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# Atypical response of virus energized jute (*Corchorus olitorius*) seeds in producing higher fibre yield with sustainability under different agro-ecological situations

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Rice necrosis mosaic virus-energized jute plants with no visible virus symptoms grew faster with enlarged leaf size, vigour and produced significantly higher fibre during the vegetative phase of growth in different agro-ecological situations for the crop in India. Extent of increase in plant height, stem base diameter and fibre yield in energized plants over control grown at institute farm was 2.61, 37.09 and 31.90 % respectively under fertilizer regime of nitrogen applied @ 20 kg/ha, phosphorus @ 10 kg/ha and potassium @ 10 kg/ha. Decrease in shoot-root ratio was found to be 10% in energized plants over control at 110 days of crop growth. Similar trend in improving above stated growth parameters in energized plants over control grown in other situations was also noticed. Since jute is a rainfed crop in India, a lower shoot-root ratio in energized plants compared to the control may improve drought tolerance. Furthermore, no transmission of rice necrosis mosaic from jute to the succeeding rice crop may enable adoption of this technology to increase the yield of jute fibres.

**Key words**: Rice necrosis mosaic virus, jute, growth promotion

## INTRODUCTION

Rice necrosis mosaic virus (RNMV) produces yellow green mosaic symptoms, chlorotic streaks and necrosis in leaves of rice plants and reduces yield of rice (Inouye and Fujii, 1997; Ghosh, 1980). On the contrary, inoculation of jute (*Corchorus olitorius*) with the same virus (Ghosh, 1982, 1985) promotes growth and enhances fibre yield without any visible expression of symptoms. Such effect is associated with the presence of RNMV which is demonstrated through electron microscopic and serological studies (Ghosh,1982,1985). Inoculated jute plants have a faster growth rate and enhance juvenility without any detrimental effects (Ghosh,1982). Enhanced growth promotion in jute is more pronounced with half the recommended dose of fertilizers (Ghosh,1988) and without any plant protection measures. RNMV-induced growth promotion and higher yield potential of jute is passed through seed of inoculated jute (Ghosh,2002; Ghosh *et al.*,1997) and such seeds are termed as energized seeds (Ghosh,2002). To observe the adaptability of energized jute seeds, trials have been conducted in on-farm plots located in various agro-ecological areas of India to have a definite cost- effective package for enhancing yield of jute fibre for each area.

## MATERIALS AND METHODS

### *Production of energized seeds*

Energized seeds of jute (cv. JRO-524) were produced at the institute farm of Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore, West Bengal, India through mechanical inoculation on 15-day-old jute plants with sap from leaves of rice plants (*Oryza sativa* cv. Khitish) infected with RNMV under glasshouse conditions. Simultaneously, control jute seeds were produced under identical conditions in glasshouse .

Seeds (both energized and control) were then used for planting trials during first week of April at Nawgaon of Assam, Kendrapara and Salepur of Orissa and at the institute farm at Barrackpore, West Bengal. Granular fertilizers like nitrogen @ 20 kg/ha, phosphorus @10 kg/ha and potassium 10 kg/ha were used to grow plants during the present investigation. Recommended dose of granular fertilizers like nitrogen @ 40 kg/ha, phosphorus @20 kg/ha and potassium @ 20 kg/ha were also used to grow plants for observing the difference in plant growth and yield between these two treatments. The fertilizer P and K were used at a single dose while nitrogen was applied in split doses of 50% at the time of sowing and 50% after final thinning (30 days after germination) of crop as per standard practices.

Plants were grown with four replications of treatments in 50 $m^2$ each for 110 days under field conditions at each site for two consecutive years. Plants were harvested during third week of July by cutting at the stem base and retted under slow flowing water. The fibres extracted from stems were dried and weighed for comparison. Results obtained for each year were pooled and analysis of variance was calculated for comparison.

### *Shoot : root ratio*

Jute plants in both treatments were grown in five replications with half the recommended dose of fertilizers at the institute farm to assess the effect of treatments on shoot-root ratio at 50 and 110 days after planting.

Disease and insect pest incidence at each location was recorded during the growth season.

### *Residual effect*

As in jute-based cropping systems, rice was planted in plots after harvest of RNMV-energized jute plots and harvest of plots with non-infected jute plants. The experiment was conducted in plots located at Kendrapara (Orissa) and Nawgaon (Assam) with four replications. Yield of rice crop in both cases was determined at maturity and statistically analyzed as in other trials for assessing critical difference.

## RESULTS

### *Agronomic traits and yield*

RNMV energized jute plants grew faster with enhanced vigour and dark green coloured enlarged leaves compared to control plants in fields having different agro-ecological conditions and soil physical properties (Table 1). No visible virus symptoms were noticed in any of the RNMV energized jute plants. In general, significant improvement in yield attributing characters like plant height, stem base diameter and yield of jute was obtained with half the recommended dose of fertilizers.

Pooled analyses for least significant difference (LSD) for treatment x location, treatment x year and treatment x year x location with the results obtained in different locations over two years revealed that at the institute farm the extent of increase in plant height, stem base diameter and fibre yield in energized plants over control (when plants grown with nitrogen @ 20 kg/ha, phosphorus and potassium @ 10 kg/ha each) was highly significant and the same were 2.61, 37.09 and 31.9% respectively. But when such effects on energized plants, grown with nitrogen @ 20 kg/ha, phosphorus and potassium

**Table1** : Physico-chemical properties of soil at different agro-ecological situations

| Parameters | Barrackpore (West Bengal) | Nawgaon (Assam) | Kendrapara (Orissa) | Salepur (Orissa) |
|---|---|---|---|---|
| pH | 7.2 | 5.6 | 5.8 | 5.9 |
| Organic Carbon (%) | 0.56 | 0.7 | 0.57 | 0.34 |
| Available Nitrogen (Kg/ha) | 315 | 287 | 285 | 297 |
| Available Phosphorus (Kg/ha) | 13.8 | 20.9 | 21.7 | 42.8 |
| Available Potassium (Kg/ha) | 232 | 139 | 172 | 150.5 |

@ 10 kg/ha each, were compared with the control plants grown with Nitrogen @ 40 kg/ha, phosphorus and potassium @ 20 kg/ha each the plant height and base diameter in RNMV energized plants were significantly reduced by 2.48 and 11.0%, respectively, but fibre yield increased significantly by 5.8% (Table 2).

At Nawgaon, Assam the extent of increase in plant height, basal diameter and dry fibre yield in energized plants (grown with $N_{20}P_{10}K_{10}$) over the respective control was recorded as 7.8, 12.77 and 14.98%, respectively. At this location, energized plants grown with $N_{20}P_{10}K_{10}$ also showed increased plant height, base diameter and fibre yield by 3.37, 8.16

**Table 2** : Yield attributing characters and fibre yield of RNMV-energized jute grown under field having different agro-ecological conditions ( mean average of two years pooled)

| Fertilizer treatment and type of jute | Barrackpore (West Bengal) | | | Nawgaon (Assam) | | |
|---|---|---|---|---|---|---|
| | Plant height (cm) | Base Diameter (cm) | Fibre weight (q/ha) | Plant height (cm) | Base Diameter (cm) | Fibre weight (q/ha) |
| $N_{20}P_{10}K_{10}$+ Control | 153.1 | 1.2 | 20.7 | 256.0 | 0.94 | 22.7 |
| $N_{20}P_{10}K_{10}$+ Energized | 157.0 | 1.7 | 27.3 | 275.8 | 1.06 | 26.2 |
| $N_{40}P_{20}K_{20}$+ Control | 161.3 | 1.9 | 25.8 | 267.0 | 0.98 | 24.6 |
| LSD of Treatment (5%) | 2.04 | 0.22 | 1.94 | 7.27 | 0.43 | 1.32 |

| Fertilizer treatment and type of jute | Kendrapara (Orissa) | | | Salepur (Orissa) | | |
|---|---|---|---|---|---|---|
| | Plant height (cm) | Base Diameter (cm) | Fibre weight (q/ha) | Plant height (cm) | Base Diameter (cm) | Fibre weight (q/ha) |
| $N_{20}P_{10}K_{10}$+ Control | 240.0 | 1.66 | 23.7 | 234.0 | 4.3 | 19.7 |
| $N_{20}P_{10}K_{10}$+ Energized | 264.0 | 1.91 | 26.3 | 274.0 | 5.4 | 25.4 |
| $N_{40}P_{20}K_{20}$+ Control | 262.0 | 1.89 | 25.9 | 213.0 | 5.0 | 22.5 |
| LSD of Treatment (5%) | 4.67 | 0.04 | 1.21 | 3.97 | 0.98 | 1.04 |

| LSD(P=0.05) | Plant height | Base Diameter | Fibre weight |
|---|---|---|---|
| Treatment x Location | 0.83 | 0.103 | 0.58 |
| Treatment x Year | 0.36 | 0.057 | 0.31 |
| Treatment x Year x Location | 1.22 | 0.247 | 1.12 |

Fertilizer : Nitrogen @ 20Kg/ha and 40 Kg/ha;
Phosphorus and Potassium @ 10Kg/ha,
Energized: Plants grown from seeds obtained from RNMV-inoculated jute plants.
Control : Plants grown from seeds obtained from corresponding healthy jute plants.

and 6.1% respectively over control plants grown with $N_{40}P_{20}K_{20}$. Such increases were also significant.

At two locations namely, Kendrapara and Salepur in Orissa, a similar trend for enhanced growth and yield of fibre was observed for energized plants grown with $N_{20}P_{10}K_{10}$ over control plants grown with either $N_{20}P_{10}K_{10}$ or $N_{40}P_{20}K_{20}$. Among the two locations, highest plant growth and yield were obtained with energized plants compared to control plants at Salepur location (Table 2).

In general,, RNMV-energized jutes showed significantly higher growth and production of dry fibre yield with a lower dose of fertilizers at four locations (Table 2). Root growth was more pronounced and extensive in RNMV-energized plants when grown with $N_{20}P_{10}K_{10}$ compared to control plants with a higher dosage of fertilizer (Fig 1).

### *Shoot-root ratio*

Increases in dry matter yield of both shoots and roots in energized plants at both stages of crop growth compared to the control were significant. The extent of increase in dry matter of shoots was 39.3% and 30.4% at 50 and 110 days after planting respectively, over the control whereas dry matter of roots was increased to about 45% over the control at both stages of crop growth (Table 3). The root-shoot ratio appeared to be slightly less compared to that of the control but such change was not significant. .

### *Incidence of major diseases and insect pests*

Diseases such as root rot, stem rot and anthracnose were prevalent in jute plants grown with different levels of fertilizers at Nawgaon, Assam. However, incidence of these diseases (damage rated on

**Table3**. Comparison of dry matter yield and shoot-root ratio of energized and control jute (cv.JRO-524) plants at different times after planting under field condition at Barrackpore

| Days after planting | Treatment | Dry matter yield (g/plant)* | | | | Shoot - root ratio | % decrease (-) over control |
|---|---|---|---|---|---|---|---|
| | | Shoot | % increase (+) over control | Root | % increase (+) over control | | |
| 50 | $N_{20}P_{10}K_{10}$ + control plants | 40.8± 0.88 | - | 7.8± 0.64 | - | 5.67 | - |
| | $N_{20}P_{10}K_{10}$ + RNMV-energized plants | 57.1± 0.63 | (+) 39.3 | 11.3± 0.89 | (+) 44.9 | 5.49 | (-) 3.17 |
| 110 | $N_{20}P_{10}K_{10}$ + control plants | 185.6± 0.71 | - | 26.7± 0.66 | - | 6.98 | - |
| | $N_{20}P_{10}K_{10}$ + RNMV-energized plants | 242.1± 0.82 | (+) 30.4 | 38.6± 0.67 | (+) 44.6 | 6.28 | (-) 10.0 |
| LSD (0.05) | | 2.16 | | 1.98 | | 1.20 | |

*Mean average of 5 replications± S.E
Fertilizer : Nitrogen @ 20Kg/ha and 40 Kg/ha
Phosphorus and Potassium @ 10Kg/ha
Energized : Plants grown from seeds obtained from RNMV-inoculated jute plants
Control : Plants grown from seeds obtained from corresponding healthy jute plants

**Table 4** : Incidence of diseases and insect pests on jute under different fertilizer regime at different agro-ecological locations

| Fertilizer treatment and type of jute | Diseases incidence (%)* | | | | | Insect pests incidence (%)* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nawgaon | | | Kendrapara | | Nawgaon | | | Kendrapara | |
| | Root rot | Stem rot | Anthracnose | Root rot | Stem rot | Semilooper | Apion | Bihar hairy caterpillar | Semilooper | Cockchaffer beetle |
| $N_{20}P_{10}K_{10}$ + Control | 4.84±0.75 | 6.64±1.01 | 11.34±1.36 | 4.3±0.04 | 6.1±0.07 | 5.45 ±1.20 | 3.92±0.06 | 7.69 ±1.06 | 5.3±0.70 | 3.6±0.04 |
| $N_{20}P_{10}K_{10}$+ Energized | 2.52±0.82 | 4.37±0.78 | 8.17±0.94 | 4.5±0.10 | 6.4±0.15 | 3.92±0.72 | 2.8±0.01 | 5.78 ±0.22 | 5.5±0.66 | 3.7±0.16 |
| $N_{40}P_{20}K_{20}$+ Control | 6.11±0.92 | 7.43±0.93 | 13.62±1.58 | 4.7±0.09 | 6.5±0.77 | 7.49±1.31 | 4.2±0.04 | 8.88 ±2.02 | 5.6±0.32 | 3.8±0.09 |

*Incidence based on number of plants affected/100 basis
Fertilizer : Nitrogen @ 20Kg/ha and 40 Kg/ha
Phosphorus and Potassium @ 10Kg/ha
Energized: . Plants grown from seeds obtained from RNMV-inoculated jute plants
Control : Plants grown from seeds obtained from corresponding healthy jute plants

number of plants/ 100 basis) was found to be much lower in energized jute plants fertilized with $N_{20}P_{10}K_{10}$. Comparative analysis of results revealed that incidence of root rot, stem rot and anthracnose were reduced by 54.9, 30.7 and 29.4%, respectively, in energized plants grown with $N_{20}P_{10}K_{10}$ over control (Table 4). Incidence of these diseases in control plants grown with $N_{40}P_{20}K_{20}$ was also lower in energized jute fertilized with $N_{20}P_{10}K_{10}$ by 139.8, 40.7 and 41.8%,, respectively. With regard to insect pest incidence at Nawgaon, incidence (damage rated on number of plants/ 100 basis) of semilooper (*Anomis sabulifera*), apion (*Apion corchori*) and Bihar hairy caterpillar (*Spilosoma obliqua*) appeared to be more in non-energized plants than energized ones. In case of energized jute fertilized with $N_{20}P_{10}K_{10}$, the reduction in incidence of these insects was 32.1, 41.5 and 38.7%,, respectively,, when compared to control plants fertilized with $N_{20}P_{10}K_{10}$, and 41.7, 50.5 and 49.9%, respectively, when compared to control plants fertilized with $N_{40}P_{20}K_{20}$.

In the Kendrapara region of Orissa, incidence of root rot and stem rot was moderate in both types of plants irrespective of the fertilizer rate. Anthra-

**Table 5** : Yield of succeeding rice crop after cultivation of energized and control jute in different agro-ecological conditions

| Fertilizer treatment and type of jute | Yield of succeeding rice (q/ha) at on farm* | |
|---|---|---|
| | Kendrapara | Nawgaon |
| $N_{20}P_{10}K_{10}$ + Control | 28.9 ± 0.99 | 26.45 ± 0.43 |
| $N_{20}P_{10}K_{10}$ + Energized | 31.1 ± 0.91 | 27.35 ± 0.78 |
| $N_{40}P_{20}K_{20}$ + Control | 29.7 ± 0.65 | 29.55 ± 0.99 |

*Mean average of 4 replications ± S.E.
Fertilizer : Nitrogen @ 20Kg/ha and 40 Kg/ha
Phosphorus and Potassium @ 10Kg/ha
Energized: Plants grown from seeds obtained from RNMV-inoculated jute plants
Control Plants grown from seeds obtained from corresponding healthy jute plants :

cnose disease was not present at this location. Semilooper and cockchafer beetle (*Oxicetonia versicolor*) were present at moderate levels in all plots of RNMV-energized plants and control plants.

### *Residual effect of virus-energized jute cultivation*

No symptom expression of RNMV was observed in rice crops grown in the same plots where energized jute was the previous crop at Kendrapara of Orissa and Nawgaon of Assam (Table 5). At Kendrapara, the yield of rice was 31.1 q /ha in plots where RNMV-energized jute was grown with half the recommended dose of fertilizer as compared to a rice yield of 28.9 q/ha where control jute was grown and fertilized with $N_{20}P_{10}K_{10}$ and 29.7 q/ha when control jute was grown and fertilized with $N_{40}P_{20}K_{20}$. A similar trend in results was obtained at Nawgaon where yield of rice was 27.35 q/ha where energized jute was grown and 26.45 q/ha where the control jute was fertilized with $N_{20}P_{10}K_{10}$, and 29.55 q/ha with control jute was fertilized with $N_{40}P_{20}K_{20}$. Improvement in yield of succeeding rice crop was noticed in increased fertilizer rate in plants located at Nawgaon where control jute was grown but it was not so at Kendrapara because drought situation prevailed at initial stage (after transplanting) of rice plant growth.

## DISCUSSION

The investigation revealed that RNMV-energized jute performed well with improved vegetative growth and yield of fiber without any expression of virus symptoms in different agro-ecological locations. These results indicated that energized seeds possess one or more growth promoting factor(s). Possibly due to RNMV inoculation, some modifications in host biology especially in accentuation of the activity and production of growth regulator like cytokinin (Ghosh,1982) occurred and that might have played a critical role in reducing the normal time taken for germination and also for improving the percentage of seed germination. (Ghosh *et al.*, 1997).

On- farm trials (pooled for two years) with RNMV-energized jute at different agro-ecological locations in eastern India showed increased growth and yield of fibre with half the recommended dose of fertilizers. Results obtained at CRIJAF farm indicated higher plant height and base diameter with no increase in dry fibre yield in normal jute fertilized with $N_{40}P_{20}K_{20}$ compared to energized jute fertilized with $N_{20}P_{10}K_{10}$. This indicated greater efficiency in vascular tissue differentiation to form higher number of fibre bundles, precursor of fibres, in such energized jute than control jute within 110 days of growth (Ghosh and Mitra, 1987). Pooled data on fibre yield, obtained at different locations revealed the reproducibility of the property of energized jute seeds in different years with regard to expression of improved biological parameters and sustenance of such inherent potentiality in plants. Thus for Assam region a new technology with lower input for enhancing fibre production to the tune of 37g/ha has been evoked.

In case of energized jute plants the shoot-root ratio at 50 and 110 days after planting was reduced as compared to non-energized controls. This ratio is a morphological attribute. It has value for improving water balance (Bernier *et al.*,1995) and the net product of the differential distribution of carbohydrates between root and shoot. This distribution was reported to be genetically controlled but is also subjected to modification by external factors like nutrients (Vose, 1962). In the present study, occurrence of a lower shoot-root ratio along with a higher amount of roots (Fig. 1) in RNMV-energized plants indicated a high water stress avoidance potential as compared to non-energized plants where shoot-root ratio was higher with comparatively lower root mass. Thus, a mechanism of combating drought stress (Bernier *et al.*,1995) in jute has been developed by RNMV technology.

In a jute based cropping system in eastern India, rice is grown in fields where jute was grown previ-

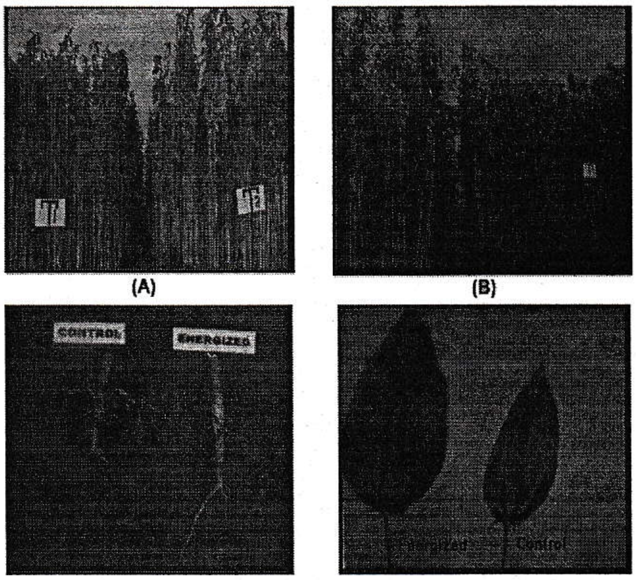


**Fig. 1.** Yield attributing characters of energized jute plants *vis-à-vis* control (A) Comparison of jute plant height for T1 ($N_{20}P_{10}K_{10}$ + control plants, i.e. cv JRO-524) and T2 ($N_{20}P_{10}K_{10}$ + RNMV-energized plants i.e. cv JRO-524E) under field condition; (B) Comparison of jute plant height for T2 and T3 ($N_{40}P_{20}K_{20}$ + control plants, i.e. cv JRO-524) under field condition (C) Comparative root morphology of control (cv JRO-524) and RNMV-energized jute plants (cv JRO-524E) (D) Comparison of the size of leaf lamina of control (cv JRO-524) and RNMV-energized jute plants (cv JRO-524E).

ously. Cultivation of RNMV-energized jute has raised concern for spread of the virus from jute to rice (Inouye and Fujii, 1997 ; Ghosh, 1979). Earlier work (Ghosh, 1985) on this aspect reported no transmission of the virus from the RNMV inoculated jute to rice crops under field condition. This was explained as due to phylogenetic differences between the two crops and due to host specificity of the fungal vector, *Polymyxa graminis*, to monocotyledonous plants in field soil (Ghosh, 1985). During the present investigation, growing RNMV-energized jute in different agro-ecological situations followed by rice crops in the same field showed no detrimental effect on rice plants. Growth of rice plants was found satisfactory with no reduction in yield (Table 5). Hence, the cultivation of energized jute in this rotation appeared to be safe and beneficial for the farmers.

In addition to increase in yield, RNMV-energized jute was not predisposed to higher damage by diseases and insect pests. Ghosh (1982,1995) reported that higher growth in jute was mainly due to enhancement of cytokinin-like material. Perhaps, either the virus upon entry into the host or the metabolite (s) produced *in situ* due to host-virus interaction might have imparted some level of resistance to biotic stress by modulating and/or activating enzyme-linked regulatory systems in plants (Pradhan and Ghosh, 1995). Enhancement in tillering and yield of some monocot plants is reported to be possible with the use of *Bacillus subtilis* A-13 in soil, infested with *Rhizoctonia, Pythium* and *Fusarium* and such effects were explained as siderphore activity (Suslow and Schroth, 1982). But in the present case possibly a symbiotic or pseudo-symbiotic relationship between the virus and the host has developed by which the plant itself is benefitted. Even though such virus-induced growth promotion has been found to be a heritable trait, no integration of this virus with the genomic constituent of energized jute plants has been observed (Roy et al.,2006). This warrants further study to determine the mechanism(s) responsible for the value added traits in RNMV-energized jute.

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