I. INTRODUCTION
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Jute is aptly called the carrier of world trade, since it has been in use for packaging and bulk movement of a great number of items. Its uses are manifold. The commonest item manufactured from it is the gunny bag for storing and transporting agricultural products and such commodities as cement and salt. Gunny bags are cheap, durable and exceptionally strong. They can be roughly treated, stacked without slippage and resist repeated wetting and drying with minimum loss of strength. Tiny holes in the bag can be sealed by mere scrapping or by easy sewing (Bose, 1955).

Jute in the form of closely woven hessian is made into sail cloth, tents, deck chair covers, hammocks, tarpaulines, upholstery fabrics and wall covers substituting paper. It also serves as underlay of linoleum, a product which is becoming increasingly popular in tropical countries. A specialized jute cloth serves as carpet-backing which has been gaining market in West Europe and USA, as it is less inflammable than synthetic substitutes.

Suitcases, kitbags, rucksacks, mailbags and handbags are manufactured with hessian as the raw material. Tailors and cobblers use jute materials for buckram and linings bituminized and rubberized jute bags are used to transport fertilizers and a number of chemicals.

Jute laminated with paper and polythene has various uses. The jute caddies, a waste product, play a major role in the manufacture of insulation boards. The jute stick, a by-product, is used to make particle board, hard board, duplex board, kraft paper and newprint or even rayon.

Jute strips manufactured in tape looms make conveyor belts and driving belts of various kinds.

A. Current situation

Bangladesh gets bulk of her foreign exchange earnings by export of raw jute and finished jute products. Her economy is still largely dependent on export of jute and jute goods.
In India, jute earns nearly 2500 million rupees worth of foreign exchange largely by exporting manufactured items. With the introduction of bulk handling system for both agricultural and industrial cargo and increasing use of woven synthetic fibre, the position of jute as the cheapest packaging material has been substantially threatened. The situation is worsened as the cost of production has increased due to rising demand for increased wages by mill workers as well as demand of better price of raw jute by jute growers.

The jute-industry in India has been seriously thinking to replace the outmoded machinery and rationalize the manufacturing system that would reduce the cost on labour at the mill yard. The industry is also demanding that the price of raw jute has to be kept low vis-a-vis inroads of synthetic fibre, which throws a challenge to agricultural scientists to device ways and means to reduce its cost of production.

Since raw jute prices in recent years are not attractive, farmers are ready to adopt improved techniques only if they do not involve any additional expenditure.

The general recommendation for improving jute yield is as follows:

i) Use of good seed of an improved (high-yielding) variety that suits the area, with germinability not less than 80%.

ii) Good land preparation.

iii) Timely thinning of jute seedlings and simultaneous removal of weeds.

iv) Application of manures and NPK fertilizers on the basis of soil test.

v) Keeping soil reaction within a range of 6.0 to 7.0 (pH).

vi) Timely control of major pests and diseases.

vii) Harvest at 120 days.

A survey of the literature reveals that there is no precise information available regarding the best time for thinning and weeding and its effect on the yield of the crop. It is not definitely known how yield is affected by delayed
or premature thinning. Situation demanded investigation on the following line:

1. To find out the correct time of thinning and weeding in terms of crop-age.

2. To find out if the time of thinning and weeding would alter with variation in spacing.

3. To find out if the time of thinning and weeding would be influenced by application of N-fertilizer as top-dressing.

Information on the above three, it was thought, would facilitate optimizing yield by adjusting time of thinning, manner of crop arrangement (spacing) and application of fertilizer within the existing expenditure frame of small growers.

Before proceeding further it may be useful to give a gist of steps involved in jute cropping from land preparation to drying of fibre.

The Jute Plant and Cultivation Technique

Jute fibre is extracted from the bark of two cultivated species of plants viz. Corchorus olitorius L. and C. capsularis L. which are also known as 'tossa jute' and 'white jute', respectively in the trade circle. Since the fibre is obtained from the bark, yield is associated with vegetative growth of the crop; unlike grain crops, the flowering phase marks the initiation of waning of fibre production.

It has been demonstrated by several workers that the yield of a jute plant has strong positive correlation with plant height and base diameter of the plant (Shukla et al., 1967, Sinha Mahaputra et al., 1977 and Singh 1970). Plant height and base diameter again have strong reciprocal positive correlation. The yield of an unit area is, therefore, a product of mean yield per plant and the plant population. Therefore, factors that support a tall crop of optimum population would increase yield. As fibre (jute) is extracted from the stem of the plant a prolonged vegetative phase (not less than 120 days) is necessary to make the crop tall enough to yield remunerative quantity of fibre. The crop is customarily harvested when it flowers. In West Bengal most of jute varieties flower between late August and mid September. Accordingly, the crop has to be sown some time in April or latest by first week of May, according to the variety used.
Sowing is, however, permissible earlier in March where pattern of rainfall is helpful as is the case in North Bengal.

A synopsis of cultivation technique is given below to elucidate the objective of the work presented.

**Step-I. Preparation of land**

Jute seeds are very small and emerging seedlings are delicate; hence the soil has to be well pulverised before sowing. The land is repeatedly ploughed and harrowed till a fine tilth is obtained. During land preparation all weeds are removed as far as possible to reduce initial competition from weeds. The land becomes ready for sowing when moisture ranges between 21 and 40 percent.

**Step-II. Sowing**

By and large sowing is done by broadcasting the seed followed by raking and beaming. Raking helps the seed to lodge lightly below soil and beaming (laddering) makes the soil compact so that the vital soil moisture is not lost quickly.

The seed rate recommended for broadcast has been 9 pounds per acre (Mukherjee, 1924) for *capsularis* varieties. Since 1940 the seed rate has been 10 pounds and 6 pounds per acre for *capsularis* and *olitorius* varieties respectively (Patel & Ghosh 1941; Kundu, 1959); the seed rate for broadcast sowing continues to be 10 and 6·kg per hectare.

The seed rate recommended is much higher than the final stand required, which varies between 368000 to 486000 per hectare in accordance with fertility of soil; Ghosh (1983) and Pal et al. (1981) found the number between 4.1 to 5.0 when crop was raised in rows 30 cm apart and 5.0 and 7.0 lakh/ha when rows were 20 cm apart. A gramme of *olitorius* jute (CV.JRO632) seed counts 500 and that of *capsularis* 300, in average. Table-1 gives the number of viable seeds to be sown at the prevailing seed rate, at different levels of germinability.
TABLE-1
Estimated number of viable seed dropping per ha of broadcast plot.

<table>
<thead>
<tr>
<th>Germinability (%)</th>
<th>When seed rate is 10 kg/ha of <em>capsularis</em> or 6 kg/ha of <em>olitorius</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>13,62,000</td>
</tr>
<tr>
<td>90</td>
<td>12,25,800</td>
</tr>
<tr>
<td>80</td>
<td>10,89,600</td>
</tr>
<tr>
<td>70</td>
<td>9,53,400</td>
</tr>
<tr>
<td>60</td>
<td>8,17,200</td>
</tr>
<tr>
<td>50</td>
<td>6,81,000</td>
</tr>
</tbody>
</table>

It is evident that a large number of seedlings are required to be removed to obtain the optimum stand which may vary between 368000 and 486000 in broadcast plot, 4.1 to 5.0 lakh in rows 30 cm apart and 5.0 to 7.0 lakh in rows 20 cm apart.

The question arises whether the excess seed sown is a wastage or a necessity. Many workers pointed out that in broadcast fields the excess seed is a necessity. The opinions are:

i) In terms of actual stand required at harvest one seldom needs for a hectare more than a kilogram of *olitorius* seed or 1.6 kg of *capsularis* seed. But it is impossible to broadcast this small amount at equidistant point (10-15 cm apart). Therefore, the practice is to sow a larger number to obtain a uniform cover, so that the desired spacing could be obtained by pulling out or thinning the excess seedlings.

ii) Commercial seeds usually have low germinability; a high seed rate compensates.

iii) The delicate jute seedlings when crowded, can compete more effectively against weed seedlings that germinate and grow simultaneously. A high seed rate ensures this.
iv) An isolated single seedling often fails to generate enough force to break through the overlying crust of soil, when the number is larger they come up easily.

v) High seed rate covers the risk of mortality due to drought. (Kundu, 1959). In row crop the seed rate recommended is lower, since the drill developed for the purpose requires much less seed to drop them almost continuous in a row (Saraswat et al., 1984).

Drill sowing in rows requires a near perfect land preparation which permits no clod that would interfere with operation of the drill. In the time-consuming process of land preparation the soil-moisture gets quickly lost and the hand-pushed drill that sows one row at a time is time-consuming. However, row cropping has been recommended as a measure that makes many intercultural operations easier ensuring high yield. Though empirical results favour adoption of row cropping, the cost of the drill, non-availability of its accessories and the time-consuming operation of drill has not made it popular. The spacing recommended is 30 cm between rows and 7.5 cm between plants in a row. Pal et al. (1981) found better yields with closer spacing i.e. with rows 20 cm apart when cultivar used was JRO 632.

Step-III. Thinning

The seedling population has to be thinned, both when broadcast or raised in rows to effect the recommended spacing.

In a broadcast crop the plants are spaced out 10-15 cm apart by manual thinning and in a row crop the space between neighbouring two plants in a row is 7.5 cm in average.

a) Weeding

Removal of weeds in time is as important as the thinning operation. Weeds are removed once when land is prepared. After jute seedlings emerge post emergence weeding is done along with thinning operation. A second weeding is helpful but is often not necessary if pre-emergence weeding and the first post-emergence weeding is done with care.

In a row crop, use of wheel hoe between rows further keeps down the weeds.
Till now there has been no precise recommendation on time of thinning. Farmers take to thinning and weeding any time between third to fifth week from germination. Where germination is thick, thinning is done in two instalments according to convenience of the farmer.

The unwanted surplus jute seedlings and weeds deplete the soil much of its nutrients; hence it is necessary to find the optimum time for thinning (Saraswat 1974).

**Step-IV. Manuring and fertilizer application**

Jute responds quickly to application of nitrogenous fertilizer except where P or K status (in soil) acts as limiting factor (Chaudhuri 1951; Das 1957; Dargan 1971; Cheng 1970).

In villages most small farmers either use a small quantity of cowdung manure or nothing at all. There, jute has to thrive on residual nutrients applied to preceding crop or by native fertility.

Current recommendation says one may topdress jute with 40 kg N/ha in tossa varieties and 60 kg N/ha in a white jute variety (Mandal 1981). He also recommends use of P2O5 half the quantity of N applied and K2O equal in quantity of N used. Fertilizer application however, would vary from soil to soil.

**Step-V. Harvest**

Jute is customarily harvested when the crop is in flower. The plants are cut close to ground, classified into thick and thin group and bundled. The bundles are next taken to the place of retting usually a canal, tank or a ditch. If harvest is delayed beyond flowering phase, one gets 2-3 quintal more but quality is depreciated. Early harvest at 100 or 120 days ensures good quality provided retting is normal. Since premium for quality does not match quantitative gains due to late harvest, farmers are more inclined to late harvest (Ghosh, 1983).

**Step-VI. Retting**

The bundles are kept in retting water for 10-16 days; during that period microbial enzyme acts on plant tissues and the softer tissues get dissolved.
earlier to lignified elements like fibre and wood (stick). At this point when softer tissues (in which fibre remain embedded) get dissolved the fibre is easily taken out (extracted) manually, washed and dried. Retting is the most vital operation that contributes towards quality (Kundu, et al., 1964; Bose, 1969).

The fibre after drying is ready for market.

B. The objective

Jute has always been selling in buyers' market. Most of the time the jute farmers never could have a just share of profit earned by the Industry. Sometimes the farmers even suffered losses. This situation compelled the Government of India to establish the Jute Corporation of India, whose one of the functions has been to stabilize the price line above the statutory minimum. This minimum or the floor price has not been found satisfactory by farmers.

Under the circumstances jute farmers felt shy to invest on costly inputs viz. labour, intensive interculture, fertilizers, pesticides and fungicides and often even on buying improved seed which is subsidised by the Government. As a result, the national average yield continues to be as low as 14.5 q/ha despite the fact that by adopting scientific techniques yield could be doubled as has been demonstrated by the Intensive Jute Development Project (IJDP) (Sanyal, 1976).

Currently jute farmers have shown eagerness only in buying improved seeds of high yielding jute varieties, but they are still hesitant to invest on fertilizer, herbicides and pest and disease control which require a comparatively large sum.

During the last twelve years the author has been working amongst jute farmers in his capacity of an 'extension scientist'. He found that in general, in the district of 24 Parganas, if the sowing is not too late (beyond April), proper and timely thinning and weeding ensure better yield even with native fertility as compared to plots where the operations are perfunctorily executed or neglected.
It has been stated earlier that no precise information is found in existing literature regarding time of thinning in terms of crop age linking it with yield. One does not know how far yield is affected by delayed or premature thinning.

Since these two operations (viz. thinning and weeding) can be executed by family labour as is the practice with small farmers, the author wanted to find out information on the right time for weeding and thinning and their interactions with methods of planting (spacing) and small amount of nitrogenous fertilizer.

The objective was to achieve the best possible yield with low input and clever agronomic manipulation that would be acceptable to farmers of small means who hesitate to invest large sums on jute cultivation as returns are always pitifully uncertain.

C. Review of literature

Since 96 percent of jute cultivation is confined to India, Bangladesh, Taiwan, Burma and Nepal, systematic research on jute agronomy is confined to these countries. Brazil is a new entrant in the field of production and not much of research work on jute agronomy emanates from Brazil. The author had access to literature published on work done mostly in India, Bangladesh and Taiwan. Although China is reported to grow jute (Ghosh 1983; FAO Report : TCP/Bur/8904M 1980) no literature is easily obtainable in World Journals publishing reviews or Bibliography.

On time of thinning & weeding

The earliest work describing jute agricultural technique is found in the 'Handbook of Indian Agriculture' by N.G. Mukherji (1924). On page 231 of the book a cryptic mention had been made on time of first hand weeding to be done in May and 'pulling up of weeds' to be done in June. There is no mention whether such recommendation is universal or is only applicable to Nadia district since the book largely refers to cultivation practices in the aforesaid district. Further the age of the crop at which thinning and weeding give optimum result, has not been mentioned.
In the monograph Jute in India (1959) Kundu says, during the first two months of the crop, a large number of plants has to be thinned out gradually; he too, does not mention precise time of thinning either in terms of age or height of crop. Ghosh (1983) in Handbook on Jute stated that 'when seedlings are about 10 cm tall, thinning is convenient; he however mentions the first thinning and weeding is to be done when seedlings are 18 to 21 days and the second one is done around 30 days. But he does not give any information on variation in yield due to early or late thinning. Saraswat et al. (1984) mentions that thinning is to be done twice at 3-4 weeks and 5-6 weeks stages, but without information about yield.

None have identified the optimum time for thinning and weeding linking it with yield although Das et al. (1958) indicated that thinning at third week gives better yield; but this was a tentative remark based on observations in a trial conducted for a year only.

One of the objective was, therefore, to identify the correct age of crop at which thinning and weeding is to be started for the best possible yield.

On spacing

From time immemorial jute has been sown broadcast. It was Sanyal (1952) who first demonstrated that row cropping gave better yield than broadcast. Saraswat and Pal (1984) in 'Package of practices for Jute Fibres Production' (JARI Field Bulletin No.JA 1.1) on the basis of up to date information, recommended row cropping of olitorius jute 20-25 cm apart; the bulletin does not say whether 20 or 30 cm space between rows is better. Inten-plant spacing within row is stated to be 5-7 cm. Earlier, Kundu et al. (1955) stated that jute rows placed 30 cm apart with 7.5 cm interplant spacing in a row give better yield than crop broadcast. Gurnani and Pathak (1966) claimed that a crop raised in rows 30 cm apart with plant to plant spacing of 7.5 cm yielded better than broadcast crop and almost universally.

Gupta et al. (1978) advocated the spacing system of 15 cm between rows and 7.5 cm (mean) between plants in a row. But the narrow working space between rows makes intercultural operations difficult, slow and time consuming; for practical reasons, therefore, this system of narrow spacing could not be accomodated in the present study.
Pal et al. (1981) used two spacing systems viz. 20 cm x 5-7 cm and 30 cm x 5-7 cm, and yields from these two row cropping systems against three fertilizer levels \((N_{40} P_{20} K_{40}, N_{80} P_{40} K_{80}, \text{and } N_{160} P_{80} K_{160})\) were determined for two successive years. In their paper no mention has been made about time of thinning and weeding done. They found that close spacing (20 cm between rows) gave better yield only when fertilizer level was low \((N_{40} P_{20} K_{40})\). With the increase in fertilizer level differences between 20 cm and 30 cm spacings were not significant. Pal and his co-workers did not include the broadcast system in their study.

In the present work author included broadcast system, 20 cm and 30 cm spacing between rows as well. But since use of N-fertilizer beyond 40 kg N/ha is unremunerative and unacceptable at present day condition, author chose three nutrient levels 'no nitrogen' (or native nitrogen), \(N_{30}\) and \(N_{60}\) kg/ha as three treatments.

On nutrients

Mandal, et al. (1981) made a precise review of fertilizer use in jute. They stated that the average gross nutrient removal of a jute crop yielding 20-31 q/ha of fibre to be 83-110 kg N, 36-64 kg \(P_2O_5\) and 177-198 kg \(K_2O/ha\). Uptake of nutrient varies with system of application, source of nutrients, time of thinning and weeding, climate, soil condition, etc. They recommended ammonium sulphate as the best source of N for jute and found that top dressing of ammonium sulphate in two instalments, often gave better yield than when the entire quantity was applied basal in soil.

Mandal et al. (1981), Goswami et al. (1969) and Dargan (1971) - all however recommend application of P and K fertilizer in soil before sowing and during land preparation. Mandal et al. (1981) in the review stated that application of N-beyond 60 kg/ha in olitorius crop is redundant as it is unremunerative. At the end of the above review Mandal et al. (1981) gave a cogent list of literature: but it is found that no reference has been made to interaction of spacing, time of thinning and weeding and application of Nitrogen on yield.

Gupta et al. (1978) found that the optimum amount of N for application as fertilizer varied from year to year due mostly to differences in precipitation.
From a pooled analysis they found the optimum would be around 60 kg N/ha, accommodating major factors that govern uptake and their effect on yield.

It is already stated that Pal et al. (1981) dealt with interaction of two systems of row cropping and high levels of nutrients (NPK) on population and yield.

In the present paper the author selected three levels of N (0, 30, 60 Kg/ha) each in combination with P and K applied basal at the rate of half the quantity of Nitrogen. Effect of these three levels of nutrients, three systems of spacings and three dates of thinning and weeding in 27 combinations (treatments) on yield has been presented in this paper.