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Stability assessment of jute seed production system in lower Gangetic plains of India

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ABSTRACT

Seed is a critical input for jute crop as it is not feasible to get both the seed and fibre from the same crop. Seed scarcity is a major problem for jute growers as bast fibres are the economic product. Organized jute seed production is lacking in the lower Gangetic plains zone of India, although being a major fibre growing region. Therefore, seed production potential of jute was tested under this agro-climatic zone. Ten jute varieties representing two cultivated species *viz.*, *C. capsularis* and *C. olitorius* were evaluated for five years. This paper compares the traditional models i.e., Linear regression model with the latest GGE Biplot methodology, displaying both Genotype (G) and Genotype × Environment (GE), which are the two sources of variation that are relevant to varietal evaluation. Pooled analysis of variance (ANOVA) revealed significant environmental effect. General mean seed yield of 7.40 qha^{-1} was recorded. Two environments and five varieties recorded positive index. Four varieties S–19, JRO–8432, JRO–524 and JRC–517 were grouped as adapted to high performance environments. Five varieties namely JBO–2003H, JRC–698, JRO–204, JRO–8432 and S–19 were grouped as highly-stable. The variety JRO–524 was grouped as least-stable for seed yield. The varieties S- 19 and JRO- 8432 were suitable over all environments and hence, can be recommended for - for seed production .

1. Introduction

Jute is the one of the most important commercial crops of India and an important source of natural fibres. It is commercially cultivated in India, Bangladesh, China, Nepal, Egypt, Uzbekistan, Sudan, Zimbabwe, Brazil, Thailand *etc*. In India, jute is cultivated in West Bengal, Odisha, Assam, Tripura, Meghalaya and some parts of Bihar and Uttar Pradesh. Its fibres are traditionally used in making twines, yarns, ropes, *etc*. Jute fibre-woven packing materials (gunny bags) are breathable and hence, highly valued for packing of agricultural commodities. Its pulp is used in paper industry. Its fibre is used in preparation of fashion accessories, braids, handicrafts, decoratives, reinforced plastics, particle board *etc*. Jute and Jute-blended fabrics are used in handloom (home furnishing, floor coverings, mats, apparel *etc*.), powerloom fabrics and in knitting garments, bags *etc*. It finds immense uses as a cheaper substitute of petroleum-derived geo-synthetics. Its tender leaves are nutritious (Akoroda, 1988) and have protective values. In recent years, it has also emerged as the potential source of biomass for biofuel (Ferdous et al., 2017). Recently, natural fibres have attracted the attention of intellectuals across the world being eco-friendly, annually renewable and abundantly available. Its importance can be emphasized by the fact that UN declared 2009 as the '*International year of Natural Fibres*'.

Jute is unique when compared to other crops (cereals, pulses and oilseeds where economic part is seed) as its economic part is fibre extracted from the bark of the stem. It is not feasible to get both seeds and quality fibres for industrial use from the same crop as fibre crops is harvested at 100–120 days age before flowering stage due to different photoperiod requirements (Palit, 1999) for vegetative growth (long-day) and reproductive growth (short-day). The vertical growth coupled with no branching favours high fibre yield. In contrast, seed crop requires low vertical growth and profuse branching. Accordingly, fibre crop is raised during summer season (April-July) in traditional fibre growing areas (lower Gangetic plains) and seed crop during rainy season in order to match initiation of reproductive phase with low photoperiod. Consequently, separate management practices for two types of crop (fibre and seed) has been devised. Hence, seed crop and fibre crop are two separate entities in case of jute unlike other crops.

Scarcity of jute seed is a frequent phenomenon among fibre growers as the jute seed-crop faces stiff competition from more remunerative and staple crops. In addition, jute seed production is confined to southern states of India, while the Eastern part of India belonging to lower Gangetic plain is the traditional fibre growing area. As a result,

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fibre crop growers frequently face the problems of (i) unavailability of seeds at proper time and (ii) exorbitant escalation in the cost of seeds. In this context, seed production of jute can be taken as an enterprise as it is a potential foreign exchange (approx. 2500 thousand.US$ per annum) earner also. This needs testing of seed production potential of different varieties of jute over years under West Bengal condition. Due to genotype-environment (G × E) interaction, locale-specific recommendation needs to be made for harnessing seed production potential of different varieties.

Experiments on jute seed production were conducted in different conditions of India, like north of West Bengal (Roy, 2013; Das et al., 2014), north-eastern Uttar Pradesh (Kumar et al., 2013), Andhra Pradesh (Ratnam and Narayana, 2014) and Odisha (Sarkar, 2017). However, these studies have mainly focused varietal- and management-oriented (sowing date, spacing, topping *etc*.) influences on seed production of jute. Reports regarding stability and G × E interaction of seed production potential of different jute varieties are lacking.

Hence, the present investigation was carried out to identify stable and responsive genotypes for seed production potential and to identify parameters for conducive environment. This study also compares the two traditional models i.e., classical ANOVA and Linear regression model with the latest GGE Biplot methodology, based on singular value decomposition (SVD) of environment-centered or within-environment standardized G × E data.

2. Materials and method

2.1. Experimental site and environment

The present investigation was carried out at Central Seed Research Station for Jute & Allied Fibres (CSRSJAF), BudBud, Burdwan, West Bengal, India. The experimental site is located in the lower Gangetic plains in the western part of West Bengal at 23°23′24″N latitude, 87°86′37″E longitude and at elevation of 65 m above mean sea level. The maximum temperature ranges from 23 °C to 36 °C, minimum temperature ranges from 10 °C to 23 °C and relative humidity ranges from 50 to 86% during the crop period. Nearly 1200 mm–1300 mm mean rainfall occurred during every year.

2.2. Experimental detail

The experimental material comprised of 10 cultivated varieties (Table1) of jute (4 of *Corchorus capsularis* and 6 of *C. olitorius*). The seed crop was sown in the month of June every year. The experiment was laid out in plots of 24*m* length and 5*m* width. An inter-row spacing of 40 *cm* and inter-plant distance of 5 *cm* was maintained. All the recommended package of practices was followed to get a healthy crop. A unique practice of de-topping was followed uniformly in all plots at 45 days crop age to facilitate branching and arresting the plant height. The experiment was repeated for a period of five years (2012to 2016 designated E1, E2, E3, E4 and E5). Plot-wise seed production was recorded and seed yield was calculated for hectare (ha).

Table 2
ANOVA for stability for seed yield.

Source of variations	df	MS
Varieties	9	0.77
Environment + (Variety × Environment)	40	0.24*
Environments	4	12.06***
Variety × Environment	36	1.33
Environments (Linear)	1	48.23***
Variety × Environment (Linear)	9	1.02
Pooled Deviation	30	1.29
Pooled Error	49	2.10

df: Degree of freedom, MS: Mean squares.

2.3. Statistical analyses

Data were analyzed using pooled data over the years using Windostat software (version 9.0) and stability analysis was performed according to the model of Eberhart and Russell (1966) as it was shown to be the most reliable one (Westcott, 1986). The model is as follows:

$$Y_{ij} = \mu + \beta_i I_j + \delta_{ij}$$

Where: Y_{ij} is mean of i^{th} variety in j^{th} environment, μ is mean of all varieties over all environments, β_i is regression coefficient of i^{th} variety on environmental index; which measures the response of this variety to varying environments, I_j is environmental index, *i.e.* the deviation of the mean of all the varieties at a given environment from the overall mean, and δij is the deviation from regression of i^{th} variety at j^{th} environment. According to this model, an ideal (stable) variety is one possessing higher yield, having regression coefficient (β_i) of unity and having deviation from linearity (S^2d_i) non-significantly different from zero. These genotypes perform more or less consistently over all environments. The genotypes exhibiting regression coefficient of unity ($\beta_i = 1$) are considered responsive to varying environmental conditions. The genotypes with lower value of β_i and low S^2d_i are less sensitive to the varying environmental conditions. These genotypes are generally not able to capitalize on favorable environments and hence, are specifically suitable for poor environments. The genotypes with $\beta_i > 1$ and high S^2d_i are considered highly sensitive to environments. These are suitable for input-intensive agricultural system but they fail miserably under poor environments.

Though the Eberhart and Russell (1966) model is widely used for varietal stability analysis, it suffers from the limitation of not being a predictive model (Lin et al., 1986) and lacking effectiveness in identifying stable genotypes (Manrique and Herman, 2002). Recently developed model of GGE biplot (Yan et al., 2000) holds promise in terms of elegant visual display of Genotype + Genotype × Environment interaction (Yan and Hunt, 2002). The GGE biplot method serves multiple applications, which include simultaneous visualization of mean performance and stability, mega-environment differentiation and

Table 1
Detail of jute varieties evaluated.

Code	Variety	Species	Parentage	Stem colour	Fibre yield (qha^{-1})
G1	JBO-2003-H (Ira)	*C. olitorius*	(JR0-632 × Sudan Green) × Tanganyika-1	Green	34–36
G2	JRC-212 (*Sabuj Sona*)	*C. capsularis*	Selection from indigenous type	Green	25–28
G3	JRC-321 (*Sonali*)	*C. capsularis*	Selection from indigenous type "*Hewti*".	Coppery red	20–25
G4	C-517 (*Sidhartha*)	*C. capsularis*	JRC-212 × JRC-4444	Green	20–26
G5	JRC-698 (*Shrabanti*)	*C. capsularis*	Multiple crosses involving13 parents	Green	30–35
G6	JRO-128 (Surya)	*C. olitorius*	TJ-6 × Tanganyika-I	Green	35–40
G7	JRO-204(Suren)	*C. olitorius*	IDN/SU/053 × KEN/DS/060	Green	36–38
G8	JRO-524 (*Navin*)	*C. olitorius*	Sudan green × JRO-632	Green	34–36.
G9	JRO-8432 (*Shakti*)	*C. olitorius*	IC- 15901 × Tanganyika-l	Green	35–40
G10	S-19 (Subala)	*C. olitorius*	(JRO-620 x Sudan Green) × Tanganyika-I	Red	35–40