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RESEARCH ARTICLE

FIBRE YIELD ESTIMATION IN SISAL (*AGAVE SISALANA* PERR. EX ENGELM.) THROUGH REGRESSION EQUATION BASED ON SIMPLE BIOMETRIC OBSERVATIONS

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ABSTRACT

Estimation of fibre yield in sisal (*Agave sisalana* Perr. ex Engelm.) is absolutely necessary for well ahead planning of marketing arrangements between the actual grower or cooperatives and the fibre purchaser or mills who are situated geographically in distant locations in India. There is no yield prediction method for sisal which could estimate fibre yield well ahead of harvesting. Therefore, an attempt had been made during 2010-11 at Sisal Research Station, Bamra, Sambalpur, Odisha to develop linear regression equations of fibre yield (Y) estimation by considering number of harvestable leaf (LN), leaf length (LL), leaf breadth (LB), leaf green weight (LW) as independent variables data collected from field experiment. In total, nine regression equations were developed, of which the equation, Y = -1221.428 + (23.327) x LN+ (10.761) x LL+ 21.355 [*where, Y= Fibre yield (g/plant); LN= mean Leaf number per plant (harvestable); LL= mean Leaf length (cm)*] predicted the fibre yield most accurately (2.48 t/ha) with the observed actual yield data (2.39 t/ha) and the coefficient of determination (R^2) value was near unity (0.981). Therefore, the developed regression equation can predict the fibre yield in sisal with acceptable accuracy for edapho-climatic condition prevailing in central plateau region of India.

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INTRODUCTION

Sisal is a leaf fibre producing plant of Aaparagaceae family. Different species of Agaves namely *A. sisalana*, *A. cantala*, *A. vera-cruz*, *A. amaniensis*, *A. angustifolia* and *A. fourcryodes* can produce hard fibre from its leaf. However, among the different species, *A. sisalana* contributes nearly 85% of the total sisal fibre production of the World and for India, more than 90% sisal fibres comes from *A. sisalana*. Sisal fibre is very commonly used in the shipping industry for mooring small craft, lashing, and handling cargo. Besides, it has several other domestic to industrial uses including high strength requiring long-lasting geo-textile and speciality composites. In general, sisal is not much infested by many disease and insect pest; and therefore, sisal plantation does not put pesticide load to the environment. Besides, sisal plants reduce soil erosion through its extensive root system and contributes positively to watershed management (Sarkar, 2015). Sisal has several distinguishing characteristics which makes sisal a 'speciality crop' in the changing climatic condition and for natural resource conservation (Sarkar *et al*., 2010). In spite of so much of merits in the fibre crop, research and developmental efforts put for the crop is limited in India.

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The fibre is produced yearly once during November-February (*comparatively low temperature coupled with less active growth in sisal*) from the matured and harvested leaf through removal of green material by the action of decorticator machine. Immediately after machine extraction the fibre is washed in plain water repeatedly (2-3 times), sundried for 2-3 days and then bailing is done for sale or transportation. As the produce comes under commercial fibre, it is used by the mills located faraway places (Mumbai, Kolkata, Chennai and others) from its actual places of production (Odisha, Chhattisgarh, Jharkhand etc.) in India. Regression equations were already developed for yield estimation in other fibre crops like jute (Das, 1968; Satya *et al*., 2011) and ramie (Sarkar, 2004). Long ago Singh and Sasmal (1994) established sisal yield prediction regression equation using 3 agronomic parameters such as number of thousand leaves/ha (x_1), green weight (q/ha) of leaves (x_2) and green weight (q/ha) of fibre (x_3). The equation was capable of fibre yield prediction at a situation when the sisal production technology were at early stage and the productivity level was quite low (about 10 q/ha). Now the sisal production technology has been improved in multiple factors which could enhance productivity level to a new height of about 25 q/ha. In such high yield situation, the earlier yield prediction equation does not hold good. Moreover, as the said equation used parameters (x_2 and x_3) which are measurable only after harvesting and fibre extraction, so the yield prediction was actually obtained just 2-3 days ahead of fibre bailing (after sun drying). This prediction period of 2-3 days prior to fibre transportation may not be actually helpful for the distant fibre buyer. The mills or the purchaser of the fibre would like to estimate the quantum of fibre that will be available from a particular place sufficiently well ahead before the actual harvest of leaf or fibre production for purchase planning and transportation arrangement. For assisting the supply chain of sisal fibre for smoother operation, fibre yield estimation of sisal at current level of technology development was urgently felt using simple biometric observations from only a sample area of the growing sisal plantation. Therefore, a study was conducted to estimate the fibre yield of sisal well ahead from simple biometric observations that does not require actual harvesting.

Table 1. Basic statistics of the variables

	No. of harvestable leaf/plant	Leaf length (cm)	Leaf breadth (cm)	Green weight of leaf (g)	Fibre yield/leaf (g)	Fibre yield/plant (g)
Maximum	27	133.4	10.6	628.4	34.41	862.1
Minimum	16	97.8	8.3	277.9	7.98	290.2
Range	11	35.6	2.3	350.5	26.43	571.9
Mean	21.3	111.5	9.4	421.9	22.31	475.6
Standard Deviation	3.1	9.1	0.57	94.42	5.01	161.0
Variance	9.4	83.3	0.34	8917.0	25.18	25909.4
Standard Error of Mean	0.43	1.3	0.90	12.35	0.35	2.80
CV%	14.4	8.2	6.16	22.38	22.50	33.85

Table 2. Multiple correlation matrix among the different biometric variables

Variables	No. of harvestable leaf (V_1)	Leaf length (V_2)	Leaf breadth (V_3)	Leaf green weight (V_4)	Fibre yield (V_5)
No. of harvestable leaf (V_1)	1.000	0.767	0.450	0.777	0.905
Leaf length (V_2)	0.767	1.000	0.730	0.949	0.940
Leaf breadth (V_3)	0.450	0.730	1.000	0.663	0.630
Leaf green weight (V_4)	0.777	0.949	0.663	1.000	0.915
Fibre yield (V_5)	0.905	0.940	0.630	0.915	1.000

T value	Table value	V_1-V_2	V_1-V_3	V_1-V_4	V_1-V_5	V_2-V_3	V_2-V_4	V_2-V_5	V_3-V_4	V_3-V_5	V_4-V_5
	2.011	8.18	3.54	8.43	15.17	7.57	19.25	20.86	6.24	5.65	16.20

Table 3. Regression equations for estimation of fibre yield (g/plant)

Eq. No.	Regression equations	Coefficient of determination (R^2)
1.	Y = -541.62 + (47.75) x LN+ 67.57	0.823
2.	Y = -1391.04 + (16.73) x LL + 51.27	0.906
3.	Y = -1175.79 + (175.53) x LB + 126.03	0.394
4.	Y = -185.62 + (1.563) x LW+ 63.92	0.844
5.	Y = -1221.428 + (23.327) x LN+ (10.761) x LL+ 21.355	0.981
6.	Y = -1128.96 + (12.89) x LL+ (0.40) x LW+ 50.18	0.907
7.	Y = -463.59 + (25.94) x LN+ (0.91) x LW+ 38.95	0.948
8.	Y = -1200.62 + (23.18) x LN+ (10.47) x LL+ (0.04) x LW+ 21.56	0.981
9.	Y = -1156.27 +(22.58) x LN+ (11.32) x LL+ (-12.92) x LB+ (0.030) x LW+ 21.19	0.980

where, Y= Fibre yield (g/plant); LN= mean Leaf number per plant (harvestable); LL= mean Leaf length (cm); LB= mean Leaf breadth (cm); LW=mean Leaf green Weight (g)

MATERIALS AND METHODS

Fifty sisal plants were selected randomly from sisal field planted over an area of one ha grown with care providing organic manure (FYM) @ 5t/ha, need based drip irrigation and inorganic fertilizers @ N 120 kg, P_2O_5 30 kg and K_2O 60 kg/ha. Biometrical data such as number of harvestable leaf/plant (LN), leaf length in cm (LN), leaf breadth in cm (LB), green weight of mature leaf in g (LW) and fibre yield obtained from each plant in g (Y) from all the leaves (1065 nos.) of the selected 50 sisal plants were recorded during winter season prior to actual harvesting. In sisal as per standard norms, all the mature leaves are harvested starting from the base keeping at least 12 top leaves remaining intact with the plant for further growth in subsequent years. Accordingly the harvestable leaves were identified, harvested and counted. The collected data were analysed for descriptive statistics, correlation among the parameters and regression studies as per standard statistical procedure as suggested by Panse and Sukhatme (1995). In the regression equations developed, fibre yield per plant was considered as dependent variable and all the remaining parameters as independent variables. The regression equation which contains minimum number of independent variables and showed higher value of coefficient of determination (R^2) was accepted as the regression model for estimation of fibre yield. The fibre yield so obtained using the regression model was compared with the actual fibre yield from the field.

RESULTS AND DISCUSSION

Number of harvestable leaves

It was recorded that from a full grown well maintained sisal plantation the highest number of harvestable leaves per plant were 27 and the minimum was 16, with a mean of 21.3 leaves/plant (Table 1).

Based on the finding, it could be estimated that from one ha of sisal plantation (5000 plants) the harvestable leaf numbers would be between 0.80 and 1.35 lakh.

Leaf length and leaf breadth

The maximum length of harvested leaves was 133.4 cm and the minimum leaf length was 97.8 cm with a mean of 111.5 cm (Table 1). As per the existing 'The Aloe (*kind of sisal*) fibre grading and marketing rules, 1975' of the BIS authority, the minimum fibre length for best grade fibre ('Special') should be 80 cm. So, the minimum fibre length obtained in this study was much higher (97.8 cm) than the minimum prescribed length of BIS standard. The highest and the lowest leaf breadth in the leaf sample were 10.6 cm and 8.3 cm, respectively, with a mean of 9.4 cm (Table 1).

Green weight of leaves

The highest green weight of a harvested leaf was 628.4 g and the lowest weight of a leaf was 277.9 g with a mean value of 421.9 g (Table 1). So the total green weight of harvested leaves per plant was 8.99 kg [(21.3 x 421.9)/1000], and the same for one ha plantation was 44.94 t/ha [(8.99 x 5000)/1000].

Fibre yield

The highest fibre yield per leaf was 34.41 g and the lowest fibre yield was 7.98 g, with a mean of 22.31 g/leaf (Table 1). The highest and the lowest fibre yield values per plant basis were 862.1 g and 290.2 g, respectively. The mean fibre yield per plant was 475.6 g.

Correlation studies

The multiple correlation among the different variables in the fibre yield prediction studies were significant at 5% level (Table 2). Among the parameters, there were strong correlations between the number of harvestable leaf & fibre yield (0.905), leaf length & fibre yield (0.940) and leaf green weight & fibre yield (0.915). Leaf length and leaf green weight was also strongly correlated (0.949).

Regression equations for fibre yield prediction/ estimation

Regression equations (9 nos.) were developed using different biometric variables to estimate sisal fibre yield (Table 3). Among the different equations developed, equation No. 5, where the independent variable like leaf number (LN) and leaf length (LL) were considered, estimated the fibre yield with most accurately (R^2=0.981). The values for harvestable leaf numbers and leaf length can easily be taken without actually harvesting the leaves, hence the equation is able to estimate the fibre yield well ahead. In case of single variable using equations, equation No. 2 (leaf length) could able to estimate fibre yield with higher accuracy (R^2=0.906) and the equation No. 1 (leaf numbers only) also estimated the fibre yield with acceptable accuracy (R^2 = 0.823).

Efficiency of the yield estimation equation

Using the equation No. 5, the estimated fibre yield per plant was 497.18 g/plant as stated below:

Y = -1221.428 + (23.327) x 21.3+ (10.761) x 111.55+ 21.355 g/plant

Accordingly, for one ha sisal plantation (5000 plants) the estimated fibre yield was 2485.9 kg/ha [(497.18x 5000)/1000]. The actual fibre yield obtained from one ha of sisal plantation was 2391.0 kg/ha. So the yield prediction regression equation developed (No. 5) estimated the fibre yield with 96.03% accuracy with only ±3.97% estimation error factor.

Conclusion

The regression equation, Y = -1221.428 + (23.327) x LN+ (10.761) x LL+ 21.355 [where, Y= Fibre yield (g/plant); LN= mean Leaf number per plant (harvestable); LL= mean Leaf length (cm)] developed considering leaf numbers and leaf length as independent variables to estimate the fibre yield well ahead in sisal is acceptable and useful to estimate the sisal fibre yield with higher accuracy.

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