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Estimation of yield loss in mesta crop infected by *Mesta yellow vein Mosaic virus*

Arpita Chatterjee
Assistant Professor and Head, Department of Botany, Barasat College, Kolkata, West Bengal, India

Abstract
Losses in both fibre yield, seed yield and fibre quality of Mesta crops infected with *Mesta Yellow Vein Mosaic Virus* has been studied. Estimation of yield losses were compared in field condition in infected and uninfected Mesta plants with varying fertilizers regimes. The study was conducted in three different farmers' field of Basirhat District of West Bengal, India for consecutive three years. Results showed that the disease caused considerable yield losses in Mesta plants. Further, infected plants showed reduction of fibre fineness and fibre strength, and this caused reduction of fibre quality in diseased crop.

Keywords: mesta, fibre yield, seed yield, fibre quality, fibre fineness, fibre strength, *Mesta Yellow Vein Mosaic virus*

Introduction

Hibiscus cannabinus L. in the western world is popularly known as kenaf. It belongs to the family Malvaceae. In India it is also known as bimli, bimlipatum, Deccan hemp, gogu, chana, ambadi, gongkura, sunbeeja, sunkura, etc. *Hibiscus sabdariffa* L. is another species of *Hibiscus and* commonly known as roselle. It is a close relative of kenaf. It is also called as Pusa hemp, Java jute, Thai jute, tengrapat, lalambadi, chukair, yerragogu, palechi, pundibeeja, etc. Both of these crops are collectively regarded as mesta. The chromosome number of *H. cannabinus* and *H. sabdariffa* is 2n = 36 and 2n = 72, respectively. *H. cannabinus* is faster growing crop and at around 150 days it attains maturity. The late maturing crop, *H. sabdariffa,* is ready for harvest at around 180 days.

The plants are annual, bisexual, and characterized by large cream colours, with reddish purple or a scarlet throat. The leaves are either simple or compound in case of kenaf, whereas in roselle they are alternately borne on the stem and are generally palmate, and deeply lobed. The stem of kenaf is more or less rigid whereas in roselle it is flexible (Singh, 1997) [1].

Mesta crops produce bast fibers of commerce upon retting from the stems. These fibres are used as a substitute of jute fibers. They are used for making canvas, rope, cordage, carpet backing, sacking, and fishing nets etc. They are also cultivated for seeds secondarily.

The seeds contain about 20% oil and that are used for cooking, making salad, lubricant oils, in the manufacture of paints, soap, linoleum, varnishes. Furthermore, after extraction of oil from seed a concentrated food is produced, which is known as seed-cake, and it is used for cattle. Recently, mesta plants or fibres are used in paper-industry. Mesta especially kenaf is also used as a folk remedy. It is used for bilious conditions, fever, bruises, and puerperium (Duke and Wain, 1981) [2]. It has therapeutic role in dysentery, rheumatism, coughs, eye-sore and disease of blood, throat and bile (Ambasta, 1992; Bhandari, 1978; Duke, 1986; Hazra *et al.*, 2003; Kirtikar and Basu, 1975; Pal and Jain, 1998; Watt, 1972) [3, 4, 6, 7, 8, 9]. The calyces of roselle have been found useful in the preparation of jam, jellies and sauces.

Mesta crop is cultivated in more than 26 lakh hectares of area, and produce fibres which is responsible for over 12 lakh bales annually (Singh, 1997) [1]. Data revealed that Andhra Pradesh constitutes 40.3% and 53.7% of the total acreage and production respectively and thus ranks first both in area and production. Orissa comes next and shares 15.7% and 16.0% in area and production, respectively. Bihar holds the third position and its share comes to 9.7% and 11.3% of the total area and production, respectively. West Bengal holds fourth place in area and production accounting to 4.5% and 5.7%, respectively. The contribution of other states is less than 3% (Singh, 1997) [1].

In India, among all the states, the average productivity of mesta is highest in Tripura (1441 kg/ha). It is followed by second position in Andhra Pradesh (1399 kg/ha), and then West Bengal (1334 kg/ha), Bihar (1220 kg/ha), Orissa (1083 kg/ha), Assam (880 kg/ha) and Meghalaya (844 kg/ha). The average yield is poor in other states (Anonymous, 1999).

But the average yield of mesta is quite low (900-1800 kg/ha) in India as compared with that of in Cuba (2700 kg/ha), the largest producer of these crops. Thus India is the chief importer of mesta fibres. This is due to many pathogenic attack of these crops by various pathogens, *viz.* viruses, bacteria, fungi, and nematodes.

A virus-disease very similar in symptomatology with that of reported yellow vein mosaic has been found to occur on both kenaf and roselle grown in this region causing severe retardation in growth and yield (Mandal *et al.*, 2002; Jose and Usha, 2000) [11, 12]. Survey of literature reveals the occurrence of such type of disease in endemic form in different areas in India, *viz.* Andhra Pradesh, U.P., Bihar, Orissa and West Bengal (Chatterjee *et al.*, 2005, 2006, 2007). For the last few years this type of disease is spreading at a fast rate causing very severe symptoms on leaves of infected plants with greater reduction in photosynthetic area and yield and thus assumes a major threat to production. The causal organism is a begomovirus named *Mesta Yellow Vein Mosaic Virus* (Chatterjee *et al.*, 2005; Ghosh, *et al.*, 2007). Besides these, many other viruses from different types of hosts are also found to attack these crops and induce symptoms resulting into loss in fibre yield (Chatterjee, 2020). But any detailed study on the fibre yield, seed yield, fibre quality of these crops infected with this virus has yet not studied well. This paper in an attempt in this direction.

Materials and Methods

Both fibre and seed yield losses, due to mesta yellow vein mosaic disease, were estimated by comparing infected and uninfected plants. The mesta plants were grown with varying levels of fertilizers under field condition. The study was conducted in three different farmers' field of Basirhat District of West Bengal, India for consecutive three years.

a. Yield loss assessment under different fertilizer levels

The plants were sown in the month of April for fibre purpose, whereas in the month August late sowing was done for seed purpose. Two susceptible cultivars, for kenaf HC-583 and for roselle HS-4288, were used. Healthy seedlings of mesta were grown in randomized block design (RBD), in eight small field plots (2 x 2.5 m), containing 100 plants each, 6 cm apart each other. Four varying levels of fertilizers ($N_0P_0K_0$, $N_{20}P_{10}K_{10}$, $N_{40}P_{20}K_{20}$ and $N_{60}P_{30}K_{30}$) were used, for the two cultivars (four for HC-583 and four for HS-4288). In this way three replications were maintained for each type of plant.

For disease development, the germinated plants were allowed to grow under natural environment. After the symptom appearance, the total number of plants infected with the disease were noted, and average plant height and fibre weight were also recorded. The control plants were also maintained in the similar way and they were kept under insect-proof net to avoid contact with the whiteflies that act as vector of the disease. Same plot design was also followed for the purpose to study the seed yield. To estimate the loss in fibre yield, 120 days old plants were harvested, and fully matured seeds was harvested for assessing the seed yield. The yield of the control plants with a specific fertilizer dose was compared with those of diseased counterpart.

b. Assessment of fibre quality

Fibre quality like fibre fineness and strength were estimated by comparing the fibres obtained from both infected and uninfected plants, grown under varying levels of fertilizers in field condition, as stated earlier. Fibre fineness and strength was recorded using the method followed for Airflow Fibre Fineness Tester and Fibre Bundle Strength Tester, respectively.

Results

a. Yield loss assessment under different fertilizer levels

Results showed that the disease caused considerable yield losses in mesta plants under varying levels of fertilizer conditions (Table 1). The yield loss for fibre was found to be maximum of 25.51% for HC-583 and 17.31% for HS-4288 at $N_{60}P_{30}K_{30}$ fertilizer level, whereas in case of seed yield a maximum of 30.66% for HC-583 at $N_{60}P_{30}K_{30}$ fertilizer level and 27.40% for HS-4288 at $N_{40}P_{20}K_{20}$ fertilizer level was noted. Under optimum fertilizer level ($N_{40}P_{20}K_{20}$), the minimal loss appeared for both fibre yield (9.28%) and also for seed yield (12.05%) in case of HC-583. In any variation in level (either low or high) of fertilizers used the loss become more. But in case of HS mesta plants the effect was altogether different in case of fibre yield (Table 1). Under optimum fertilizer level, *i.e.* $N_{60}P_{30}K_{30}$, minimal loss was found in case of seed yield (11.31%) in HC-583. But in case of HS-4288, at fertilizer regime $N_{20}P_{10}K_{10}$ minimum loss for fibre yield (6.77%) was noted.

Table 1: Assessment of yield loss of both fibre and seed of Mesta plants under varying levels of fertilizers in field condition.

Varying levels of fertilizers	Plant type	Fibre yield loss: Average fibre wt. (g)		Seed yield loss: Average seed wt. (g)	
		HC-583	HS-4288	HC-583	HS-4288
$N_0P_0K_0$	Healthy	486 (±0.19)	432 (±0.22)	523 (±0.36)	468 (±0.52)
	Diseased	382 (±0.20)	399.96 (±0.18)	395 (±0.06)	373.33 (±0.26)
	% Reduction	21.39	7.42	24.47	20.22
$N_{20}P_{10}K_{10}$	Healthy	447 (±0.23)	473 (±0.34)	620 (±0.36)	493 (±0.24)
	Diseased	393.06 (±0.18)	441 (±0.22)	490 (±0.17)	415 (±0.19)
	% Reduction	12.07	6.77	20.97	15.82
$N_{40}P_{20}K_{20}$	Healthy	502.67 (±0.19)	501.02 (±0.43)	595 (±0.46)	551 (±0.63)
	Diseased	456 (±0.36)	411.72 (±0.77)	523.33(±0.84)	400 (±0.36)
	% Reduction	9.28	9.31	12.05	27.40
$N_{60}P_{30}K_{30}$	Healthy	573.20 (±0.19)	581.67 (±0.09)	658 (±0.34)	498 (±0.61)
	Diseased	427 (±0.28)	481 (±0.23)	456.24 (±0.41)	441.66 (±0.18)
	% Reduction	25.51	17.31	30.66	11.31

*Mean average of 10 plants ± S.E. in parenthesis.

The result revealed 22.12% average plant height reduction in case of HC-583, and in case of HS-4288 the reduction was 16.81% in diseased condition (Table 2).

Table 2: Plant height reduction in diseased plants.

Genotype	Average no. of infected plants / plot (%)	Plant height (cm)		
		Healthy*	Diseased*	% decrease
HC-583	78	235 (±0.16)	183 (±0.11)	22.12
HS-4288	32	244 (±0.12)	203 (±0.09)	16.81

*Mean average of 10 plants ± S.E. in parenthesis.

b. Assessment of fibre quality

Under varying fertilizers levels in field condition showed that the disease caused considerable fibre quality losses and this is for both fibre strength and fibre fineness (Table 3). In each case the healthy plants showed greater fibre quality over the diseased plants.

Table 3: Fibre quality assessment in field condition in mesta crops.

Fibre Quality	Plant type	Treatments							
		$N_0P_0K_0$		$N_{20}P_{10}K_{10}$		$N_{40}P_{20}K_{20}$		$N_{60}P_{30}K_{30}$	
		HC-583	HS-4288	HC-583	HS-4288	HC-583	HS-4288	HC-583	HS-4288
Fibre fineness (tex)*	Healthy	3.72 (±0.01)	3.58 (±0.00)	3.40 (±0.02)	3.04 (±0.01)	3.82 (±0.01)	3.35 (±0.01)	3.88 (±0.03)	3.28 (±0.01)
	Diseased	3.11 (±0.01)	3.43 (±0.02)	2.92 (±0.00)	2.32 (±0.00)	3.21 (±0.01)	3.06 (±0.01)	3.26 (±0.00)	2.64 (±0.01)
	Reduction over healthy plants (%)*	16.40 (±0.11)	4.18 (±0.19)	14.12 (±0.13)	23.68 (±0.16)	15.97 (±0.08)	8.66 (±0.19)	15.9 (±0.03)	19.51 (±0.23)
Fibre strength (g/tex)*	Healthy	19.22 (±0.13)	20.19 (±0.09)	23.40 (±0.11)	21.12 (±0.12)	26.71 (±0.16)	24.21 (±0.11)	14.41 (±0.12)	17.01 (±0.09)
	Diseased	16.64 (±0.12)	17.23 (±0.05)	16.77 (±0.13)	13.05 (±0.07)	13.12 (±0.09)	14.09 (±0.08)	10.90 (±0.12)	10.92 (±0.12)
	Reduction over healthy plants (%)*	13.42 (±0.02)	14.66 (±0.19)	28.33 (±0.09)	38.21 (±0.42)	50.88 (±0.31)	70.23 (±0.12)	24.36 (±0.16)	35.80 (±0.23)

*Mean average of 10 plants ± S.E. in parenthesis.

The fibre fineness reduction of diseased crops was maximum at $N_0P_0K_2$ fertilizer level (16.40%) in case of HC-583. But in case of HS-4288 maximum reduction (23.68%) noted at fertilizer level $N_{20}P_{10}K_{10}$ (Table 3).

The fertilizer level $N_{40}P_{20}K_{20}$ caused maximum reduction in fibre strength for both species of diseased crops (Table 3). This reduction was 70.23% for HS-4288 and 50.88% for HC-583.

Discussion

The disease was first noticed in plants grown in Andhra Pradesh and then in West Bengal, India (Chatterjee *et al.,* 2005). Later on, the same disease was reported from Uttar Pradesh (Ghosh *et al.,* 2007). The disease appeared to be more in *sabdariffa* type of mesta plants than those of *cannabinus* type. The disease is transmitted through whitefly (*Bemisia tabaci*). The disease was also found to be transmitted by cleft grafting but not with sap or seed from infected plants (Chatterjee *et al.*, 2005). Molecular characterization revealed the association of a monopartite begomovirus and a betasatellite molecule having the genome size of 2.7 kb and 1.3 kb, respectively with the disease from eastern India and reported it as *Mesta yellow vein mosaic virus* (MeYVMV), a new species of *Begomovirus*. The association of an isolate of *Cotton leaf curl Multan betasatellite* was also noticed with the disease appearing in eastern India (Chatterjee and Ghosh, 2007, 2007a). Present study revealed that when mesta plants get infected at early stage of plant development with this viral disease, stunted growth was observed and resulted low fibre yield. The infected plants either did not produce any pod or even if pod was set that became few in number and thus seed yield became very low. Further, infected plants showed reduction of fibre fineness and fibre strength, and this caused reduction of fibre quality in diseased crop.

The fibre production in any bast fibre crops are regulated by the cambium activity, and the amount of fibre produced are the reflection of rate of cambium activity, due to which further production of vascular bundles, number of fibre bundles, initiation of fibre layers in plant vascular system (Agrios, 1997). Earlier study by Chatterjee and Ghosh (2008) showed that this normal cambial activity of infected plants altered due to diseased condition caused by viral infection, and this finally reflects enormous changes in anatomy of gross internal structures of mesta plants.

With regard to stem anatomy it was observed that the fibre cells present in per bundle was less in number in diseased plants. Further, the fibre bundles of infected plants was smaller in size as compared with the healthy plants. This low amount of fibre formation had direct impact on fibre yield. It proved the fact that yellow vein mosaic disease of mesta caused low fibre yield as compared with healthy mesta plants. In case of healthy plants the fibre bundles were more or less of same size in majority of the plants tested and thus it could be concluded that the fibre bundle formation maintained uniform pattern. In contrast, the uniformity of fibre bundle development was not found in diseased material. In some cases they were malformed, individual fibre cells only represented the fibre pyramids without forming the fibre bundles (Chatterjee, 2013, 2020).

It was found that in in healthy plants secondary growth is prominently more than primary vascular growth. But in case of diseased stem, to less number of secondary vascular bundles were observed with higher number of primary vascular tissues. Histological evidence also focused that this malformation of vascular system in infected mesta plants caused by this disease-causing agent emphasized improper differentiation of vascular tissue. This is finally resulted a major factor for contributing fibre yield reduction in the diseased mesta plants (Chatterjee and Ghosh, 2008).

Conclusion

The fibre yield loss for was found to be maximum of 25.51% for HC-583 and 17.31% for HS-4288 at $N_{60}P_{30}K_{30}$ fertilizer level, whereas in case of seed yield a maximum of 30.66% for HC-583 at $N_{60}P_{30}K_{30}$ fertilizer level and 27.40% for HS-4288 at $N_{40}P_{20}K_{20}$ fertilizer level was noted. Under optimum fertilizer regime ($N_{40}P_{20}K_{20}$), minimal loss was observed in fibre yield (9.28%) and also in seed yield (12.05%) in case of HC-583. In case of HS-4288, minimal loss (11.31%) was found in seed yield under optimum fertilizer regime ($N_{60}P_{30}K_{30}$), but for fibre yield minimum loss (6.77%) was found under fertilizer regime $N_{20}P_{10}K_{10}$. Average plant height reduction was 22.12% for HC-583 and 16.81% for HS-4288 in diseased condition. The reduction in fibre quality in respect to fibre fineness of diseased crops was maximum (16.40%) at $N_0P_0K_2$ fertilizer regime for HC-583, but in case of HS-4288 maximum reduction (23.68%) was noted at $N_{20}P_{10}K_{10}$ fertilizer regime. At $N_{40}P_{20}K_{20}$ fertilizer regime maximum reduction in fibre strength was observed for both HC-583 (50.88%) and HS-4288 (70.23%) of diseased crops.

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