT. The lowest seed yield (6.67g) was recorded from plant of no de-topping system in 2010 and (7.74g) was recorded from plant of de-topping at transplanting time in 2011 (Table 2). The highest seed yield (1498 and 1588 kg/ha) was recorded from the plants of de-topping at 30 DAT in both the years. The lowest seed yield (990 kg/ha) was found from the plants of no de-topping system in 2010 and (1365 kg/ha) was found from the plants of no de-topping system in 2011 (Table 2). Percent seed germination was significantly influenced by de-topping system in 2011 but not 2010. In 2011, the best quality seed (87.58% germination) was found from de-topping at 30 DAT and the lower germination of seed (84.58%) was found from de-topping at transplanting (Table 3). In 2010, the best quality seed (43.97 VI)) was found from the plants of de-topping at 30 DAT. The most inferior quality of seed (42.21 VI) was identified from de-topping at transplanting. In 2011, the best quality seed (46.06 VI) was found from the plants of de-topping at 30 DAT. The most inferior quality of seed (44.22 VI) was identified from de-topping at 45 DAT (Table 3). In 2010 and 2011, it was found that electrical conductivity (EC) value of kenaf seed was the highest (29.03 $\mu scm^{-1}g^{-1}$ and 23.71 $\mu scm^{-1}g^{-1}$) under de-topping at 15 DAT and the lowest EC value was found in de-topping at 30 DAT (24.62 $\mu scm^{-1}g^{-1}$and 18.32 $\mu scm^{-1}g^{-1}$). In 2010 and 2011, the best quality seed (66.17 and 71.92 % AA) was found from the plants of de-topping at 30 DAT. The most inferior quality of seed (63.17 and 66.50 % AA) was identified from the plants of de-topping at no de-topping management system (Table 3).

Effect of spacing

Plant spacing had significant effect on almost all the parameters in terms of spacing in both the years (Table 1-3). In 2010 and 2011, significantly, the highest plant population (26.35 and 27.93) was found in 20 cm × 15 cm spacing while the lower plant population (14.98 and 17.46) was achieved from 40 cm × 15 cm spacing. In 2010, significantly the highest mortality (24.94%) was obtained from 30 cm x 15 cm spacing. Table 1 also shows that the lowest mortality (19.77%) was found in 40 cm x 15 cm spacing. In 2011, the highest mortality (20.19%) was found from 20 cm x 15 cm spacing and the lowest mortality (6.50%) was found in 40 cm x 15 cm spacing. The tallest plant (182.30 cm and 180.10 cm) was obtained from 20 cm × 15 cm spacing which was at par with 30 cm × 15 cm spacing (180.80 and 175.0cm) and that of the lowest (176.40 cm and 169.10 cm) was in plant spacing 40 cm × 15 cm in 2010 and 2011 and 30 cm × 15 cm spacing showed the widest plant (10.49 mm and 9.29 mm) and lowest (9.61 mm and 7.90 mm) was in plant spacing having 20 cm ×15 cm **(**Table1**).** The highest number of branches/plant (2.05 and 1.12) was found from the plant having 30cm × 15cm spacing and the lowest number of branches/plant (1.72 and 0.87) was recorded from 20 cm × 15cm spacing in both the years. The highest number of pods/plant (27.95 and 25.85) was observed from 30 cm × 15 cm spacing, while, the lowest number of pods/plant (22.31 and 19.19) was produced by 20 cm × 15 cm spacing. The highest number of seeds/pod (17.32 and 17.88) was obtained in 30 cm × 15 cm spacing and the lowest number (16.35 and 17.01) was found from the 20 cm × 15 cm plants spacing in both the years. The highest seed yield/plant (8.65g and 9.64g) was obtained from 30 cm × 15 cm plant spacing and the lowest seed yield/plant (7.65g and 7.88g) was recorded from plants of 20 cm × 15 cm spacing (Table 2) in 2010 and 2011**.** The present study revealed that the highest seed yield (1373 kg/ha and 1602 kg/ha) was obtained from 30 cm × 15 cm spacing and the lowest seed yield (1053 kg/ ha and

1181 kg/ha) was obtained from 40cm × 15cm spacing (Table 2) in 2010 and 2011. Seed quality of kenaf seed varied significantly due to plant spacing. In 2010 and 2011, the best quality seed (85.25% and 88.05%) in term of germination, (44.96 SVI and 46.85 SVI) in term of seed vigour, (23.49 and 17.21 $\mu scm^{-1}g^{-1}$) in term of EC value and (69.70% and 73.90% AA) in term of accelerated ageing germination (%)(AA) was obtained in 30cm × 15cm spacing and the inferior quality seed was found in 20 cm × 15 cm spacing (Table 3).

Table 1: Effect of de-topping and spacing on plant population, mortality (%), plant height and base diameters of kenaf in 2010 and 2011

Treatment	Plant population/m^2 (no.)		Mortality (%)		Plant height (cm)		Base diameter (mm)	
De-topping	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
D_0	18.69c	22.48a	29.42a	13.62bc	184.10a	179.20a	9.89	8.45ab
D_1	20.02bc	20.94b	23.52b	18.72a	182.00ab	176.80a	9.62	8.21b
D_2	20.54ab	22.13ab	21.64b	14.85b	179.70bc	175.20ab	9.98	8.48ab
D_3	20.21ab	22.89a	23.23b	12.24cd	177.90cd	172.90ab	10.30	8.74ab
D_4	21.54a	23.43a	17.91c	10.61d	175.40d	169.30b	10.65	9.03 a
S $\bar{X}$	0.4626	0.4853	0.7109	0.5871	1.292	2.346	0.3211	0.2092
CV (%)	6.87	6.51	9.21	12.57	2.15	4.03	9.55	7.32
Level of sig.	**	*	***	***	***	*	NS	*
Spacing								
S_1	14.98c	17.46c	19.77b	6.50c	176.40b	169.10b	10.16ab	8.55b
S_2	19.27b	21.73b	24.94a	15.33b	180.80a	175.00a	10.49a	9.29a
S_3	26.35a	27.93a	24.72a	20.19a	182.30a	180.10a	9.61b	7.90c
S $\bar{X}$	0.3583	0.3759	0.5506	0.4548	1.000	1.817	0.2487	0.1621
CV (%)	6.87	6.51	9.21	12.57	2.15	4.03	9.55	7.32
Level of sig.	***	***	***	***	***	***	*	***

CV= Coefficient of variation, *= Significant at 5% level, **= Significant at 1% level, ***= Significant at 0.1% level

In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT

Note: D_0= No de-topping, D_1= de-topping at transplanting, D_2 = de-topping at 15 days after transplanting(DAT), D_3 = de-topping at 30 DAT and D_4= de-topping at 45 DAT,S_1= 40 cm x 15 cm, S_2 = 30 cm x 15 cm and S_3= 20 cm x 15 cm.

Table 2: Effect of de-topping and spacing on number of branches/plant, number of pods/plant, number of seeds/pod, seed yield/plant and seed yield/m2 of Kenaf in 2010 and 2011

De-topping.	Number of branches/plant		Number of pods/plant		Number of seeds/pod		Seed yield/plant (g)		Seed yield (kg/ha)	
	2010	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
D_0	0.00e	0.00d	19.78e	19.14c	16.71ab	17.29	6.67c	8.31b	990c	1365bc
D_1	1.23d	0.02d	21.41d	19.63c	16.93a	17.50	6.85c	7.74b	1080c	1284c
D_2	1.89c	0.54c	26.24c	21.40b	16.80ab	17.39	8.45b	8.11b	1284b	1486ab
D_3	2.75b	2.08b	28.60b	26.46a	16.77ab	17.51	9.73a	9.81a	1498a	1588a
D_4	3.59a	2.23a	31.19a	27.12a	16.48b	17.24	8.97b	9.49a	1374b	1501ab
S $\bar{X}$	0.06236	0.04082	0.5198	0.5309	0.1135	0.1220	0.2030	0.2288	3.764	5.046

De-topping.	Number of branches/plant		Number of pods/plant		Number of seeds/pod		Seed yield/plant (g)		Seed yield (kg/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
CV (%)	9.86	12.60	6.13	7.00	2.03	2.10	7.49	7.89	9.07	10.48
Level of sig.	***	***	***	***	*	NS	***	**	***	**
Spacing										
S_1	1.91a	0.93b	26.07b	23.21b	16.54b	17.27b	8.10b	8.56b	1053b	1181b
S_2	2.05a	1.12a	27.95a	25.85a	17.32a	17.88a	8.65a	9.64a	1373a	1602a
S_3	1.72b	0.87b	22.31c	19.19c	16.35b	17.01b	7.65b	7.88c	1310a	1552a
S $\bar{X}$	0.04830	0.03162	0.4027	0.4113	0.08794	0.09452	0'1573	0.1772	2.916	3.908
CV (%)	9.86	12.60	6.13	7.00	2.03	2.10	7.49	7.89	9.07	10.48
Level of sig.	***	***	***	***	***	***	***	***	***	***

Table 3: Seed germination, seed vigour index, electrical conductivity and accelerated ageing germination (%) of kenaf seed as influenced by de-topping in 2010 and 2011

De- topping.	Germination (%)		Seed vigour index		Electro-conductivity ($\mu scm^{-1}g^{-1}$)		Accelerated ageing germination (%)	
	2010	2011	2010	2011	2010	2011	2010	2011
D_0	82.58	84.67b	42.45b	44.52b	27.90b	23.54a	63.17b	66.50c
D_1	82.08	84.58b	42.21b	44.61ab	29.03a	23.71a	63.25b	68.08bc
D_2	83.50	86.08ab	43.11ab	45.29ab	26.67c	19.77ab	64.50ab	69.25b
D_3	84.08	87.58a	43.97a	46.06a	24.62d	18.32b	66.17a	71.92a
D_4	83.17	85.08b	42.58b	44.22b	27.54b	22.07ab	65.33ab	66.50c
S $\bar{X}$	0.5833	0.6236	0.4664	0.5112	0.1393	0.6391	0.8706	0.7695
CV (%)	2.43	2.52	3.77	3.94	1.78	0.63	4.68	3.89
Level of sig.	NS	**	*	*	***	***	*	***
Spacing								
S_1	82.75b	85.90b	42.53b	44.75b	27.38b	20.62b	62.40b	68.60b
S_2	85.25a	88.05a	44.96a	46.85a	23.49c	17.21c	69.70a	73.90a
S_3	81.25c	82.85c	41.09c	43.22c	30.59a	26.62a	61.35b	62.85c
S $\bar{X}$	0.4518	0.4830	0.3612	0.3960	0.1079	0.0303	0.6743	0.5961
CV (%)	2.43	2.52	3.77	3.94	1.78	0.63	4.68	3.89
Level of sig.	***	***	***	***	***	***	***	***

CV= Coefficient of variation, *= Significant at 5% level, **= Significant at 1% level , ***= Significant at 0.1% level, NS= Not Significant; In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT

Note: D_0= No de-topping, D_1= de-topping at transplanting, D_2 = de-topping at 15 days after transplanting (DAT), D_3 = de-topping at 30 DAT and D_4= de-topping at 45 DAT, S_1= 40 cm x 15 cm, S_2 = 30 cm x 15 cm and S_3= 20 cm x 15 cm.

The interaction effect of spacing and de-topping

Planting height, number of branches/plant, number of pods/plant and seed yield/m was affected by interaction between de-topping and spacing (Table 4). Significantly the highest number of branches/plant (4.03 and 2.40) was recorded from the plants having 30 cm x 15 cm spacing under de-topping at 45 DAT and the lowest number of branches/plant was recorded from no de-topping having all the plant spacing. The highest number of pods/plant (35.13 and 31.20) was obtained from de-topping at 45 DAT having 30 cm × 15 cm spacing and the lowest pod number (17.40 and 16.87) was recorded in no de-topping having 20 cm × 15cm spacing. The highest values for seed yield/ha was obtained from de-topping at 30 DAT having 30 cm × 15 cm spacing and the lowest was recorded in no de-topping having 20 cm x 15cm spacing. In 2010 and 2011, the highest germination (86.50% and 90.25%) and seed. vigour index (46.80 and 47.70) was obtained from de-topping at 30 DAT having 30cm × 15cm spacing and the inferior quality seed (80.25% and 80.50% germination and 40.08 and 42.29 seed vigour index) was found from the plants of de-topping at transplanting having 20 cm × 15cm spacing. De-topping at transplanting having 20 cm × 15 cm spacing showed higher electrical conductivity (EC) value and de-topping at 30 DAT having 30cm × 15cm spacing showed the lowest EC value. De-topping at 30 DAT having 30 cm × 15cm spacing showed higher quality seed (73.00% and 75.00% accelerated ageing germination) and de-topping at transplanting having 20 cm × 15 cm spacing showed the most inferior (60.50% and 60.25% accelerated ageing germination) quality seed (Table 5).

Relationship among the Plant Characters

The simple correlation study indicated that the number of branches/plant, number of pods/plant and seed yield/plant had negatively insignificant correlation with plant height (Table 6).

Table 4: Plant height (cm), branches/plant, pods/plant and seed yield of kenaf as influenced by spacing and de-topping.

De-topping and spacing	Plant height (cm)		Branches/plant		Pods/plant		Seed yield (Kg/ha)	
	2010	2011	2010	2011	2010	2011	2010	2011
D_oS_1	179.90	174.00	0.00f	0.00e	20.60	19.37	841	1134
D_oS_2	185.70	179.60	0.00f	0.00e	21.33	21.20	1120	1487
D_oS_3	186.70	184.10	0.00f	0.00e	17.40	16.87	1010	1473
D_1S_1	178.20	172.40	1.23e	0.00e	22.07	19.47	960	1055
D_1S_2	183.70	176.70	1.27e	0.07e	23.60	22.83	1173	1461
D_1S_3	184.20	181.30	1.20e	0.00e	18.57	16.60	1106	1335
D_2S_1	177.00	170.90	1.87d	0.40d	25.87	22.23	1114	1179
D_2S_2	180.00	174.00	1.97d	0.87c	28.90	23.70	1393	1646
D_2S_3	182.00	180.80	1.83d	0.37d	23.97	18.27	1346	1634
D_3S_1	175.50	166.40	2.68bc	2.00b	29.43	27.23	1190	1325
D_3S_2	177.90	173.50	2.97b	2.27a	30.80	30.30	1678	1768
D_3S_3	180.30	178.80	2.60c	1.97b	25.57	21.83	1625	1672
D_4S_1	171.20	161.70	3.77a	2.27a	32.37	27.77	1160	1212
D_4S_2	176.90	171.10	4.03a	2.40a	35.13	31.20	1499	1647
D_4S_3	178.20	175.20	2.97b	2.03b	26.07	22.40	1462	1645
S $\bar{x}$	2.237	4.063	0.1080	0.07071	0.9004	0.9196	65.19	87.39
CV (%)	2.15	4.03	9.86	12.60	6.13	7.00	9.07	10.48
Level of sig.	NS	NS	**	*	NS	NS	NS	NS

CV= Coefficient of variation, *= Significant at 5% level, ***= Significant at 0.1% level, NS= Not Significant

In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT

Note: D_0= No de-topping, D_1= de-topping at transplanting, D_2 = de-topping at 15 days after transplanting (DAT), D_3 = de-topping at 30 DAT and D_4= de-topping at 45 DAT, S_1= 40 cm x 15 cm, S_2 = 30 cm x 15 cm and S_3= 20 cm x 15 cm.

Table 5: Seed germination, seed vigour index, electrical conductivity and accelerated ageing germination % of kenaf seed as influenced by spacing and de-topping.

De-topping and spacing	Germination (%)		Seed vigour index		Electro-conductivity ($\mu scm^{-1}g^{-1}$)		Accelerated ageing germination (%)	
	2010	2011	2010	2011	2010	2011	2010	2011
D_0S_1	82.00	84.50	42.29	43.89	28.77c	23.47bc	61.75	64.00 ef
D_0S_2	84.50	87.50	44.41	47.06	24.59fg	18.40cde	66.50	74.00ab
D_0S_3	81.25	82.00	40.65	42.62	30.33b	28.74ab	61.25	61.50f
D_1S_1	82.25	86.25	42.45	45.12	28.47c	19.38cde	62.00	70.00cd
D_1S_2	83.75	87.00	44.10	46.43	25.14ef	18.49cde	67.25	74.00ab
D_1S_3	80.25	80.50	40.08	42.29	33.49a	33.27a	60.50	60.25f
D_2S_1	83.00	86.75	42.61	45.29	27.00d	18.52cde	62.50	71.00bc
D_2S_2	85.75	88.50	44.72	47.64	24.14g	16.32de	69.50	75.00a
D_2S_3	81.75	83.00	42.01	42.95	28.85c	24.47bc	61.50	61.75f
D_3S_1	83.50	87.00	42.85	45.71	25.30e	18.51cde	63.25	71.75abc
D_3S_2	86.50	90.25	46.80	47.70	21.25i	14.31e	73.00	75.00a
D_3S_3	82.25	85.50	42.26	44.79	27.33d	22.15bcd	62.25	69.00cd
D_4S_1	83.00	85.00	42.48	43.76	27.34d	23.23bcd	62.50	66.25de
D_4S_2	85.75	87.00	44.79	45.41	22.34h	18.51cde	72.25	71.50abc
D_4S_3	80.75	83.25	40.47	43.47	32.94a	24.47bc	61.25	61.75f
S $\bar{X}$	1.010	1.0801	0.8078	0.8855	0.2413	0.0678	1.5078	1.3328
CV (%)	2.43	2.52	3.77	3.94	1.78	0.63	4.68	3.89
Level of sig.	NS	NS	NS	NS	***	***	NS	*

CV= Coefficient of variation, *= Significant at 5% level, ***= Significant at 0.1% level, NS= Not Significant

In a column, figures having similar letter(s) do not differ significantly at 5% level as per DMRT

Note: D_0= No de-topping, D_1= de-topping at transplanting, D_2 = de-topping at 15 days after transplanting (DAT), D_3 = de-topping at 30 DAT and D_4= de-topping at 45 DAT, S_1= 40 cm x 15 cm, S_2 = 30 cm x 15 cm and S_3= 20 cm x 15 cm.

Table 6: Relationship between plant characters and plant height

Plant characters	Plant height (r value)	
	2010	2011
Number of branches/plant	-0.83323	-0.88227
Number of pods/plant	-0.74899	-0.79134
Seed yield/plant	-0.646451	-0.83537

Discussion

Planting spacing influenced the yield and quality of kenaf seed. Optimum planting density ensures kenaf plants to grow uniformly and properly through efficient utilization of moisture, nutrients and light, and thus contributes to maximize the yield of pods as well as seed. The present study showed highest seed yield from 30 cm × 15 cm spacing and the lowest seed yield from 40 cm × 15 cm spacing (Table 2). The results showed that the yield for 30 cm x 15 cm and 20 cm x 15 cm spacing were statistically similar (Table 2) in both the years. It was also noted that the number of branches/plant, pods/plant and seeds/pod were significantly highest for 30 cm x 15 cm spacing and these values were the lowest for 20 cm x 15 cm spacing. The higher seed yield in the closer spacing was, therefore, mainly attributed to higher number plants/m^2 (Table 1). It was also observed that although the yield was similar both in 30 cm x 15 cm and 20 cm x 15 cm spacing, there was a tendency of decreased yield at 20 cm x 15 cm spacing in both the years. Thus it indicates that further increase in plant population would reduce the yield. Therefore, kenaf should be planted between 30 cm and 20 cm row spacing with a plant spacing of 15 cm. The present significant yield variation in kenaf seed due to variation in planting spacing

could be supported by Scott and Cook (1995) and Webber and Bledsoe (2002). The experiment also indicated that the row spacing closer than 20 cm would reduce seed yield in kenaf which agrees the report of Webber and Bledsoe (2002).

Plant height was significantly influenced by planting spacing. The plant height increased significantly with narrower plant spacing from 40 cm x 15 cm to 30 cm x 15 cm but further narrowing of spacing did not increase the plant height (Table 1). The decrease in row spacing increased the plant population which increases the plant height because of mutual shading that usually results in stem elongation. The increase in plant height is associated with internodes elongation. The internodal elongation (etiolation effect) due to mutual shading is believed to be an auxin response (Rahman *et al.*, 2004). The present study also revealed that the plant height did not increase significantly for further decrease of row spacing after 30 cm. This type of response is probably related to the fact that the plants suffer from shortage of assimilates at ultra-high plant density that retard the further increase in plant height.

Seed quality attributes were affected significantly by planting spacing. The results showed that the highest seed germination and vigour were found for 30 cm x 15 cm (Table 3). The lowest seed quality was observed for the crop from 20 cm x 15 cm spacing. The differences in the seed quality response of kenaf for planting spacing could be related to the plant population establishment differences in this method. The plant population at 30 cm x 15 cm was 20 plants/m^2 while the plant density at 20 cm x 15 cm was 27 plants/m^2. It was noted that the pods under high density crop remained wet or damp for longer time in the field than those at low density crop. This was because of the fact that the high population at 20 cm x 15 cm could have restricted the proper movement for rapid drying of pods. This damp condition in the field during the period of ripening might have affected the seed quality adversely at the low density crops. Palaniswamy *et al.*, (1986) and Rashid and Singh (2000) reported the best quality okra seed from wider spaced crop than the closer spaced one. Based on the results of the present study, it could be concluded that the highest yield and quality of kenaf seed could be obtained for planting at 30 cm x 15 cm spacing.

De-topping has significant influence on yield of kenaf seed. In the present study, the highest yield of kenaf seed was recorded from de-topping at 30 days after transplanting (DAT) (Table 2). It was found that de-topping both earlier and later than 30 DAT reduced the seed yield (Table 2). The highest seed yield under transplanting method was mainly related to number of seeds/pod and seed yield/plant (Table 2). It was found that the delay in de-topping reduced the plant height but increased the base diameter of kenaf plant in both the years. In these cases de-topping always produced shorter plants than non-detopped plants. The decrease in plant height of kenaf for de-topping was probably related to the apical dominance phenomena. Removal of top (de-topping) reduced the auxin content in the top portion of the plants that retarded the increase of height in plant. Aziz (2002) reported that de-topping at 45 DAE gave maximum number of branches per plants in chickpea. Singh *et al.* (2002) stated that de-topping of okra plant produced the higher number of seeds/pod compared to that of pods taken from non-detopped plants. In pigeon pea, Sharma *et al.* (2003) reported that nipping of terminal bud at 50 DAS significantly reduced the height of the plant and increased the number of primary and secondary branches, pods/plant and seed yield. Uddin (2006) reported that top removal in okra produced the maximum seed yield over no de-topped plants. Islam and Iqbal (1992) also reported that seed yield in the de-topped plants was much higher than of normal plants in Jute (*Corchorus olitorius* L. and *Corchorus capsularies* L.). These reports support the results of the present study and from the study it could be concluded that the highest yield of kenaf seed could be obtained by de-topping at 30 DAT.

Seed quality attributes such as laboratory germination and vigour showed significantly highest performance for de-topping at 30 days after transplanting of 20 days old seedling in transplanted crop (Table 3). The vigour was evaluated in terms of vigour index, accelerated ageing germination and electrical conductivity test. All these vigour tests confirmed that the seeds obtained from the crop de-topped at 30 DAT showed highest vigour status. Thus, it could be concluded that both highest yield and quality of kenaf seed could be obtained by de-topping at 30 DAT.

Conclusions

The result of the present study concludes that the highest yield of kenaf seed was obtained for the crops sown at 30 cm × 15 cm spacing and the highest values were found with de-topped at 30 DAT. The best quality seed in respect to germination and vigour was also obtained for at 30 cm × 15 cm spacing. The study concludes that late season kenaf produces highest seed yield with best quality when sown at 30 cm × 15 cm spacing and for de-topping at 30 DAT.

References

AOSA (Association of Official Seed Analysis) (1983) Seed Vigour Testing Handbook. Contribution No. 32 to the Handbook on Seed Testing.

Aziz MA (2002) Response of chickpea to nipping. *Pakistan Journal of Scientific and Industrial Research*, **43(3)**: 191-193.

Bukenya-Ziraba R (2004) *Hibiscus cannabinus* L., PROTA 2: Vegetables/Legumes. PROTA, Wageningen, Netherlands.

Islam KMM and Iqbal S (1992) Effect of deheading and seedling transplanting time and yield of jute, kenaf and mesta in off season seed production. Ann.

Rep.(1993). Bangladesh Jute Res. Inst., Dhaka.241p.

ISTA (1999) International Rules for Seed Testing, 2003. Zurich, Switzerland, ISTA.

Mostofa MG (2012) Genetic divergence combining ability, heterosis and gene action for yield characters in Kenaf (*H. cannabinus*) Ph. D. Thesis, Dept. Genet. & Pl. Breed., Bangladesh Agril. Univ., Mymensingh, Bangladesh.

Palaniswamy V, Vanangamudi K, Jayarajad T and Karivaratharaju TV (1986) Influence of date of sowing and spacing on seed quality in Bhendi *(Abelmoschus esculentus L.* Moench). *South Indian Horticulture*, **34(1)**: 23-25.

Rahman MM, Hampton JG and Hill MJ (2004) Effect of seed moisture content following hand harvest and machine threshing on seed quality of cool tolerant soybean (*Glycine max* (L.) Merrill.). *Seed Science and Technology*, **32**: 149-158. DOI: 10.15258/sst.2004.32.1.15

Rashid MA and Singh DP (2000) A manual on vegetable seed production in Bangladesh, AVRDC-USAID Bangladesh project, HRC, BARI, Joydebpur, Gazipur-1701.

Scott AW Jr and Cook CG (1995) Growing kenaf for seed in south Texas. Proc. Int. Kenaf Assn. Conf. Irving, TX. 7:133–135.

Sharma A, Potdar MP, Pujari BT and Dharmaraj PS (2003) Studies on response of pigeonpea to canopy modification and plant geometry. *Karnataka Journal of Agricultural Research* **16(1)**: 1-3.

Singh J, Singh N, Malik YS, Nehra BK, Mehla CP, Singh J and Singh N (2002) Effects of spacing and pruning on seed crops of okra. *Haryana Journal of Horticultural Science* **31(1-2)**: 113-115.

Uddin MM (2006) Yield and Quality of okra seed as influenced by crop management practices. PhD Thesis, Dept. of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh.

UNDP and FAO (Food and Agriculture Organization) (1988) Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2, Agro-ecological Regions of Bangladesh. pp. 212-221

Webber CL and Bledsoe VK (2002) Kenaf yield components and plant composition. In: J.Janick and A. Whipkey (eds.), Trends in new crops and new uses. ASHS Press, Alexandria, VA. pp. 348-357.