In the present investigation, the influence of the major nutrients viz. nitrogen, phosphorus, potassium, calcium and magnesium and two of the micronutrients viz. zinc and molybdenum on yield and properties of jute fibre, has been studied. Two common varieties of the two species of jute viz. JRO-632 of C. olitorius and JRC-212 of C. capsularis have been used as materials for study. The response of these nutrients to jute largely depends on the existing soil fertility status as well as on the physical properties of the soil. Judicious application of fertilizer is essential for optimum yield without adversely affecting the fibre qualities.

CHAPTER II : Section-I

Effect of Nitrogen, Phosphorus and Potassium:

1. In a fertilizer trial with olitorius jute, N was applied at 0, 50, 75 and 100 kg N/ha either alone or in combination with 25 kg P₂O₅/ha and 25 kg K₂O/ha in a 'sandy loam' soil (Texture: 60.1% total sand, 23.1% silt and 16.5% clay) with medium to high in N and K, rich in P but low in organic carbon having an average pH 6.7. With application of N alone, the fibre yield progressively increased upto 25.4% over control at 75 kg N/ha but the yield was depressed on further increasing the
dose of N. Although application of P and K with N increased the yield in all the treatments as compared with the control, the combination showed a depression in yield as compared with application of N alone. Moderately high K-status and rich P-status of the soil appear to be the only plausible explanation for this adverse effect of P and K on *olitorius* jute.

The fibre quality was adversely affected to some extent with gain in yield. Fibres tended to be coarser and bundle tenacity decreased to some extent with gain in yield due to application of N alone or with P and K. The optimum dose of N alone in the existing soil condition should be between 25 to 50 kg N/ha so that strength and fineness of fibre are not much affected with gain in yield (Fig. VIII). The brightness of fibre also decreased to some extent in all the treatments excepting at N<sub>50</sub>P<sub>0</sub>K<sub>0</sub>. Favourable effect was observed in respect of length:diameter ratio of ultimate fibre cells when N was applied alone (L/d ratio: - 136.1 at N<sub>50</sub>P<sub>0</sub>K<sub>0</sub> and 135.7 at N<sub>100</sub>P<sub>0</sub>K<sub>0</sub>). In better quality yarns ultimate fibres are longer and more slender and therefore the length:diameter ratio is comparatively higher. In jute this ratio rarely exceeds 120.

Bulk density of *olitorius* fibre (higher density being a characteristic of better quality jute) tends to decrease at higher levels of N either alone or with P and K. The lower bundle tenacity of fibre in all the treatments including control...
may be attributed to adverse retting conditions.

Jute fibre, unlike cotton and ramie, is characterised by the presence of a large amount of non-cellulosic substances such as lignin and hemicelluloses which are known to have great influence on the properties of jute.

So far as chemical constituents of olitorius fibres under trial are concerned, lignin has slightly increased in all the treatments and hemicellulose in most of the treatments due to application of N at higher doses either alone or in combination with P and K. Higher values of lignin and hemicellulose are known to be associated with lower strength and higher irregularity of yarn. As observed there is a trend towards decrease in bundle tenacity of fibre with increase of its hemicellulose content (Fig. IX).

Alpha-cellulose content of jute slightly increased with higher gain in yield (at N$_{75}$P$_0$K$_0$) and it has a positive correlation with strength of fibre, of course, depending on the length of cellulose chain molecule.

2. In a similar type of 'sandy loam' soil rich in N and P, moderate to high in K, medium in organic carbon with an average pH 6.5, capsularis jute did not respond to application of N either alone or in combination with P and K. The treatments were 0, 50, 100 and 150 kg N/ha alone or with 25 kg P$_{205}$/ha and
25 kg K₂O/ha. There was only a marginal gain in yield at 50 kg N/ha alone (5.7% over control) and 10 to 12% decrease in yield was observed in other treatments excepting at N₁₅₀P₂₅K₂₅ where a small gain in yield (3.9% over control) was observed. The species of *capsularis* jute are normally responsive to higher levels of N. But here fertilization of a soil containing sufficient quantities of N, P and K appears to have adverse effect on the crop. Inadequate rainfall might be another cause of non-responsiveness. Nitrogen being a mobile nutrient requires sufficient moisture for its uptake by *capsularis* jute which depends mainly on surface nitrogen because of its shallow root system. Application of P and K has not any additional advantage in that soil already rich in P and K.

With depression in yield, the fineness or bundle tenacity of *capsularis* fibre was not adversely affected as compared with the control. Low bundle tenacity of fibre in all the treatments might be due to adverse retting conditions. All the samples including control were however, retted under identical conditions. As in *olitorius* the length:diameter ratio of ultimate fibre cells was better with application of N alone. There were, however no significant variations in other physical and chemical characteristics of fibre due to different treatments.
3. Moderate application of N at 0, 20, 40 and 60 kg N/ha along with 20 kg P₂O₅/ha and 40 kg K₂O/ha in the 'sandy loam' soil (pH 7.0), medium in N and K, rich in P but low in organic carbon produced increase in yield of *olitorius* jute up to 22.4% at N₆₀P₂₀K₄₀ over control. In another trial on the same type of soil when N was applied at 0, 10, 20, 30, and 40 kg N/ha along with 20 kg P₂O₅/ha and 40 kg K₂O/ha, the yield gradually increased up to 26.0% at N₄₀P₂₀K₄₀ as compared with the control at N₀P₂₀K₄₀. The plant heights also gradually increased with increasing doses of N (Fig. XI). In such cases the fineness or bundle tenacity of fibre was not adversely affected with gain in yield. On the other hand, the brightness of fibre improved to some extent in all the treatments as compared with the respective controls. Thus moderate fertilization of a soil containing moderate quantities of N and K is beneficial to *olitorius* jute in respect of its yield and quality.

4. *C. capsularis* jute in the same soil also gave good response to N. The yield gradually increased up to 91.6% over control when N was applied at 0, 30, 60, and 90 kg N/ha along with 30 kg P₂O₅/ha and 60 kg K₂O/ha. Bundle tenacity of fibre also improved slightly in all the treatments with N. Brightness of fibre was not adversely affected. The fibre, however, tended to be coarser at increasing levels of N (Fig. X).
Strength, fineness and lustre are usually considered as most important in judging a fibre quality. Each and every parameter should be considered separately for assessment of quality of the fibre since finest fibre may not always prove strong enough in a spinning trial. From that point of view *capsularis* fibre has not been much affected with substantial gain in yield due to fertilization with N at 30 to 90 kg N/ha of a 'sandy loam' soil containing moderate quantities of N and K.

5. It would be observed from the results of different trials that the bundle tenacity of fibre of the same species varied from trial to trial. This is mainly due to variable retting conditions from year to year, quality of jute largely depending on retting. Over-retting makes the fibre weaker whereas under-retting makes it coarser due to incomplete removal of periderm and other adhering tissues. Maturity of plants also influences the fibre quality. In individual trials, however, these conditions were kept similar as far as practicable and the results as compared with the respective controls have been given.

**Change in Soil Properties:**

6. As observed from some soil analysis data before sowing and after harvest of *olitorius* jute, the soil depletion of P varied from 55.6 to 76.6 kg P₂O₅/ha, K depleted in the range of 90 to 115 kg K₂O/ha, whereas status of N remained practically
unaltered due to replenishment of this element by normal leaf-fall. These results are, however, variable due to interactions of various factors such as leaching of the nutrients by rain water and various physico-chemical and biological activities continuously going on in the soil system.

Nitrogen used in combination with P and K appears to assist jute plants in better utilization of P, since soil depletion of P has been found to be somewhat higher in all the treatments where N was applied in combination with P and K.

Soil samples collected just after harvest showed higher pH values than those of the samples collected before sowing. This might be due to greater micro-biological activity in the fertilized soil with higher moisture content, since bacteria usually favour an alkaline pH.

CHAPTER II : Section-2

Effect of Calcium and Magnesium:

The effect of calcium and magnesium on jute has been studied in different categories of soil with different pH values.

7. In a slightly alkaline 'sandy clay loam' soil (Texture: 48.2% total sand, 24.4% silt and 27.0% clay) rich in P, K and organic carbon, medium in N and containing exchangeable magnesium in the range of 2.0 to 2.4 meq/100 g soil, magnesium
sulphate (MgSO₄·7H₂O) produced beneficial effect on yield of *olitorius* jute (JRQ-632). The treatments included 0, 20, 30 and 40 kg MgO/ha. The NPK status of the soils of different treatments was similar. The yield increased upto 13.0% at 30 kg MgO/ha as compared with the control. Fibre fineness improved in all the treatments (Fig.XII). Apparently the bundle tenacity of fibre decreased to some extent due to treatments with magnesium. Finer fibre is however, associated with better yarn strength because of the greater flexibility of fibre strands and their ability to pack more closely together in the yarn.

8. Calcium when applied as calcium chloride in the slightly alkaline soil (pH 7.9) produced beneficial effect on growth of *olitorius* jute in a pot culture experiment. The nutrient was applied in the range of 10 to 40 kg CaO/ha, the soil being rich in N, P and K and contained 14.2 meq exchangeable Ca/100 g soil. Both the plant height and yield per plant increased over control in all the treatments with calcium chloride.

9. In acidic 'loam' soil (texture: 41.3% total sand, 41.6% slit and 16.5% clay) medium in N and K, rich in P but low in exchangeable magnesium (1.2 meq/100 g soil) and having an average pH 5.5, magnesium sulphate had no significant effect either on yield or quality of *olitorius* jute. The treatments included 0, 10, 20, 30 and 40 kg MgO/ha along with 20 kg P₂O₅/ha, 20 kg K₂O/ha and 40 kg N/ha in all the treatments.
including control. There was only 4.2% increase in yield at 20 kg MgO/ha. On further increasing the dose of the nutrient there was a tendency towards decrease in yield. There was no appreciable change in physical properties of fibre due to different treatments.

10. Magnesium sulphate in the same acidic 'loam' soil had a detrimental effect on capsularis jute (JRG-212). The fibre yield decreased between 3.5 to 15.0% disproportionately in the different treatments when the nutrient was applied in the range of 10 to 40 kg MgO/ha along with 30 kg P\textsubscript{2}O\textsubscript{5}/ha, 30 kg K\textsubscript{2}O/ha and 60 kg N/ha in all the treatments. The lustre and fineness of capsularis fibre, however, improved in all the treatments.

The adverse effect of the nutrient on yield of capsularis jute and non-response to olitorius jute might be due to inability of the nutrient to reduce the soil acidity. Jute normally favours slightly alkaline to slightly acidic pH, a pH value of 6.5 being optimum.

11. Liming of the same acidic soil produced beneficial effect on yield of olitorius jute. When the soil was limed at 0.6 to 2.4 tonnes CaO/ha, the pH gradually increased from 5.6 to 6.5. Lime was applied at 0, 0.6, 1.2, 1.8 and 2.4 tonnes CaO/ha along with 20 kg P\textsubscript{2}O\textsubscript{5}/ha, 20 kg K\textsubscript{2}O/ha and 40 kg N/ha. The yield progressively increased from 2.5 to 22.2% over control. However, the fibres became slightly coarser in all the treatments with
lime (Fig. XIII) and the lustre of fibre decreased to some extent.

12. C. capsularis jute on the other hand did not respond to application of lime in the same acidic soil. Due to liming of the capsularis plots at 0.6 to 2.4 tonnes CaO/ha, the soil pH gradually increased from 5.4 to 6.7. The doses of lime were 0, 0.6, 1.2, 1.8 and 2.4 tonnes CaO/ha along with 30 kg P$_2$O$_5$/ha, 30 kg K$_2$O/ha and 60 kg N/ha in all the treatments. The yield increased only by 4.4% at 1.2 tonnes CaO/ha and the fibre properties were not adversely affected. It appears that a soil pH around 5.5 is as effective as a neutral pH for capsularis species of jute.

13. In the neutral 'sandy loam' soil (pH 7.0) rich in P and medium in N and K, liming produced no beneficial effect on yield of olitorius jute. There was a tendency towards decrease in yield in all the treatments of lime which included, 0, 0.3, 0.6, 0.9 and 1.2 tonnes CaO/ha along with 20 kg P$_2$O$_5$/ha, 20 kg K$_2$O/ha and 40 kg N/ha. Due to liming, the soil pH gradually increased up to 8.1 (initial pH 7.0). This alkaline pH appears to be unfavourable for olitorius jute. The fibres tended to be coarser in all the treatments with lime, whereas bundle tenacity of fibre remained practically unaffected.
14. In the same soil, magnesium sulphate in combination with NPK increased the yield of *olitorius* jute by 16.2% at 40 kg MgO/ha. There was no significant variation in fineness or bundle tenacity of fibre. The fibre lustre however, improved markedly when the nutrient was applied at 20 to 30 kg MgO/ha. Thus application of magnesium sulphate in a neutral 'sandy loam' soil containing around 2.0 meq magnesium/100 g soil appears to be beneficial for *olitorius* jute so far as its yield and fibre lustre are concerned.

CHAPTER III

Effect of Micro-nutrients (Zinc and Molybdenum):

Micro-nutrients are known to play important role in the efficient maintenance of physiological functions and in vigorous growth of plants. Plants of different species have different enzyme systems and hence their nutrient requirements may vary.

In the present investigation exploratory trials have been conducted with two of the micro-nutrients - Zinc (Zn) and molybdenum (Mo) on *olitorius* variety of jute (JRO-632) in all the experiments.

15. In one experiment Zn, Mo and a combination of the two were applied in the 'sandy loam' soil (Av. pH 7.3) along with different levels of N. Before the experiment the soil was
medium in N, made rich in P and K but it was low in organic
carbon and contained 11.6 ppm total Mo (average) and 8.3 ppm
dithizone extractable Zn (average). Zinc was applied as zinc
sulphate (ZnSO$_4$) at 5.6 kg/ha (1.02 ppm as Zn), Mo as ammonium
molybdate $\left[\text{(NH}_4\right)_6\text{Mo}_7\text{O}_{24}\cdot 4\text{H}_2\text{O}\right]$ at 1.0 kg/ha (0.24 ppm as Mo)
and a combination of two (Zn + Mo) at the same doses along with
0, 20, 30 and 40 kg N/ha. It was found that Zn or Mo or their
combination had no significant effect either on yield or on
physical properties of fibre such as fineness and bundle strength,
whereas N had prominent effect on yield particularly at 30 and
40 kg N/ha. The fibres also became coarser to some extent at
higher levels of N. The combination of Zn and Mo depressed the
yield to some extent.

In the subsequent experiments, Zn and Mo were applied at
different levels, the soil status of N, P and K being similar
in all the treatments.

16. In a preliminary pot-culture experiment with Mo, the
nutrient enhanced the plant growth when applied in the range
of 0.7 to 0.8 ppm Mo in a soil rich in N, P and K and containing
7.0 ppm total Mo (average). Zinc in the same type of soil
containing 12.5 ppm dithizone extractable Zn (average) improved
the height and base diameter of plants only to a small extent
at 1.0 ppm application of Zn.
On the basis of those results, further field experiments were carried out with Zn and Mo in soils containing around the similar levels of the micro-nutrients.

17. Zinc when applied in the range of 0.5 to 1.5 ppm as Zn in a *sandy clay loam* soil containing 10 ppm dithizone extractable Zn (average) had no significant effect on *olitorius* jute. Only 4% increase in yield was obtained at 0.5 ppm application of Zn, zinc sulphate being the source of the nutrient.

Thus application of Zn in soils already containing 10.0 to 12.5 ppm dithizone extractable zinc was not effective on *olitorius* jute. The fibres, however, tended to be coarser to some extent and there was no appreciable variation in bundle tenacity or lustre of fibre due to different treatments.

18. Application of Mo in a 'sandy loam' soil containing 9.0 ppm total Mo (average) improved the growth and fibre yield of *olitorius* jute. The soil was rich in P, medium in N, K and organic carbon with an average pH 6.4. Ammonium molybdate when applied in the range of 0.2 to 1.0 ppm as Mo along with 40 kg N/ha increased the yield in all the treatments which included 0, 0.2, 0.4, 0.6, 0.8 and 1.0 ppm Mo. Application of Mo in the range of 0.4 to 0.6 ppm increased the fibre yield by 15.0 to 16.3% over control. At higher doses of Mo, there was a tendency towards decrease in yield of fibre (Fig.XV).
The important physical properties of fibre such as strength, fineness and lustre were not adversely affected due to treatment with Mo. Thus Mo seems to be beneficial for *olitorius* jute when applied in the range of 0.4 to 0.6 ppm in the above soil status.

Molybdenum is known to increase the number of non-symbiotic nitrogen-fixing bacteria in soil and thus it may be helpful towards nitrogen economy.

**Important Results and Future Lines of Work**

From the overall results the following findings need special mention in the interest of the jute growers and jute industry as a whole. Further research to supplement/substantiate some of the results would be useful and of interest.

(i) Use of fertilizers without any information on the fertility status of the soil may not only be useless but also counterproductive in some cases. Application of N, P and K in soils already containing adequate quantities of the nutrients had adverse effect on yield and quality of jute fibre.

(ii) Jute-producing soils in the areas under investigation are rich in P and further application of phosphatic fertilizers will be mere wastage.
(iii) Moderate application of N in neutral 'sandy loam' soil (medium in N and K, rich in P) improves brightness of fibre along with increase in yield. *C. capsularis* jute in the same soil gives good response to N, but the fibre tends to be coarser, although bundle tenacity of fibre remains practically unaffected.

(iv) Application of lime in acidic soil increased the fibre yield of *olitorius* jute whereas *capsularis* jute did not respond to lime in that soil. Further investigation in this line is necessary to supplement these results.

(v) Magnesium produced brighter and finer fibre in most of the trials. The nutrient when used as magnesium sulphate increased the yield of *olitorius* jute in normal soils but in acidic soil it failed to increase the yield of *olitorius* or *capsularis* jute. Use of the nutrient after reducing the soil acidity by liming or its use as carbonate salt (magnesite or dolomite) might be useful. Future work may be directed in that line.

(vi) Existing soil zinc appears to be sufficient for jute crop and further addition was found to be ineffective on *olitorius* jute.

Although statistically insignificant, molybdenum increased the yield of *olitorius* jute without adversely affecting the fibre qualities in the existing soil status of the micro-nutrient. Further research in this line has great potentiality since Mo is known to assist nitrogen-fixation in soil and thus may help towards nitrogen-economy.
(vii) The fertilizers (NPK) seem to have some influence on the important chemical constituents of jute fibre viz. lignin, hemicellulose and alpha-cellulose. Lignin and hemicellulose tend to increase with use of higher doses of N, either alone or with PK, and with increase in hemicellulose content, the bundle tenacity of fibre tends to decrease.

Alpha-cellulose content of fibre tends to increase with higher gain in yield due to application of N alone.

Further research in this line will be of technological and academic value.

(viii) Length:diameter ratio of ultimate fibre cells increased (indicating better spinnability) with application of N alone. But use of PK with N reduced that ratio to some extent. Further research to investigate the specific roles of P and K in nutrition of jute crop is expected to be rewarding.