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Effect of plant growth regulators on the quality of bast fibres in *Abelmoschus esculentus* (Linn.) Moench.

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Abelmoschus esculentus (Linn) Moench. vernacularly variously called okra, bhindi or ladies' fingers, is a vegetable crop and a source of soft fibre which has not been commercially exploited. The use of its fibre as an admixture with jute and also in paper and cardboard manufacture is already documented. The present investigation highlights the effect of plant growth regulators like gibberelic acid (GA) and naphthalene acetic acid (NAA) on the quality of bast fibres in *A. esculentus*. The fibre quality was best in GA 100 + NAA 50 μg mL^{-1} treatment. Fibre macerate studies showed an increase in fibre length and the slenderness ratio was also high. The Runkel ratio for the above treated fibre was between 1 and 2 rendering it suitable for the textile industry. Proximate analysis of retted fibres revealed a lower moisture and ash content and an increase in wax content. Fourier transform infra-red (FTIR) spectroscopy analysis registered a high crystallinity index. The physico--mechanical properties showed considerable improvement of fibre quality. Considering the above criteria, GA100 + NAA 50 μg mL^{-1} treatment brought about advantageous changes for improving the quality of fibres. This study is significant in promoting the exploitation of a non-conventional bast fibre source for use in textile industry.

Keywords: *Abelmoschus esculentus*, bast fibers, quality, plant growth regulators, naphthalene acetic acid (NAA), gibberellic acid (GA)

Introduction

Abelmoschus esculentus (Linn) Moench. belonging to family Malvaceae, commonly called »Ladies' fingers« or »Okra« / »Bhindi«, is an annual, 3–7 feet tall, pubescent herb. The plant is considered to be African or Asian in origin and is valued for its edible tender fruits as vegetable. The stalks as a source of fibre have not been commercially exploited. After the harvest of the fruits the stalks are generally allowed to go waste or used as fuel. If however they are collected green and subjected to retting, a useful fibre can be extracted which is white, light cream or yellow in color, silky, strong and pliant. It can be spun into yarn and be used for rope, twine and sacking. The fibre can be spun on jute mill machinery. It can be used in an 85% admixture with 15% jute in sacking cloth. The fibre is also suitable for the manufacture of paper and cardboard (ANONYMOUS 1985). The earlier studies on bast fibres were directed toyield and quality but

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studies on the improvement of bast fibres for textiles using plant growth regulators are fragmentary (ATAL 1961, ALONI 1990). The present study was directed to the improvement of fibre quality for the textile industry using plant growth regulators like NAA and GA in *A. esculentus.*

Materials and methods

Plant material

Seeds of *A. esculentus* were procured from the National Seeds Corporation, Ambattur, Chennai, India and used to raise plants for the experiments. Seedlings were raised in wide pots of 60 cm diameter and transplanted to pots of a uniform size of 30 cm diameter. The pots were filled with sand, red soil and farmyard manure in the ratio of 1:1:1 and maintained under garden land conditions. Five to six plants were grown in each pot and ten pots were maintained for each treatment including controls. Plants were irrigated uniformly throughout the period of experiment and treatments were given when plants were 10 days old.

Various combinations of different concentrations of plant growth regulators (PGRs) like NAA and GA were applied as foliar sprays (Tab. 1). The spraying was done at the end of each week for seven consecutive weeks. The experiment was repeated thrice and plants were harvested after 45 days. Ten samples were observed and analyzed in each of the studies undertaken. The parameters taken for study included stem height, length of internodes, diameter, fibre yield, fibre dimensions, analytical characters like moisture content, ash and wax content and crystallinity index of fibres and physico-mechanical properties of fibres.

Tab. 1. Combinations and concentrations of plant growth regulators (PGRs) applied as foliar sprays

S.No.	Treatment	PGRs used	Concentration
1.	Control	–	–
2.	GA 100	GA	100 μg mL^{-1}
3.	NAA1	NAA	50 μg mL^{-1}
4.	NAA2	NAA	100 μg mL^{-1}
5.	NAA3	NAA	200 μg mL^{-1}
6.	GN1	GA+NAA	100 + 50 μg mL^{-1}
7.	GN2	GA+NAA	100 + 100 μg mL^{-1}
8.	GN3	GA+NAA	100 + 200 μg mL^{-1}

Fibre dimensions

Fibre macerates were prepared from stripped bark samples, which were cut into 10 x 5 mm segments. They were treated in Jeffrey's Maceration fluid (JOHANSEN 1940) for a duration of 10 hours at 50°C in an oven. Samples were washed thoroughly and stored in 70% alcohol for studying of the microscopic features and for collection of the morphometric data. Macerated fibres from the base, middle and tip regions were pooled from ten samples for each treatment and 100 fibres were chosen at random for measurement and the mean was calculated. Length (L), diameter (D), Lumen width (LW) and Wall thickness (WT) were measured using a micrometer. The following derived values were calculated from the data on the dimensions of fibres following TAMOLONG et al. (1980).

$$\text{(i)} \quad \text{Slenderness ratio (SR)} = \frac{\text{Length of fibre}}{\text{Diameter of fibre}}$$

$$\text{(ii)} \quad \text{Flexibility ratio (FR)} = \frac{\text{Lumen width of fibre}}{\text{Diameter of fibre}} \times 100$$

$$\text{(iii)} \quad \text{Runkel ratio (RR)} = 2\times \frac{\text{Wall thickness}}{\text{Lumen width}}$$

Wall Characteristics

Unstained fibre macerates from both control and treated samples were viewed under polarized light. Photomicrographs were taken under a Nikon microscope equipped with a polariser and an analyser in cross-position. A first-order red plate was placed over the polariser at an angle of 45° to create a red background (BENNET 1950, DAYANANDAN and PON SAMUEL 1979). Documentation was done using 100 ASA Konica colour negative film, processed and printed at local commercial laboratories.

Analytical studies

The retted fibres were sun-dried and powdered using a homogeniser. The crude powder samples from each of the control and experimental species were passed through 40 mesh and by repeated sieving, a fine powder was obtained. Proximate chemical analysis including estimation of percentage moisture, estimation of ash and alcohol-benzene solubility percentage were carried out for both treated and control samples employing the protocol mentioned in Tappi test methods (ANONYMOUS 1993).

The crystallinity index of the control and treated samples was calculated by Fourier Transform Infrared Spectroscopy (FTIR) following the protocol of SILVERSTERIN (1980) and MERRITT (1986). The retted fibres were homogenized, sieved and ground with potassium bromide in the ratio of 1:80 using a mortar and pestle. From the ground sample, pellets of 0.2mm thickness were made according the protocol developed by KEMP (1991). The pellets were used in a Bruker IFS66V spectrophotometer and the spectrum was recorded as percentage transmittance over a wave number range of 4000–400 cm^{-1}.

Crystallinity index was calculated following the NELSON and O'CONNOR (1964) formula

A1372 / A2900 where the band appearing at 1372 cm^{-1} was taken as the crystalline band and the band at 2900 cm^{-1} as amorphous band. In the present study, the bands around 1378–1374 cm^{-1} and 2923–2916 cm^{-1} were taken to arrive at the crystallinity index:

A 1372 = Absorbance for band at a frequency of 1372 cm^{-1}

A 2900 = Absorbance for band at a frequency of 2900 cm^{-1}

Physico-mechanical properties

The different physico-mechanical properties of fibres studied were tensile property, elongation percentage and fibre fineness. The tensile properties were measured using Instron Model 1121 Tensile tester (BOOTH 1968). A gauge length of 15mm with a rate of extension of 5mm/min pretension of 1kg/dtex was used. Cross head speed of 50mm/min was

used while testing all the fibres. The maximum load supported by the fibre was reported as the breaking load and the corresponding elongation as the breaking elongation. Tenacity and elongation were determined from the average of 20 tests. Elongation was expressed as elongation percentage.

$$\text{Tenacity} = \frac{\text{Breaking strength of fibre}}{\text{tex of fibre}} \quad \text{expressed as g/tex.}$$

The gravimetric fineness of fibre expressed as mass per unit length was determined by the cutting and weighing method developed by DURAISWAMY (1991) and was referred to as the tex of the fibre. The mean fibre weight per unit length was calculated and expressed in terms of tex values.

$$\text{Tex of fibre} = \frac{\text{Weight of fibre bundle}}{\text{Length of fibre bundle}}$$

Statistical analysis

Data on fibre dimensions, analytical studies and physico-mechanical parameters were subjected to statistical analyses. Arithmetic mean and standard deviation were calculated for all the data of treated and control samples. Tests of significance for comparison of fibre dimensions, morphological and analytical data in the different treated and control samples were done taking the respective sample means at 0.05 level of significance (SCHEFLER 1969) Analysis of variance (ANOVA) was conducted for comparison of physico-mechanical properties between the different treated and control samples (SCHEFLER 1969). The studentised range, the least significant difference at 0.05 level between any two means, was calculated for each parameter according to SNEDECOR and WILLIAM (1967).

Results and discussion

Exo-morphological characters

The exo-morphological characters like stem height, length of internodes and diameter in control and treated plants is given in Table 2. The mean height at zero hour was 7cm. The plant height was maximum (109.1cm) in GA100 treated plants followed by plants treated with GA(100 μg mL^{-1}) in combination with NAA (50 μg mL^{-1}). Plants treated with GA in combination with NAA at a concentration of 200 μg mL^{-1} showed the least increment in height. A similar trend was observed for length of internodes where a maximum increase of 11.35 cm was observed at the end of seven weeks of spraying in plants treated with GA at a concentration of 100 μg mL^{-1}. The difference in internodal diameter between the treated and control plants was not significant, though all the treated plants showed a higher value than that of the control (Tab. 2).

Fibre Yield

The fresh weight was maximum (120.3 g) in plants treated with GN1 followed by GN2 and GN3. The fresh weight of all the treated plants was higher than that of the control except in the case of plants treated with NAA50 (Tab. 3).

Tab. 2. Comparison of exo-morphological characters in control and treated plants of *Abelmoschus esculentus.* *Significance (p) at 0.01 level. Different alphabets between treatments indicate significance at 0.05 level.

Parameters	F-value	p	Treatments							
			Control	NAA 50	NAA 100	NAA 200	GA 100	GN 1	GN 2	GN 3
Height (cm)	206.97	*	(a)	(a)	(a)	(a)	(c)	(c)	(b)	(a)
Mean			35.00	43.40	37.30	38.80	109.10	109.80	62.20	38.20
SD			± 3.80	± 4.35	± 3.80	± 4.34	± 3.25	± 15.98	± 7.42	± 3.43
Length (cm)	30.30	*	(a)	(a)	(a)	(a)	(c)	(bc)	(b)	(a)
Mean			6.37	6.22	6.18	5.25	11.35	9.60	8.17	5.40
SD			± 1.30	± 1.25	±.76	±.63	± 1.16	± 2.21	± 1.18	±.91
Diameter (mm)	21.44	*	(a)	(b)	(b)	(c)	(b)	(d)	(bc)	(bc)
Mean			5.04	6.24	6.28	7.27	6.08	8.31	6.83	6.39
SD			±.28	±.40	±.36	± 1.04	±.27	± 1.19	±.38	±.56

Tab. 3. Comparison of fibre yield in control and treated plants of *Abelmoschus esculentus.* **Significance (p) at 0.01 level.

Parameters		F-value	p	Treatments							
				Control	NAA 50	NAA 100	NAA 200	GA 100	GN 1	GN 2	GN 3
Fresh	Weight gm	438.13	**	(a)	(a)	(c)	(c)	(b)	(e)	(d)	(d)
	Mean			31.00	28.21	65.52	59.00	39.30	100.56	92.50	90.45
	SD			1.84	3.62	1.87	1.50	2.64	2.00	2.15	2.79
Dry	Weight gm	42.07	**	(a)	(a)	(ab)	(ab)	(ab)	(d)	(c)	(bc)
	Mean			.600	0.540	.995	.945	.980	2.880	1.833	1.35
	SD			0.023	0.023	0.029	0.031	0.015	.376	0.416	0.144

Fibre dimensions

The fibre length in control and treated samples is given in Table 4. Length of fibres was maximum in plants treated GA100 + NAA50 μg mL^{-1} (4188 μm). Increasing concentrations of NAA along with GA and treatment with NAA alone brought about an increment of fibre length. Breadth of fibres was maximum (21.12 μm) in plants treated with NAA200 μg mL^{-1} and minimum (14.81 μm) in control plants. In GA100-treated plants the breadth of fibres was 15.0 μm. Wall thickness was maximum (6.534 μm) in plants treated with a combination of GA100 and NAA50 μg mL^{-1}, followed by plants treated with GN2 and GN3. Wall thickness was minimum (3.29 μm) in plants treated with NAA100 μg mL^{-1}. Lumen width was minimum (7.038 μm) in control plants and maximum (12.024 μm) in plants treated with NAA200 μg mL^{-1}. Plants treated with NAA50 μg mL^{-1} and NAA100 μg mL^{-1} and GA100 + NAA200 μg mL^{-1} showed higher lumen width values.

Tab. 4. Effect of PGRs on fibre dimensions of *A. esculentus*. ** Significance at 0.01 level, *significance at 0.05 level.

Dimensions	Treatments	Mean (μm)	± SD	t-value	p-value
Length	Control	2270	183.40	–	–
	NAA 50	3862	706.06	9.01	0.000**
	NAA 100	3654	431.54	4.47	0.000**
	NAA 200	3421	269.76	4.66	0.000**
	GA	**4202**	487.61	12.74	0.000**
	GN I	4188	422.86	7.44	0.000**
ult1	GN II	3866	430.77	5.52	0.000**
	GN III	3602	218.41	1.20	0.000**
Breadth	Control	14.81	3.88	–	–
	NAA 50	20.48	5.46	7.33	0.000**
	NAA 100	20.90	6.14	7.25	0.000**
	NAA 200	**21.12**	4.71	8.81	0.000**
	GA	15.00	3.90	1.27	0.204
	GN I	16.15	4.21	2.01	0.046*
	GN II	16.46	5.45	3.63	0.000**
lpar	GN III	17.62	4.56	3.10	0.002**
Lumen Width	Control	7.04	3.38	–	–
	NAA 50	9.42	3.34	0.69	0.000**
	NAA 100	10.35	4.98	4.76	0.000**
	NAA 200	**12.02**	4.06	8.17	0.000**
	GA	7.00	2.70	0.36	0.148
	GN I	7.15	3.05	0.72	0.148
	GN II	7.66	4.18	1.65	0.100
	GN III	9.52	4.37	3.89	0.000**
Wall Thickness	Control	3.89	1.31	–	–
	NAA 50	**5.53**	2.14	9.13	0.000**
	NAA 100	5.27	2.39	4.40	0.000**
	NAA 200	4.55	1.49	2.67	0.009**
	GA	4.00	1.47	2.53	0.012*
	GN I	4.50	1.26	2.83	0.005**
	GN II	4.40	1.81	2.16	0.032*
	GN III	4.05	1.49	0.71	0.481

Wall characteristics

The characteristics of unstained fibre observed under polarisation microscope showed variations in lamellation and composition of cell wall. The number of lamellae or layers were more in the treated plants and was maximum in plants treated with GA100 + NAA50. The pitting on the fibres was oblique and multi seriate. The wall showed deposition of lignin in plants treated with GA100 while cellulose deposition was high in plants treated with NAA alone and with a combination of GA and NAA (Fig. 1).

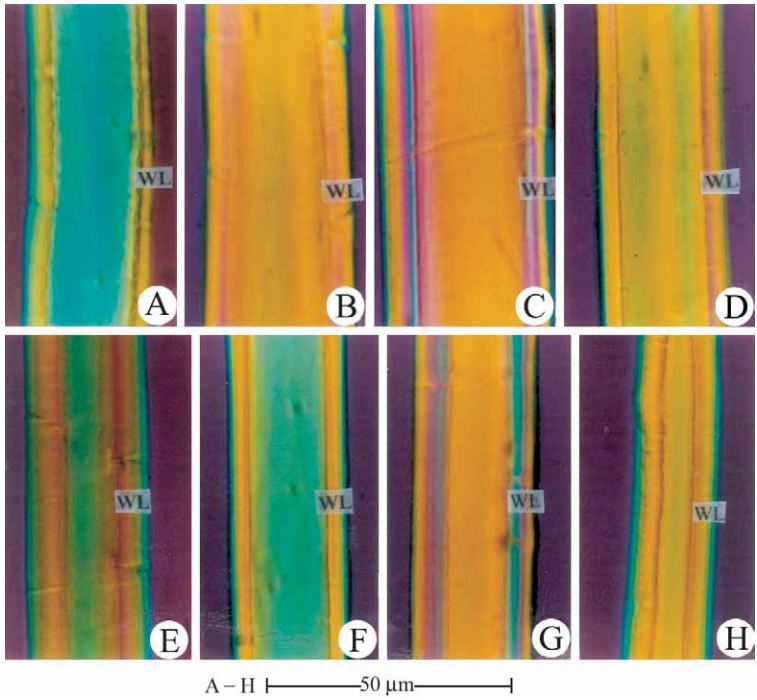

Fig. 1. Fibre macerates of *A. esculentus* as seen under polarization microscope. **A** – control, **B** – NAA 50 µg mL^{-1}, **C** – NAA 100 µg mL^{-1}, **D** – NAA 200 µg mL^{-1}, **E** – GA 100 µg mL^{-1}, **F** – GA 100 µg mL^{-1} + NAA 200 µg mL^{-1}, **G** – GA 100 µg mL^{-1} + NAA 50 µg mL^{-1}, **H** – GA 100 µg mL^{-1} + NAA 100 µg mL^{-1}. The colors green and blue indicate lignin while yellow and pink indicate the presence of cellulose

These observations on fibre dimensions and yield were in accordance with earlier observations of ATAL (1961) on hemp where gibberellin treatment at 100 µg mL^{-1} led to an increase in fibre length. The observations corroborated the findings of ALONI (1987), where combinations of PGRs such as GA and NAA brought about increased fibre length in a wide variety of commercially important plants. The increase in length of fibres could be correlated with the plant height and increase in internodal length. The observations on lumen width and wall thickness were in conformity with earlier observations where ALONI (1990) reported that IAA alone or low GA and high IAA combination induced short fibres with thick lignified walls. Lumen width of fibres showed a strong correlation with mechanical properties. Lesser lumen width imparted favorable mechanical properties to the fibres. MAITI (1970) reported that higher strength is shown by long fibre cells because short fibre cells have many weak points at the cementing region of fibre cells forming fibre strands, but in fibre filaments having long fibre cells, there are few weak points at the time of tension caused by the breaking load. Thus, longer fibres showed higher tenacity. It was also reported that increase in number of wall layers increased the fibre tenacity (MAITI 1980). Hence, in the present investigation, plants treated with a combination of 100 µg mL^{-1} GA and 50 µg mL^{-1} NAA showed favorable fibre dimension and wall characteristics related to better physico-mechanical properties in terms of length and width.

Derived values of fibre dimensions

The derived values for Slenderness ratio, Flexibility ratio and Runkel's ratio are given in Table 5. The slenderness ratio was maximum in GA100 followed by GN1 while the flexibility ratio was low in GN1 when compared to control samples. Runkel's ratio was ideal in GN1 treatment with a value of 1.30.

Slenderness ratio is related to the dimension of fibres such as length and breadth. It may also be referred to as the L/B ratio. The preferred L/B ratio for use in textile industries is between 200–300 (MAITI 1980). Observation on the L/B ratio on the control plants in *A. esculentus* was in accordance with MAITI (1980). But in GA100, NAA 50, GN1 treated plants, a high L/B ratio of 280, 188 and 259 respectively was noticed.

Runkel's ratio is related to lumen width and wall thickness of fibres. Runkel's ratio between 1 and 2 rendered the fibres suitable for use in textiles (MANIMEGALAI, 1999) while Runkel's ratio of 1 or less than 1 was considered to be favorable for paper making in bamboos (TAMOLONG et al. 1980). Similarly, GN1 treatment gave a value of 1.3, which is preferable for the textile industry.

Tab. 5. Effect of PGRs on derived values of fibre dimensions in *A. esculentus.* **Significance at 0.01 level, *significance at 0.05 level.

Derived Values	Treatments	Mean	± SD	t-value	p-value
Slenderness Ratio	Control	153.30	25.27	–	–
	NAA 50	188.60	50.28	2.24	0.027*
	NAA 100	174.80	34.62	2.53	0.012*
	NAA 200	162.70	25.23	4.64	0.000**
	GA	**280.10**	62.27	8.73	0.000**
	GN I	259.30	43.54	3.32	0.001**
	GN II	234.90	50.28	1.37	0.172
	GN III	204.40	27.31	1.95	0.053
Flexibility Ratio	Control	47.50	14.24	–	–
	NAA 50	45.90	12.49	4.86	0.000**
	NAA 100	49.50	18.08	0.96	0.336
	NAA 200	**56.90**	12.00	4.62	0.000**
	GA	46.60	11.35	1.06	0.291
	GN I	44.20	16.50	0.20	0.844
	GN II	46.50	14.04	2.41	0.017*
	GN III	54.00	14.23	2.58	0.011*
Runkel's Ratio	Control	**1.90**	0.85	–	–
	NAA 50	1.17	1.09	4.58	0.000**
	NAA 100	1.01	1.31	0.50	0.617
	NAA 200	0.75	0.44	4.68	0.000**
	GA	1.14	0.84	0.54	0.583
	GN I	1.30	0.59	2.55	0.012*
	GN II	1.15	0.93	0.30	0.764
	GN III	0.85	0.80	2.05	0.043*

Analytical studies

The moisture content, ash content and alcohol-benzene solubility percentage for both control and treated samples are depicted in Table 6. The moisture level and ash content was found to be low in GN1 treatment when compared to control. The alcohol-benzene solubility percentage indicative of wax content increased on GN1 treatment and the maximum value was observed in GA100 treatment.

The crystallinity index was estimated by FTIR analysis of the samples based on the protocol of NELSON and O'CONNOR (1964). Crystallinity index was maximum (1.61) in plants treated with NAA200 followed by NAA100 (0.8191) and GN1 treated plants (0.4521). The crystallinity index was at a minimum in control plants (Tab. 7).

The moisture content is directly related to strength and extension of fibres besides dye absorption. Low moisture content enhanced the drying of fabric (ANONYMOUS 1960). In the

Tab. 6. Effect of PGRs on proximate chemical analysis of retted fibres *A. esculentus.* **Significance at 0.01 level, *significance at 0.05 level.

Analytical Parameters	Treatments	Mean	± SD	t-value	p-value
Percentage of moisture	Control	**8.7**	0.20	–	–
	NAA 50	8.35	0.20	2.14	0.099
	NAA 100	6.9	0.20	11.02	0.000**
	NAA 200	7.01	0.01	13.16	0.000**
	GA 100	6.8	0.20	11.63	0.000**
	GN1	7.96	0.20	4.53	0.008**
	GN2	8.53	0.20	1.04	0.357
	GN3	8.37	0.20	2.02	0.113
Percentage of Ash	Control	2.5	0.20	–	–
	NAA 50	1.56	0.20	5.75	0.005**
	NAA 100	1.67	0.20	5.08	0.007**
	NAA 200	2.3	0.20	1.22	0.088
	GA 100	1.68	0.20	5.02	0.007**
	GN1	1.76	0.20	4.51	0.011*
	GN2	2.6	0.20	0.61	0.573
	GN3	1.9	0.20	3.67	0.021*
Alcohol-benzene solubility percentage	Control	2.42	0.35	–	–
	NAA 50	3.32	0.01	4.32	0.12
	NAA 100	4.71	0.26	9.14	0.001
	NAA 200	6.07	0.11	17.76	0.000**
	GA 100	**6.9**	0.62	11.39	0.000**
	GN1	2.9	0.30	1.89	0.132
	GN2	3.68	0.20	5.62	0.005**
	GN3	4.21	0.20	8.66	0.001**

Tab. 7. Effect of PGRs on crystallinity index of cellulose in *A. esculentus*

S. No.	Treatments	Crystallinity Index
1.	Control	0.3536
2.	NAA 50	0.5800
3.	NAA 100	0.8191
4.	NAA 200	**1.61**
5.	GA 100	0.4660
6.	GN 1	0.4521
7.	GN 2	0.4434
8.	GN 3	0.3834

present study, the moisture content of control plants corresponded with the reports of ALKA et al. (1995). In view of the above, GN treated plants showed favorable proportions of ash and percentage moisture. Wax in fibres could bring about reduction in wettability, which in turn increased the duration of dye uptake. An optimum content of wax imparted desirable lubricating properties for spinning. The present observations corroborated the earlier reports of SEKAR (2000) on jute as far as control plants were concerned.

The degree of crystallinity decreased with increase in percentage moisture in kenaf and jute while in mercerised cotton the negative effect was observed (MUKHERJEE and RADHAKRISHNAN 1972). The degree of crystallinity improved with delignification and partial or complete removal of hemicellulose. In the present study, the crystallinity index was high in GN1-treated plants as compared to the control, rendering it suitable for spinning.

Studies on physico-mechanical properties

The physico-mechanical properties including elongation, fineness and tenacity of control and treated samples are given in Table 8. Elongation was maximum in control plants (13.391%) followed by the GA100 treated plants (9.6802%). Elongation was minimum (4.14%) in GN3 treated plants while fineness of fibre was minimum in GA100 plants (2.06 tex) and maximum (4.7 tex) in plants treated with 100 μg mL^{-1} GA and 200 μg mL^{-1} NAA (GN3). Tenacity was minimum in control plants (13.62 g/tex) and maximum in GN1 (43.28 g/tex) followed by GN2 and GA100 treated plants (Tab. 8).

Flexibility of fibres has a direct correlation with elongation. Maximum elongation percentage was observed in GN3 treatment in *A. esculentus*. Though the elongation percentage values obtained in the present study for control plants of *A. esculentus* did not correspond to the earlier observation of ALKA et al. (1995) in Bhindi, the values were close to the results obtained by CHENG et al. (1992) in ramie yarn.

The tenacity of fibres depends on the breaking load of the fibres and is inversely proportional to fineness or tex of the fibre. In the present investigation, fibres of GN1 treated plants in the investigated species show a high tenacity value. Present results of the control samples were similar to those in cotton, jute and sunnhemp (ISHTIAQUE 2000, SINHA and CHATTERJEE 1977, NAVIN et al. 1986). The fibres in the treated plants investigated at present, show a higher tenacity value than cotton or pineapple leaf fibres, used for apparel (DURAISWAMY and CHELLAMANI 1993).

Tab. 8. Comparison of physico-mechanical properties in *A. esculentus* as effected by PGRs. **Significance (p) at 0.01 level. Different alphabets between treatments indicate significance at 0.05 level

PMP	F-value	p	Control	NAA 50	NAA 100	NAA 200	GA 100	GN 1	GN 2	GN 3
Elongation %	10.1569	**	(c)	(ab)	(ab)	(a)	(bc)	(ab)	(ab)	(a)
Mean			13.3908	5.1826	6.3650	4.6762	9.6802	5.6116	5.7736	4.1402
SD			±3.9436	±.9527	±1.8527	±2.3407	±1.448	±1.8155	±2.4458	±1.3531
Fineness tex	91.7266	**	(ab)	(c)	(b)	(d)	(a)	(ab)	(d)	(d)
Mean			2.5000	3.4700	3.5000	4.3400	2.0600	2.3000	4.3750	4.7000
SD			±.3162	±.1776	±.3069	±.2266	±.0997	±.2235	±.2995	±.2289
Tenacity g/tex	42.1887	**	(a)	(b)	(b)	(b)	(c)	(d)	(c)	(b)
Mean			13.62	17.87	18.26	18.56	30.61	43.20	31.50	21.71
SD			±0.301	±1.988	±1.183	±2.083	±0.754	±1.984	±2.475	±0.582

In the world of today, the commercialization of natural fibres is losing prominence owing to competition from synthetic fibres and the difficulties in large-scale production due to the cultivation of cash crops by farmers. The crop plant presently investigated could be used as an unconventional fibre source besides being used as a vegetable. This study is significant in not only promoting the exploitation of unconventional bast fibre sources for use in the textile industries, but also in the advocation of the growing of these plants as dual crops by farmers.

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