African Journal of Biotechnology Vol. 10(28), pp. 5461-5467, 20 June, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.979
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Seed yield and quality of okra as influenced by sowing dates

A. Chattopadhyay[1]*, S. Dutta[1] and S. Chatterjee[2]

[1]All India Coordinated Research Project on Vegetable Crops, Bidhan Chandra Krishi Viswavidyalaya, Directorate of Research, Kalyani-741235, Nadia, West Bengal, India.
[2]All India Coordinated Research Project on Cropping System Research, Bidhan Chandra Krishi Viswavidyalaya, Directorate of Research, Kalyani-741235, Nadia, West Bengal, India.

Accepted 23 February, 2011

Field trials were conducted at the Gangetic Alluvium of eastern India to find out the most suitable sowing time to achieve higher yield, comparatively less incidence of yellow vein mosaic virus (YVMV) and quality seed of okra over four consecutive years having seven sowing times at fortnight interval (1st February, 16th February, 1st March, 16th March, 1st April, 16th April and 1st May). The seed yield attributing characters differed significantly with different sowing dates. The maximum matured pods per plant (14.57) and the longest matured pod (18.00 cm) was observed from 1st April sowing which was statistically similar with that of number and length recorded between16th February and 1st May sowing dates. However, seeds sown in 16th February significantly produced the highest mean seed yield (6.84 q/ha) followed by 1st March (6.18 q/ha) sowing over the years. Seeds sown in either 16th February or 1st March produced the best quality seed (85.30 and 80.0% germination; 45.0 and 44.0 g test weight 29.75; 11.79 and 11.64 vigour index, respectively). Correlation study clearly revealed that seeds per pod and test weight significantly contributed to the seed yield. Rainfall was found to be the major contributor with a significant negative effect on yield over the year. The seed yield of okra was highly influenced by the incidence of YVMV and higher yield was obtained during disease free period, particularly between February and March. The income per rupee investment of okra seed crop was found to be the maximum (2.40) when sown at 2nd fortnight of February.

Key words: Okra, seed yield, seed quality, economics.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench) is one of the world's oldest cultivated crops believed to have originated from the Hindustani Centre, chiefly of India, Pakistan, Burma (Zeven and Zhukovsky, 1975) and Africa origin (Thomson and Kelly, 1979), and it still remain the most important fruit vegetable grown in the tropical area. The special taste and nutritional value of this crop had attracted more attention in some tropical and subtropical areas of the world (Kochhar, 1986). It is a nutritious vegetable which plays an important role in meeting the demand for vegetables in our country where vegetables are scanty in the market. Seed can only geminate in relatively warm soils, no germination occurs below 16°C. A monthly average temperature range of 21 to 30°C is considered appropriate for growth, flowering and pod development (Tindall, 1983; Nonnecke, 1989). Being a warm season crop, it requires high day and night temperatures for best production, but the growers start its cultivation from January as off season-early crop to get higher prices. Okra generally takes two months for harvestable pods, which extends from February to November, but most of the production occurs in the summer months. However, the average yield of the crop is comparatively low (10.30 t/ha) in India as compared to the other developed countries of the world (NHB, 2009).

The yield could reach as high as 30 t/ha (Koay and Chua, 1978). The unavailability of quality seed and heavy incidence of biotic stresses particularly yellow vein mosaic virus (YVMV) are the most important reasons for

*Corresponding author. E-mail: chattopadhyay.arup@gmail.com.

low yield. The disease YVMV transmitted by the whitefly (*Bemisia tabaci*) is reported to be one of the most destructive plant diseases in India causing great loss by affecting quality and yield of fruits, as high as 93.80% depending on age of plant at the time of infection (Sastry and Singh, 1974). Sowing time has a great impact on seed production and quality of okra (Singh et al., 1986; Hossain et al., 1999; Yadav and Dhankar 2001; Moniruzzaman et al., 2007). Besides, the time of seed sowing has a direct bearing on the incidence of YVMV disease in eastern India. Different environmental factors during seed production can influence seed yield and quality. It is very likely that with the increased critical approach to seed quality required for modern methods of vegetable production, we will have to make a greater distinction between seed quality and seed yield during the field multiplication of a cultivar. Adetunji and Chheda (1989) suggested that where limited resources prevent the use of several locations, different dates of planting for two or more years could be used to evaluate okra varieties for seed yield without losing much information on their relative ranking. Different cultivars require different climatic condition as well as different sowing time and a good cultivar sown at improper time to give poor yield. Therefore, proper and suitable date of sowing is critical for seed production of the crop. The information available so far regarding suitable sowing time for okra seed production is inadequate under the Gangetic plains of eastern India which is the most productive vegetable growing zone in the country. Therefore, the present investigation was carried out to find out the most suitable sowing time to achieve higher yield and quality seed of okra.

MATERIALS AND METHODS

The field experiment was carried out at District Seed Farm, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India during four consecutive years (2006 to 2009) following randomized block design in three replications having seven sowing times at fortnight interval (1st February, 16th February, 1st March, 16th March, 1st April, 16th April and 1st May). The farm was located at 23.5°N latitude and 88°E longitude, at an elevation of 7.8 m above mean sea level. The soil of experimental site was typical alluvial (Entisol) and sandy loam in texture having pH 6.5. The total organic C, total N, available P and K were 0.69%, 0.080%, 14.50 kgh^{-1} and 152.6 kgh^{-1}, respectively. The zone is classified as one having a tropical humid climate with three distinct seasons divided into winter (November-February), summer (March-May) and rainy season (June-October). The mean minimum and maximum temperatures during the period of experimentation varied between 15.7 (February) and 38.2°C (May). The annual rainfall varied from 1400 to 1500 mm, most of which was received from June to August. Manures and fertilizers (well rotten cowdung at 15 t ha^{-1}120-60-60 kg ha^{-1} N, P_2O_5, K_2O) were applied to the experimental plot. Half nitrogen and full phosphorus and potash were applied as basal and rest half of the nitrogen was top dressed 30 days after sowing. Seeds (cv. Parbhani Kranti) were pre-soaked in water for 24 h and they were dibbled with 2 seeds/hill at 60 x 30 cm spacing in a plot size of 3.6 x 3.0 m at fortnight interval starting from 1st February to 1st May of each year. Thinning of plants was done 15 days after sowing keeping one plant per hill. All the recommended cultural practices and plant protection measures were followed throughout the experimental period (Chattopadhyay et al., 2007). Growth (plant height at flowering stage), seed yield and yield attributes (pod length, pods/plant and seeds/pod) were recorded from randomly selected 15 plants from the inner rows of the plots. Data on 1000 seed weight (g), seed germination (%) and seed vigour index were recorded from 36 days old dry pods as suggested by Anitha et al. (2001). For seed germination, seeds collected from middle position pods (5 to 8 nodes) were placed on filter paper (Whatman No.1) moistened with distilled water in 155 mm glass Petri dishes. Three replicates of 50 seeds from each sowing were kept in an incubator at 25°C. Germination of seedling was recorded up to 10 days and then evaluated according to ISTA (1985). Seed vigour index was calculated by using the formula suggested by Maquire (1962) which is as follows:

$$\text{Index of seed vigour} = \frac{\text{Number of normal seedlings}}{\text{Days to first count}} + \frac{\text{Number of normal seedlings}}{\text{Days to final count}}$$

The disease intensity of the experimental plots was measured following 0-4 scale and the percent disease index (PDI) of yellow vein mosaic virus at different days after sowing (DAS) was estimated in each sowing time by using the following formula:

$$\text{PDI (\%)} = \frac{\text{£ Disease intensity of observed plot}}{\text{Maximum scale x Number of plants observed}} \times 100$$

The population dynamics of whitefly was also monitored through out the growing seasons. The economic analysis of seed production of okra was worked out on the basis of prevailing prices of inputs and seed yield at the time of this study. The treatment means were separated by Least Significant Difference (LSD) at 5% level of significance for better interpretation of the results as advocated by Gomez and Gomez (1984). Correlations between variables were tested for significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effects of sowing time on growth and seed yield attributing characters

The tallest plant at flowering stage (56.47 cm) was recorded at 16th April sowing followed by 1st May (55.32 cm). This was mainly due to prevailing favourable weather condition for their growth. The shortest plant (45.94 cm) was recorded at 1st February sowing which was statistically different from other sowings (Table 1). It might be due to prevailing low temperature in February (average max. 24.5°C and min. 11.30°C), which ultimately restricted vegetative growth of the plants. The observation is in agreement with the findings of previous workers (Hossain et al., 1999; Moniruzzaman et al., 2007).

The seed yield attributing characters differed significantly with different sowing dates. The maximum matured pods per plant (14.57) was recorded from 1st April sowing which was statistically at par with pod number observed between 16th February and 16th April sowing

Table 1. Effect of sowing dates on growth and yield attributing characters (pooled over four years).

Sowing date	Plant height (cm) at flowering	Pod length (cm)	Pods/ plant	Seeds/ pod
1st February	45.94	14.35	11.05	45.66
16th February	50.44	16.82	12.90	48.30
1st March	51.46	17.40	13.00	47.35
16th March	52.32	17.56	13.27	47.07
1st April	54.71	18.00	14.57	46.30
16th April	56.47	17.83	14.28	36.60
1st May	55.32	17.00	13.35	30.30
L.S.D. at 5%	3.20	2.08	1.72	2.53

dates (Table 1). The results are in agreement with those of previous workers (Mondal et al., 1989; Hossain et al., 1999) who found that the okra sown in April produced highest number of pods per plant as compared to other sowing dates. The longest matured pod (18.00 cm) was also observed from 1st April sowing which was statistically similar with that of length recorded between16th February and 1st May sowing dates. The lowest significant values for pods per plant and pod length were observed in 1st February sowing. However, the number of seeds per pod was found maximum (48.30) at 16th February sowing which was at par with sowing dates between 1st March and 1st April. However, the number of seeds per pod significantly decreased from 16th April sowing date. This may be attributed to shedding of pollens under subsequent rainfall at the time of their peak flowering stages, which leads to improper pollen tube growth and fertilization, resulting to less seeded pods.

Effects of sowing time on seed yield

The seed yield of okra differed significantly with sowing dates (Table 2). Seeds sown in 16th February significantly produced the highest mean seed yield (6.84 q/ha) followed by 1st March (6.18 q/ha) sowing over the years. This was attributed to production of more number of seeds per pod and number of fruits per plant at this time. The direct influence of number of pods per plant on seed yield had already been reported by previous workers (Akinyele and Osekita, 2006). The seed yield was statistically at par with the sowing dates between 16th February and 1st April during 2006 and 2007 and between 16th February and 16th March during 2008 and 2009. However, a gradual decline in seed yield has been observed with delayed planting dates. Significantly, the lowest mean seed yield (3.68 q/ha) was observed when sown at 1st May. The results find support from the observation of Moniruzzamam et al. (2007) who recorded the highest seed yield of okra when sown during the month of February in Bangladesh.

Effects of sowing time on seed quality attributing characters

Seeds sown in either 16th February or 1st March produced the best quality seed (85.30 and 80.0% germination; 45.0 and 44.0 g test weight 29.75; 11.79 and 11.64 vigour index, respectively), whereas 16th April and 1st May sowings produced inferior seed (63.60 and 56.0% germination; 32.33 and 31.60 g test weight; 10.90 and 10.82 vigour index, respectively). The higher germination percentage and seed vigour index was recorded from 16th February and 1st March sowing because the matured pods faced less amount of rainfall during their harvesting period, resulting to more production of bold seeded pods at that time (Table 3). However, rainfall at the time of seed maturity in delayed sowing is generally trapped in the area of embryonic axis, nodal zone and cotyledons of the seed. This leads to suffocation, resulting to delayed as well as weak seedling growth as observed by Heydecker (1977). The present findings are in close conformity with previous workers (Huda and Samiruddin, 1987; Moniruzzamam et al., 2007) who recommended that mid February to mid March is the best time for quality seed production of okra under Bangladesh condition which is very similar to our agro-climatic condition.

Correlation analysis

There were correlations between growth, reproductive characters and seed yield. Seeds per pod and test weight were significantly and positively correlated with seed yield as also reported by Akinyele and Osekita (2006). Significant positive correlations exist between plant height at flowering and pod length, plant height at flowering and pods per plant, pod length and pods per plant, seeds per pod and test weight (Table 4).

Table 2. Effect of sowing dates on seed yield (q ha^{-1}) of okra over four years.

Sowing date	Seed yield (q ha^{-1})				Mean yield (q ha^{-1})
	2006	2007	2008	2009	
1st February	5.05	4.62	6.10	6.07	5.46
16th February	6.37	5.51	7.80	7.69	6.84
1st March	6.08	5.12	6.82	6.72	6.18
16th March	5.74	4.95	6.15	5.35	5.54
1st April	5.49	4.40	5.31	4.91	5.02
16th April	4.16	3.83	4.39	4.34	4.18
1st May	3.72	2.87	4.00	4.16	3.68
L.S.D. at 5%	1.25	0.82	0.73	1.02	-

Table 3. Effect of sowing dates on seed quality of okra (pooled over four years).

Sowing date	Germination (%)	Test weight of 1000 seeds (g)	Seed vigour index
1st February	75.00 (60.00)	41.66	11.34
16th February	85.30 (67.45)	45.00	11.79
1st March	80.00 (63.44)	44.00	11.64
16th March	72.60 (58.44)	38.83	11.29
1st April	67.60 (55.30)	33.66	11.08
16th April	63.60 (52.89)	32.33	10.90
1st May	56.00 (48.45)	31.60	10.82
L.S.D. at 5%	5.50	1.30	0.16

Figures in parentheses are angular transformed values.

Table 4. Pearson's correlation matrix between variables.

Character	PL	PPP	SPP	TW	PY
PHF[a]	0.854*	0.924**	-0.592	-0.783*	-0.631
PL		0.939**	-0.117	-0.409	-0.175
PPP			-0.259	-0.625	-0.374
SPP				0.771*	0.891**
TW					0.940**

[a] PHF, Plant height at flowering; PL, pod length; PPP, pods/plant; SPP, seeds/pod; TW, test weight; PY, pod yield. *Significant at 5% level; **Significant at 1% level.

Trend analysis of seed yield of okra over the year and regression analysis with various climatic factors

Exponential trend analysis has been performed to judge the percent growth rate of seed yield of okra in different dates of sowing over the year studied (Table 5). It was registered that there was a declining trend in yield in 2007 (Figure 1) with sharp increase in the next year. This may be due to significant detrimental effect of rainfall over seed yield (Table 6). Highest growth rate of seed yield over the year (9.56%) was observed in case of okra sown on 16th February followed by a sharp increase in 8.65, 6.90 and 6.05% which were registered in case of sowing date on 1st February, May and March, respectively. Okra showed a declining trend in yield (-1.46%) over the year when it was sown in April. So, the trend shows that the best time of sowing of okra should be at early to mid February in order to obtain good yield. Regarding climatic factors, rainfall is found to be the major contributing factor over the yield in 2007 and 2008 with a significant negative effect on yield.

Effects of sowing time on percent disease index of YVMV

The population dynamics of whitefly was monitored through out the seasons and found to be remarkably low

Table 5. Year-wise exponential trends of okra seed yield according to different dates of sowing.

Date of sowing	Exponential trend	Percent growth rate (%)
1st February	$Y = 4.4057e^{0.083x}$ $R^2 = 0.6008$	8.65
16th February	$Y = 5.392e^{0.0913x}$ $R^2 = 0.5052$	9.56
1st March	$Y = 5.3071e^{0.0587x}$ $R^2 = 0.3295$	6.05
16th March	$Y = 5.5213e^{0.0006x}$ $R^2 = 0.0070$	0.06
1st April	$Y = 5.1971e^{-0.0147x}$ $R^2 = 0.0372$	-1.46
16th April	$Y = 3.9079e^{0.0264x}$ $R^2 = 0.3026$	2.68
1st May	$Y = 3.0898e^{0.0667x}$ $R^2 = 0.2662$	6.90

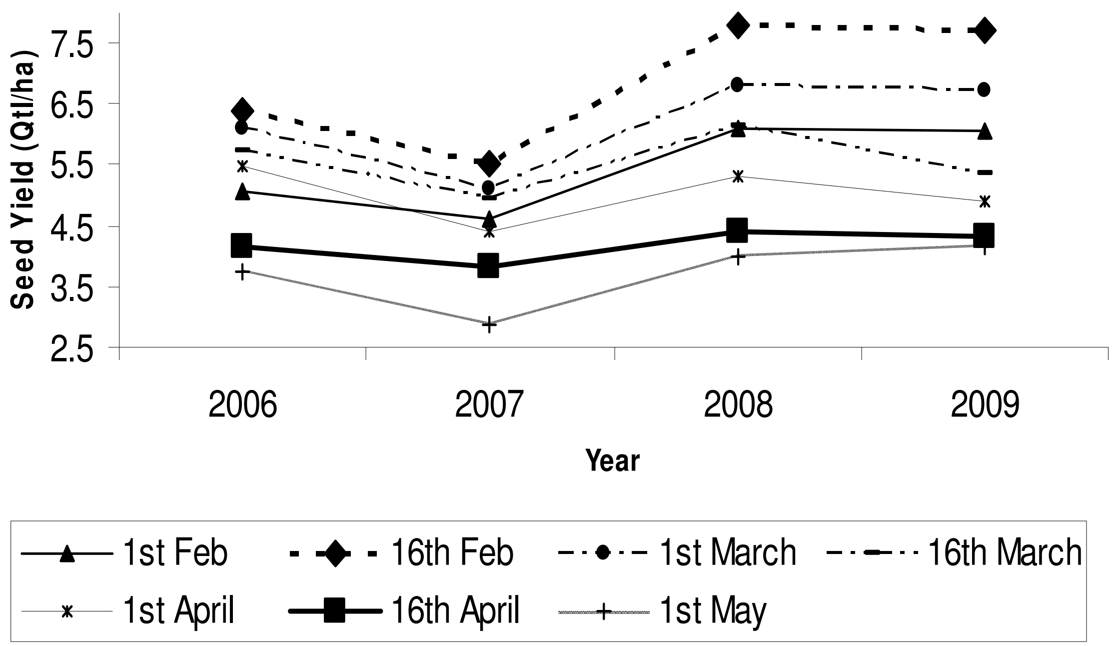

Figure 1. Year-wise trends of okra seed yield according to different dates of sowing.

Table 6. Step-wise regression model on seed yield of okra with various climatic parameters over the year.

Year	Regression equation	Variable (X_1)	Excluded variable
2006	$Y = 9.570 - 0.094 X_1$	Minimum humidity	Maximum temperature, minimum temperature, maximum humidity, rainfall
2007	$Y = 5.098 - 0.011 X_1$	Rainfall	Maximum temperature, minimum temperature, maximum humidity, minimum humidity
2008	$Y = 6.437 - 0.120 X_1$	Rainfall	Maximum temperature, minimum temperature, maximum humidity, minimum humidity
2009	$Y = 14.547 - 0.282 X_1$	Maximum temperature	Minimum temperature, maximum humidity, Minimum humidity, rainfall

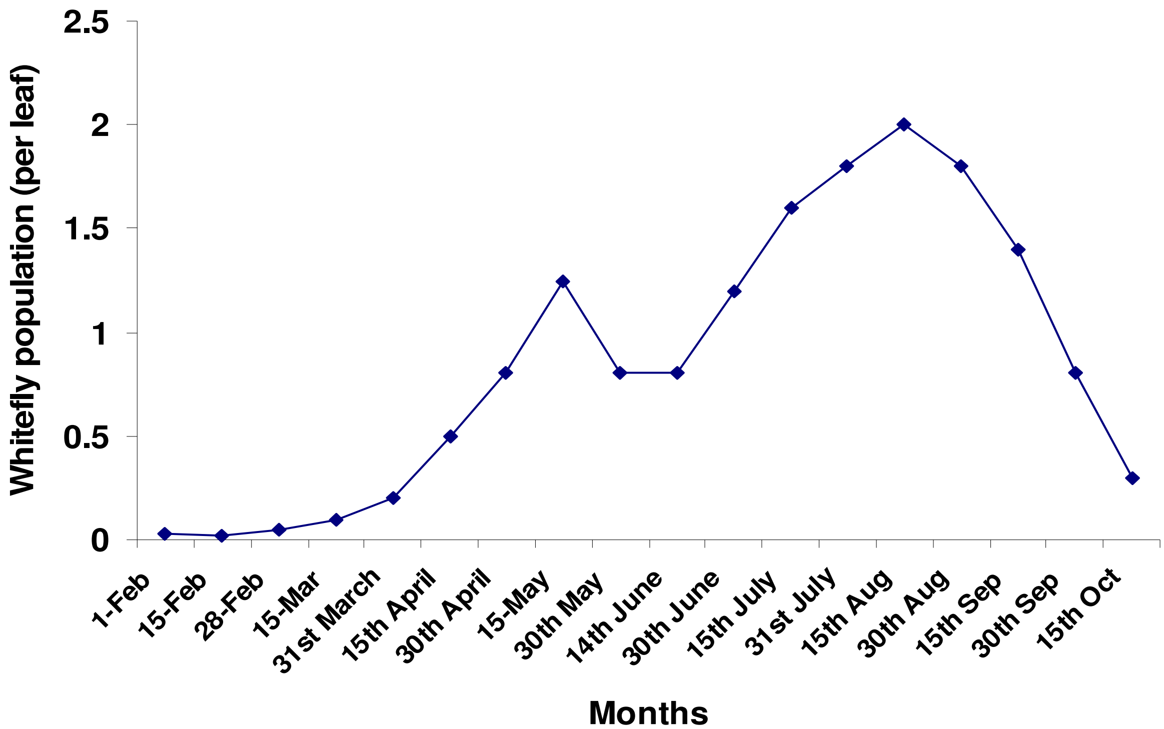

Figure 2. Monitoring of whitefly population at periodic interval (pooled over four years).

Table 7. Estimation of percent disease index (P.D.I %) of yellow vein mosaic virus disease (YVMV) at different sowing dates (pooled over four years).

Sowing date	P.D.I (%) estimated at different days after sowing (DAS)			
	35 (DAS)	45 (DAS)	55 (DAS)	65 (DAS)
1st February	0.0	0.0	5.8	17.2
16th February	0.0	4.5	15.6	23.6
1st March	2.5	21.6	32.2	39.4
16th March	12.7	33.2	56.5	71.2
1st April	11.8	37.6	63.2	78.9
16th April	14.9	32.7	58.2	74.8
1st May	23.2	41.7	68.5	86.7

DAS, Days after sowing.

during February to 1st fortnight of April and reached its peak in the month of August (Figure 2). The percent disease index of YVMV at different sowing dates was estimated at periodic interval (Table 7) and it has been observed that there was a positive correlation between whitefly population and disease incidence. The seed yield of okra was highly influenced by the incidence of YVMV and higher yield was obtained during disease free period, particularly between February-March. Delayed sowing has caused more incidence of disease resulting to reduction of seed yield and seed quality. More than 30% disease incidence within forty five days after sowing was observed in the plants with sowing dates that started from second fortnight of March onwards which may be a cause of poor yield as compared to the previous sowing dates.

Effects of sowing time on economic analysis of seed production

The economic analysis revealed that seed production of okra was found to be remunerative on and from 1st February to 2nd April sowing date (Table 8). The income per rupee investment of okra seed crop was found to be the maximum (2.40) when sown at 2nd fortnight of February followed by sowing on 1st March. (1.90).

Table 8. Economic analysis of okra seed crop based on mean seed yield.

Sowing date	Gross return (Rs.)	Net return (Rs.)	Income per rupee investment
1st February	56,000	36,000	1.80
16th February	68,100	48,100	2.40
1st March	58,000	38,000	1.90
16th March	50,800	30,800	1.54
1st April	45,200	25,200	1.26
16th April	38,500	18,500	0.92
1st May	34,300	14,300	0.71

Considering the cost of cultivation of okra seed crop = Rs. 20,000/- ha^{-1}, farm gate price of okra seed = Rs. 100/- kg^{-1}.

In conclusion, sowing of okra seed at 2nd fortnight of February was found to be the most suitable approach to get higher yield, comparatively lower YVMV disease incidence and better quality seeds under the Gangetic alluvium of eastern India.

REFERENCES

Adetunji IA, Chheda HR (1989). Seed yield stability of okra as influenced by planting date. Plant Breed. 103: 212-215.

Akinyele BO, Osekita OS (2006). Correlation and path coefficient analyses of seed yield attributes in okra (*Abelmoschus esculentus* L. Moench). Afr. J. Biotechnol. 5: 13330-1336.

Anitha P, Anitha P, Sadhankumar PG, Rajan S (2001). Effect of maturity stages on seed quality of okra. Vegetable Sci. 28: 76-77.

Chattopadhyay A, Dutta S, Bhattacharya I, Karmakar K, Hazra P (2007). Technology for Vegetable Crop Production. Published by All India Coordinated Research Project on Vegetable Crops, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani-741235, Nadia, West Bengal, India, p. 226.

Gomez KA, Gomez AA (1984). Statistical Procedures for Agricultural Research (2nd Ed.). John Wiley and Sons. New York. p. 680.

Heydecker W (1977). Stress and seed germination: an agronomic view. In the physiology and biochemistry of seed dormancy and germination. (eds. A.A. Khan), Amsterdam, North Holland Publishing Company

Hossain MD, Salam MA, Islam MS, Masud MAT (1999). Yield and quality of okra (BARI Dherosh-1) seed as influenced by time of sowing and plant spacing. Bangladesh J. Seed Sci. Technol. 3(1-2): 83-87.

Huda MN, Samiruddin M (1987). Vegetable Seed Technology in Bangladesh. 1st Pub. BADC. Dhaka, p. 282.

ISTA (International Seed Testing Association) (1985). International Rules for seed Testing. Rules (1985). Seed Sci. Tech. 13: 356-513.

Kochhar SL (1986). Tropical Crops. A text book of economic botany. Macmillan Indian Ltd., pp. 263-264.

Koay SH, Chua SE (1978). Effect of fertilizers on vegetative growth and pod production in okra *(Hibiscus esculentus* L.). Singapore J. Prio. Ind. 6: 76-79.

Mondal G, Malik SC, Maity TK (1989). Effect of sowing date and spacing on the growth and yield of okra. Crop Res. Hisar. 2(2): 230-231.

Maquire JD (1962). Speed of germination-aid in selection and evaluation for seedling emergence and vigour. Crop Sci. 2: 176-197.

Moniruzzaman M, Uddin MZ, Choudhury AK (2007). Response of okra seed crop to sowing time and plant spacing in south eastern hilly region of Bangladesh. Bangladesh J. Agril. Res. 32(3): 393-402.

National Horticulture Board (2009). Indian Horticulture Database, Ministry of Agriculture, Government of India.

Nonnecke IL (1989). Vegetable Production. Van Nostrand Reinhold AVI Publishing, pp. 608-609.

Sastry KSK, Singh SJ (1974). Effect of yellow vein mosaic virus infection on growth and yield of okra crop. Indian Phytopath. 27: 294-297.

Singh KP, Malik YS, Lal S, Pandita ML (1986). Effects of planting dates and spacing on seed production of okra (*Abelmoschus esculentus* (L). Moench. Haryana J. Hort. Sci. 15(3-4): 267-271.

Thomson HC, Kelly WC (1979). Vegetables Crops. McGraw Hill Co. New York, p. 562.

Tindall HD (1983). Vegetables in the Tropics. McMillan AVI., pp. 325-327.

Yadav SK, Dhankar BS (2001). Seed production and quality of okra (*Abelmoschus esculentus* (L.) Moench) as affected by sowing time and position of fruit on plant. Seed Res. 29(1): 47-51.

Zeven AC, Zhukovsky PM (1975). Dictionary of Cultivated Plants and their Centres of Diversity. Centre for Agricultural Publishing and Documentation, Wageningen, The Netherlands, p. 210.