EFFECT OF NPK AND S FERTILIZER ON GROWTH AND YIELD OF WHITE JUTE ADVANCED LINE BJC-370

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CERTIFICATE

This is to certify that thesis entitled, ***"Effect Of NPK and S Fertilizer on Growth and Yield of White Jute Advanced Line BJC-370"*** Submitted to the ***Faculty of Agriculture***, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN DEPARTMENT OF SOIL SCIENCE**, embodies the result of a piece of *bona fide* research work carried out by ***Abu Taher Mozammel Hossain*** Registration No. **25263/00371** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged by him.

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DEDICATED TO
MY
BELOVED PARENTS

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ABSTRACT

A field experiment was carried out in Young Brahmaputra and Jamuna Floodplain (AEZ-8) at research field in Central Research Station, Manikganj under Bangladesh Jute Research Institute, to study the effect of NPK and S fertilizer on growth and yield of white Jute BJC-370. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments used were T_1 control (0 kg NPK & S ha^{-1}), T_2 (45, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_3 (45, 10, 60, 20 kg ha^{-1} NPK & S respectively), T_4 (45, 15, 90, 30 kg ha^{-1} NPK & S respectively), T_5 (90, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_6 (90, 10, 60, 20 kg ha^{-1} NPK & S respectively), T_7 (90, 15, 90, 30 kg ha^{-1} NPK & S respectively), T_8 (135, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_9 (135, 10, 60, 20 kg ha^{-1} NPK & S respectively) and T_{10} (135, 15, 90, 300 kg ha^{-1} NPK & S respectively). The results indicated that the fibre yield, stick yield, green weight with leaves, plant height (PH) and base diameter (BD) were found statistically significant. The highest plant height (3.44 m) and base diameter (10.22 mm) were recorded in the plants treated with T_9 and T_8 treatment respectively at 120 DAS. The highest fibre yield (3.70 t ha^{-1}), stick yield (8.14 t ha^{-1}) and green weight with leaves (62.45 t/ha) was found in treatment T_8 and the lowest fibre, stick and green weight with leaves yield were found in control treatment. Dry matter production of root, bark, stick and leaves at different stage were significantly varied with different treatments except 30 DAS. The yields of fibre due to different treatments ranked in the order of $T_8 > T_{10} > T_9 > T_6 > T_4 > T_7 > T_5 > T_3 > T_2 > T_1$. The N, P, K and S contents as well as their uptake by jute plants were also increased due to application of different treatments. The treatments had no significant effect on soil properties like soil pH, organic carbon, total N, available P, exchangeable K and available S. The economic analysis demonstrated that the highest net benefit of Tk. 78444 ha^{-1} was obtained in T_8 treatment.

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IST OF ACRONYMS

ACRONYM	FULL WORD
AEZ	Agro-Ecological Zone
@	At the rate
BCR	Benefit Cost ratio
BD	Base Diameter
BJRI	Bangladesh Jute Research Institute
$CaCl_2$	Calcium Chloride
cc	Cubic centimeter
cm	Centimeter
conc.	Concentrated
$CuSO_4.5H_2O$	Green vitriol
cv.	Cultivar(s)
CV%	Percentage of Coefficient of Variance
DAS	Day After Sowing
DM	Dry Matter
e.g.	example
et al.	and others
$FeSO_4$	Ferrous Sulphate
FYM	Farm Yard Manure
g	Gram
H_3BO_3	Boric Acid
$HClO_4$	Perchloric acid
HNO_3	Nitric acid
H_2O	Water
H_2O_2	Hydrogen per oxide
H_2SO_4	Sulfuric acid
i.e	that is
K	Potassium
$K_2Cr_2O_7$	Potassium Dichromate
kg	Kilogram
kg ha^{-1}	Kg per hectare
K_2SO_4	Potassium Sulfate
LSD	Least Significant Difference
M	Molar
m	Meter
Max.	Maximum
meq	Milliequivalent
Min.	Minimum
ml	Milliliter
mm	Millimeter
TSP	Triple Super Phosphate
MP	Muriate of Potash
N	Nitrogen

Chapter 1
Introduction

ACRONYM	FULL WORD
N	Normal
NaOH	Sodium Hydroxide
nm	Nanometer
NPKS	Nitrogen, Phosphorus, Potassium and Sulphur
NS	Non Significant
OM	Organic matter
P	Phosphorus
PH	Plant Height
pH	Hydrogen ion concentration
ppm	Parts per million
RCBD	Randomized Complete Block Design
RH	Relative Humidity
^0C	Degree Celsius
%	Percent
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
$SnCl_2$	Stannous chloride
t ha^{-1}	Ton per hectare
USDA	U.S.Department of Agriculture

INTRODUCTION

Most of the fibre for clothing comes from the plants. Cotton is first of them and next is jute. Natural fibres draw an extra attraction for quality, comfort and environmental sustainability. The demand of natural fibre is increasing day by day.

Jute (*Corchorus sp.*) an important and the largest natural fibre crop belonging to the family Tiliaceae, is an eco-friendly and the major cash crop of Bangladesh. Its cultivation area and total production was 4.57 lakh hectare and 47.34 lakh matric tons, respectively, in the last decade (BBS, 2005). Jute sector as a whole accounts for 10% labour and 7% of GDP of Bangladesh. At present about 35% of the total production are directly engaged in this sector. It covers 4.14% of total cropped area and account 16% of foreign exchange through export of raw jute and jute products (BBS, 1997). Jute is still the most important agricultural crop for earning the foreign exchange for the country.

Besides this, jute fibre and jute sticks are largely used for different domestic purposes. In addition, jute plants improve soil productivity and also exert its positive role towards soil properties through its cultivation practices with residues viz. root, leaf defoliation and root proliferation in the field.

Fertilizers are an established agronomic input to crop production. The full benefit from the yielding varieties can be realized only if proper use is made of balanced fertilizers. But world wide energy crisis caused fertilizer shortage and as a result unprecedented escalation in their price for which the under developed country like Bangladesh is very badly hit. But to meet the higher crop production of country intensive use of fertilizers is imperative.

The nutrient removed by different crop may be used as a guide to efficient understanding of soil fertility of crop management (Alam *et al.*, 1991). Removal of nutrients by crops varies considerably depending upon certain factors such as nutrient supply in the soil fertility, rainfall, rooting behaviors of crop species and varieties.

Islam (1982) also reported that nutrient content and its uptake by plants are also influenced by soil fertility and fertilizer management nutrient availability and its uptake by crops are important aspects of crop growth and yield. In cereal crops, where just grain is removed, much lower quantities of nutrients are lost than the crops where the entire above ground portions were harvested (Tisdale *et al.*, 1968) like jute. When a fertilizer material is applied to a soil, some of its taken up by the plant, some are either lost or fixed in the soil system or remain as residual fertilizers. Alam *et al.* (2000) reported higher uptake of N with higher doses of N fertilizer.

Assessment of the fertilizer requirements of jute, both *Corchorus capsularis* and *Corchorus olitorius*, is very important (Dargan, 1969). Of the plant nutrients NPK and S have the great influence on the growth and yield of the fibre crops.

As the fertilizer status of the soils of Bangladesh is being depleted day by day due to continuous cultivation of HYV with intensive cropping pattern, NPK and S are of negative balance in most soils, it is urgent need to use balanced nutrient for higher crop production (Bhuiyan, 1992). Higher fibre yield was obtained with the combined NPKS and Zn (100-10-30-20-4 kg/ha) with *olitorius* variety O-9897 (Anonym 1990).

BARC (1989) recommended to use S in jute cultivation for higher yield. Application of P is needed for jute growth which reported by various workers (Jain and Pandey, 1967 and Lin, 1956).

BJC-370 is an advanced breeding line developed by BJRI. The fertilizer requirement of this variety to achieve maximum yield is yet to be decided.

Considering the above condition the present experiment has been undertaken with the following objectives:

1. To observe the effect of N P K and S fertilizer on the growth and yield of jute.
2. To find out the optimum dose of N P K and S fertilizer for jute (*Corchorus capsularis*) production.

Chapter 2

Review of literature

REVIEW OF LITERATURE

Jute being a tropical crop requiring warm humid climate, its commercial cultivation has remained confined to Bangladesh and India and a few other countries in the world. Jute is the second next to cotton as a fibre crop but it has received very little attention in respect of its development. The volume of reported scientific information on the aspect of jute production is meagre. A review of the research works done so far as pertinent to this study is presented below:

Nitrogen is vitally important plant nutrients (Tisdale *et al.*, 1990) and Nitrogen is positive balance in soil with N dose.

Das *et al.* (1999) showed that at 90 days after sowing, biomass production of jute increased of jute with upto 80 kg N ha^{-1}.

An adequate supply of nitrogen is associated with high photosynthetic activity, vigorous vegetative growth and dark green color of plant leaves. Nitrogen is regarded as most influential plant element in the regulation of jute growth and production. Alam *et al.* (2000) reported plant height, base diameter of jute were increased with the application of nitrogen fertilizer.

ICJC (1969) reported that applied N enhances the fibre yield of jute.

Experimental report of Pandey and Goswamy (1965) indicated that the fibre yield of *Capsularis* jute increased progressively with the increase of nitrogen as high as 60 kg/ha.

Gupta and Sen (1975) reported that the application of nitrogen increased the frbre yield significantly and also improved the yarn tenacity. The increase in fibre yield with application of nitrogen resulted from an increase in plant height, basal diameter and green weight.

Singh *et al.* (1979) reported that nitrogen application improved the fibre yield/ha as well as per plant and plant height though the effects were non significant. They thought that the lack of significant response to application of fertilizer nitrogen might be attributed to high nitrogen status of the soil.

Gupta and Bhatytacharya (1981) observed that jute gave higher fibre yields with nitrogen at 40 kg/ha applied to the soil and 10 kg in 2 foliar sprays than 50 kg N/ha applied to soils.

Sarkar and sarkar (1985) grew ramie during 1981-1982 and 1982-1983. Nitrogen was applied: (1) a single application, (2) in two split dressings, and (3) in three split dressing at the rates of 25, 50 and 75 kg N/ha at each cutting. Highest fibre yield, dry matter (DM) production and nitrogen resulted from the two-split application of nitrogen. At all levels DM and fibre yield were enhanced with increase in a rate upto 50 kg N/ha and declined at 75 kg N/ha.

Razzaque and Gaffer (1980) conducted an experiment at the Agronomy field laboratory, Bangladesh Agricultural University, Mymensingh. The levels of nitrogen were 20 and 30 kg/ha and the frequency of foliar applications were 9, 6, 5 and 4 times in the growing season. They found that the application of the whole amount of urea in 4 installments had given the best performance. The other treatments where urea applied in 5, 6 and 9 installments had given identical results.

BJRI (1986) reported that the fibre yield of jute (both total fibre and fibre weight per plant) followed a curvilinear relationship with increasing doses of nitrogen (kg/ha). It showed that the maximum fibre (8.43 g/plant) could be obtained at 143.6 kg N/ha.

BJRI (1987) documented the responsiveness of O-9897 variety to higher doses of nitrogen fertilizer and recommended 100-150 kg N/ha for the fibre production of O-9897.

Alam *et al.* (1989) conducted and experiment to investigate split application of urea on the yield of jute. There doses of urea 50,100,150 N kg/ha were splited into four times of application. Among the four splited times of applications, half dose at sowing and half dose after 45 days gave highest yield.

Chaudhury *et al.* (1998) reported a positive effect of K on jute fibre yield per plant.

Alam *et al.* (2000) observed significant effect of K on base diameter, plant height and weight of green plants with leaves. They found highest plant height with the application of 100 kg K/ha.

Dutt (1962) observed a chlorosis of jute in Corchours and concluded that this chlorosis was by sulphur deficiency.

Pandey *et al.* (1967) studied on the response of jute to increasing levels of nitrogen upto 180 kg/ha applied either alone of with half of the quantity of P and K. Application of nitrogen increased the fibre yield, the optimum being 71.00 kg/ha for *Capsularis* and 49.92 kg/ha for *Olitorius*. Addition of P and K without nitrogen, depressed the fibre yield. Higher level of nitrogen reduced the quality of fibre. Study also reflected that combined application of NP and K yielded the highest fibre.

Results from field experiments in a red lateritic soil using ^{15}N-labelled ammonium sulphate and ^{32}P-labelled super phosphate, Karim *et al.* (1973) showed that for jute nitrogen was best in a single broadcast application 45 days after sowing.

In a three year trial at Barrakpore, Jain and Pandey (1967) reported that the mean yield of white jute (*Corchorus capsularis*) fibre increased from 12.3 to 21.4 q/ha when 45 kg N/ha was applied as ammonium sulphate. A further 45 kg N per ha application raised the fibre yield to 24.3 q/ha. Plant heights also increased by N. There was only slight response to P and none to K.

Khan and Islam (1961) reported that N supply markedly increased the leaf growth of jute plants. The maximum leaf growth was with N in combination with 10 to 15 lbs. of P_2O_5 per acre.

Bhattacharya and Gupta (1983) found that jute given 40 kg N + 10 kg ferrous sulphate/ha as a basic dressing and 10 kg N/ha in 2 foliar sprays gave fibre yield of 4.1 t/ha which was 47% higher than those obtained without N or Fe.

Alam *et al.* (1990) conducted another experiment at Faridpur and Kamalpur. At Kamalpur the highest fibre yield was obtained with 150-10-30-20-4 kg N-P-S and Zn/ha. A good response to the application of sulphur at the rate of 20 kg S/ha was observed at this location. The data of Faridpur site shows that the higher fibre yield was obtained with 100-10-30-20-4 kg NPKS & Zn/ha. There was no response to the application of sulphur at the rate of 20 kg S/ha.

Ali and Razzaque (1986) conducted three identical experiments using D-154 variety of jute as a test crop in Mymensingh and Jamaplur in order to evaluate the effect of N, P, K, S and Zn and got no significant effect of sulphur in any of the experimental sites.

BJRI (1986) found that sulphur independently increased dry matter weight of jute slightly but dry matter weight increased greatly when sulphur, zinc and phosphorus were applied combinedly.

Alam *et al.* (1989) conducted an experiment in 1988 at three different regions of Bangladesh (Kishorganj, Faridpur and Manikganj) having 14 different N, P, K, S and Zn treatment combinations. The other two experimental findings show that higher yield of jute was obtained with 150-10-30-20-4 kg N-P-K-S-Zn/ha, respectively at both Kishorganj and Faridpur location. At Kishorganj the yield of jute slightly increased due to application of sulphur but at Faridpur there was no effect of sulphur on the yield of jute at the rate of 20 kg/ha.

Alam *et al.* (1990) conducted experiments at Manikganj, Kishorganj, Rangpur and Faridpur. Three doses of urea 50, 10, 150 kg N/ha were splited into four times of application i.e. (1) T_1-half dose at sowing and half dose after 45 days (control); (2) T_2-half dose at 14-21 days after sowing (DAS) (1^{st} weeding) and half at 42-49 DAS (3^{rd} weeding), T_3-$1/3^{rd}$ dose at 14-21 DAS (1^{st} weeding), $1/3^{rd}$ dose at 42-49 DAS (3^{rd} weeding); T_4-1/3 rd dose at sowing, $1/3^{rd}$ dose at 2-3 DAS (2^{nd} weeding) and 3^{rd} dose at 42-49 DAS (3^{rd} weeding). The data were statistically analyzed and found non significant for fibre yield. But among the four times of application of urea three times (T_3) gave the highest yield of fibre.

Islam *et al.* (1992) conducted an experiment at old Barhmaputra Flood plain soil in 1989 to study the influence of nitrogen and zinc rates on the yield and yield components of jute cv. 0-4. Nitrogen from 0-67.5 kg/ha in increments of 22.5 kg progressively increased both fibre and stick yields. Significant increase in yield was first observed at the 45 kg N/ha level compared to the control, which persisted upto the highest rate. This influence on yield was attribute to significant increases in both plants height and stem diameter of individual plants. Nitrogen did not influence the bark thickness, bark-stick ratio and harvest index. Zinc rate did not produce any significant effect on the yield and yield parameters. Strong correlations between yield and yield parameters except bark thickness were observed, but plant diameters were found to be the major determinant to final yield.

Chaudhury and Chattapadhay (1998) stated that *Corchorus capsularis* was given 30 1bs. P_2O_5, 5 lbs. K_2O and 150 mds. farmyard manure per acre in all combinations together with N at 0, 6, 120 and 180 lbs. per acre. All rates of N gave significant increase in fibre yield as did farmyard manure manure and K alone or in combinations.

Alam *et al.* (2003a) conducted experiment with a white jute breeding line BJC-2142 to ascertain the nutritional requirement for its optimum growth and yield at three different regions of Bangladesh (Manikganj, Rangpur and Faridpur) having 17 different N,P,K and S treatment combinations. They showed significant effects of NPKS fertilizer application on fibre and stick yield of the pipeline material BJC-2142 at all locations. Highest fibre and stick yields were obtained with 90-10-40-20 and 90-10-80-20 kg NPKS per hectare at Manikganj, 90-10-40-20 and 90-10-60-20 kg NPKS per hectare at Rangpur and 120-10-40-20 and 120-10-40-20 kg NPKS per hectare at Faridpur respectively.

Alam *et al.* (2003b) conducted another experiment at Manikganj with four treatments i.e. (1) NPKS (2) NPKSZn (3) NPKSB and (4) NPKSZnB to find out the effect of nutrients on the yield and quality of jute fibre as regard to its spinning capabilities. Highest fibre and stick yields were obtained with the nutrient combination of NPKSZnB.

Khandker *et al.* (2004) conducted experiment with a white jute variety BJC-2142 to ascertain the nutritional requirement for its optimum growth and yield at three different regions of Bangladesh (Manikganj, Rangpur and Chandina) having eighteen selective dose of NPKS fertilizer. They showed that the fibre and stick yield (2.77 t/ha and 6.33 t/ha) were found with 150-10-40-20 NPKS kg/ha at Manikganj but at Rangpur those were found (2.89 t/ha and 7.39 t/ha) with 90-10-40-10NPKS kg/ha and 90-10-10-20 NPKS kg/ha respectively.

Khandker *et al.* (2005) conducted an experiment with a white jute breeding line BJC-2142 to ascertain the nutritional requirement for its optimum growth and yield. Eighteen selective dose of NPKS fertilizer were used. Experiments were conducted at Manikganj and Rangpur. They showed that highest fibre and stick yield were obtained with 150-10-40-20 NPKS kg/ha at Rangpur. But at Manikganj the highest fibre yield was found with 90-20-40-20 NPKS kg/ha and stick yield with 30-10-40-20 NPKS kg/ha. They also observed that the highest N dose yielded the highest fibre at Rangpur. Study indicated that K 40 kg/ha was enough to produce the highest jute fibre at both the places. Additional higher dose of K (60& 80 kg/ha) decreased the fibre yield. Results also showed that P 10 kg/ha and S 20 kg/ha influenced the growth and yield of the variety.

Khandker *et al.* (2006) conducted another experiment with a white jute advance line BJC-2142 to ascertain the nutritional requirement for its optimum growth and yield with ten combined treatments of NPK and S fertilizer. Experiments were conducted at Kishorganj, Chandina and Faridpur. Results of the experiments showed significant treatment difference with the production of fibre and stick. The highest fibre yield (3.19 t/ha) was obtained with 100-15-10-30 NPKS kg/ha and stick yield (7.22 t/ha) with 100-10-60-20 NPKS kg/ha at Kishorganj. They also observed that fibre and stick yield was lower with all the maximum N dose treatment combination.

Chapter 3
Materials and methods

MATERIALS AND METHODS

This chapter includes a brief description of the experimental soil, jute variety, land preparation, experimental design, treatments, cultural operations, collection of soil samples and analytical methods etc. followed in the experiment to study the effect of N, P, K and S on the growth and yield of jute.

3.1 Experimental site

The research work relating to the study of the effect of NPK and S on the growth and yield of jute was conducted at the Central Research Station, Manikganj under Bangladesh Jute Research Institute, during the Kharif-I of 2005. The following map shows the specific area of experimental site. (Figure 1.)

3.2 Description of soil

The soil of the experimental field belongs to the Sonatala series under the Agroecological Zone, Young Brahmaputra and Jamuna Floodplain (AEZ-8). The General soil type of the site is Noncalcareous Grey Floodplain Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. The morphological, physical and chemical characteristics of initial soil are presented in Table 1 and 2.

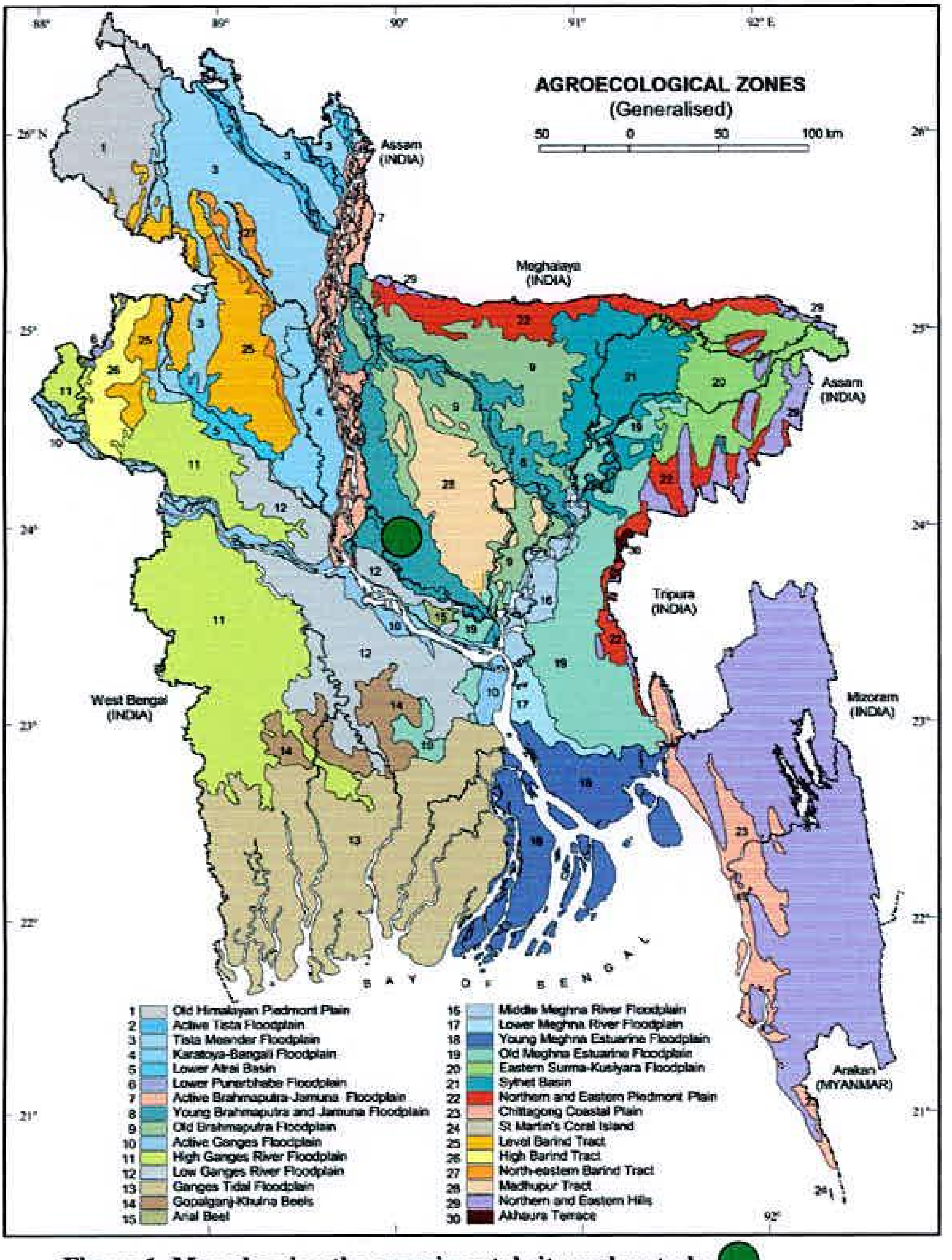

Figure 1. Map showing the experimental site under study

3.3. Climate

The climate of the experimental area is characterized by sub tropical accompanied by heavy rainfall during the months from May to September and scanty rainfall during the rest of the year. The weather condition of crop growing period was as usual and the total rainfall during the cropping period (April to August, 2005) was 1552 mm. The average maximum and minimum air temperature during crop growing period was 34.4 and 24.1°C respectively. The average temperature, humidity and rainfall data during the cropping period are shown in Figure 2 and Appendix XIV.

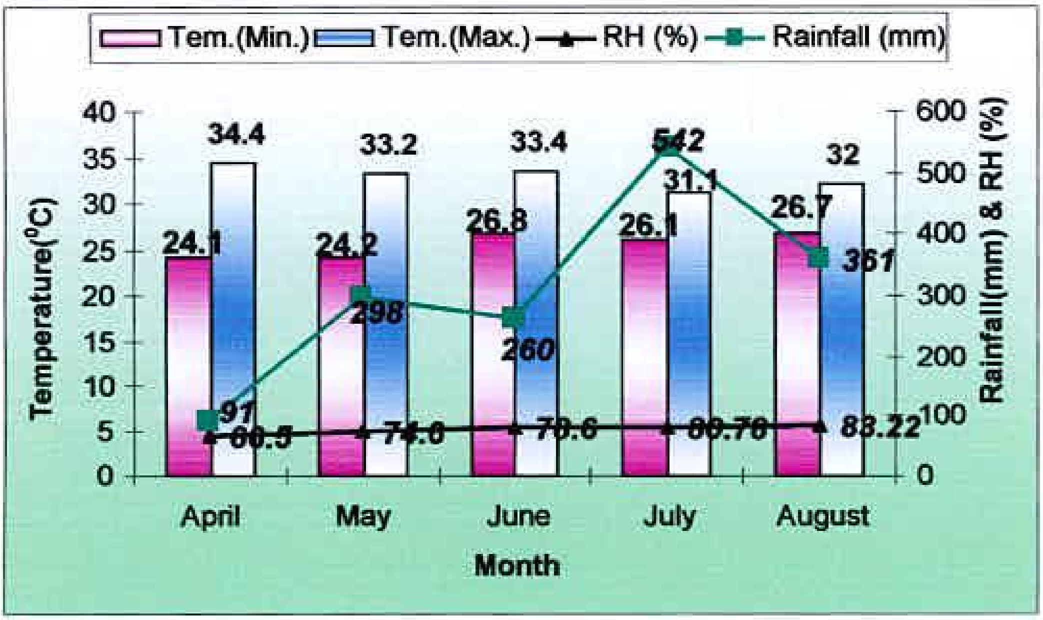

Figure 2. Weather data of Manikganj, during 2005

Table 1. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Central Research Station, (JAES), Bangladesh Jute Research Institute.
AEZ no. 8	Young Brahmaputra and Jamuna Floodplain
General Soil Type	Noncalcareous Grey Floodplain Soils
Land type	Medium high land
Soil series	Sonatala
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

Table 2. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis.	
% Sand	70
% Silt	13
% Clay	17
Textural class	Sandy Loam
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.06
Available P (ppm)	4.05
Exchangeable K (meq/100 g soil)	0.10
Available S (ppm)	1.52

3.4 Description of the jute variety

The high yielding advanced breeding line of white jute (BJC-370) developed by Bangladesh Jute Research Institute was used as the test crop in this experiment. The percentage of the seed germination was 98. Harvesting time of this line is 110 to120 days after sowing. The variety is resistant to diseases, insects and pest attack.

3.5 Land Preparation and sowing seed

The land was well prepared by four times cross ploughing with tractor followed by harrowing and laddering. The individual plots were made 7.5 cm high and 9 inches deep drain were made around the each plot to restrict the lateral runoff of irrigation or rainfall water. Jute seed were sown at the rate of 8 kg/ha or 7.2 g/plot in line by hand on April 5, 2005 by making narrow and shallow furrows with iron rod keeping the row to row distance of 30 cm.

3.6 Layout and design of the experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and ten treatments. Each block was Sub-divided into 10 unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 30. The unit plot size was 3m × 3m. Plot to plot distance was 1m and drain was 9 inches deep. The layout of the experiment has been shown in Figure 3.

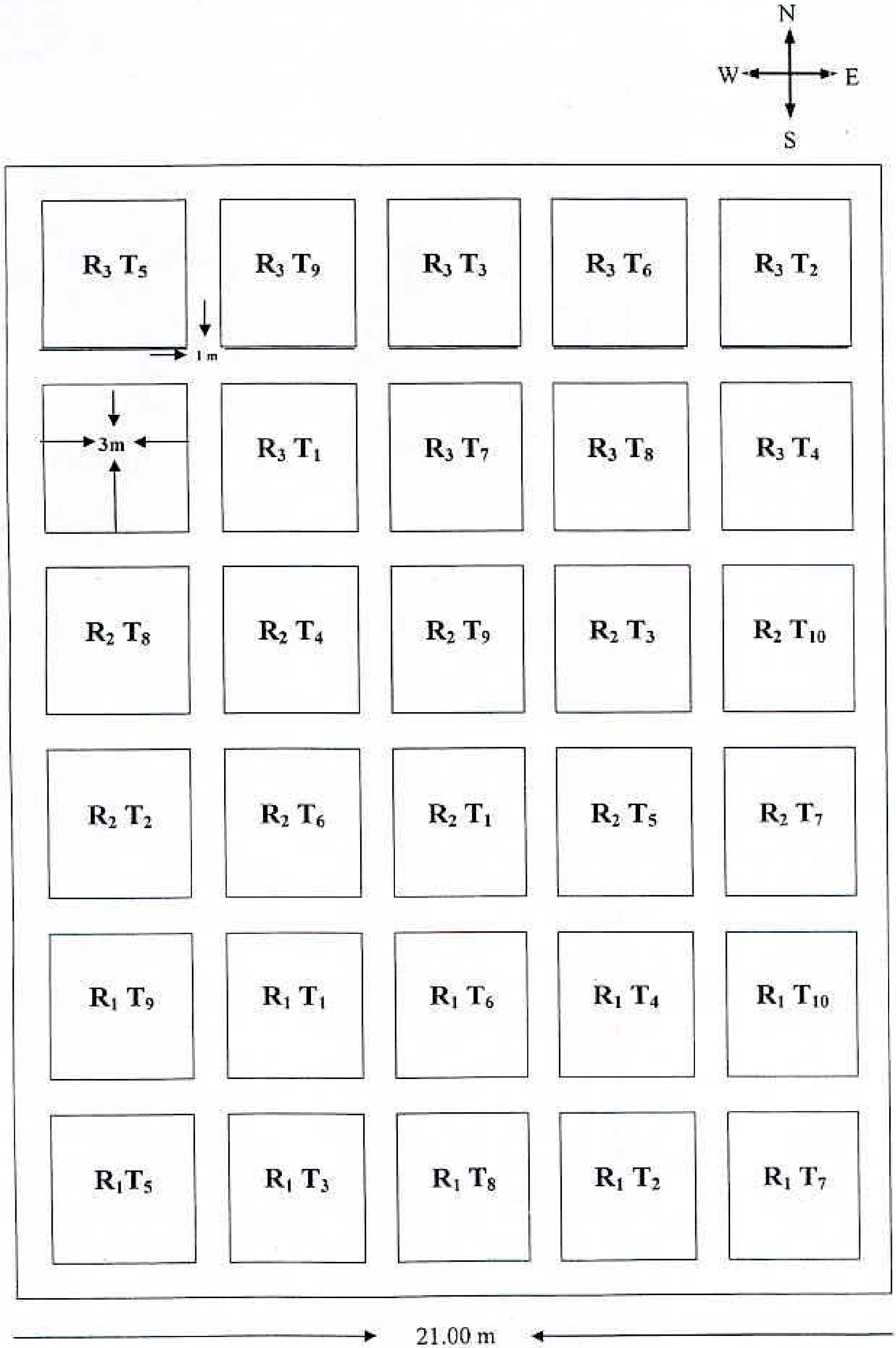

Figure 3. Layout of the experiment

3.7 Treatments

There were ten treatments of different combination of NPK and S including a control.

Treatments were as follows:

Treatment	Combination of N P K & S (kg/ha)			
	N	P	K	S
T_1	0	0	0	0
T_2	45	5	30	10
T_3	45	10	60	20
T_4	45	15	90	30
T_5	90	5	30	10
T_6	90	10	60	20
T_7	90	15	90	30
T_8	135	5	30	10
T_9	135	10	60	20
T_{10}	135	15	90	30

3.8 Fertilizers application

N was applied in the form of urea. P, K and S were applied in the form of triple super phosphate (TSP), Muriate of potash (MP) and gypsum respectively. Full dose of P, K, S and half dose of N were added to the soil during final land preparation on the sowing date. The rest amount of N was top dressed at 45 days after sowing (DAS).

3.9 Cultural operation

After sowing of seeds a common irrigation was given by sprinkler irrigation system to ensure germination of seeds. The soil was loosened at 25 DAS. Gap filling (By resowing of seeds), weeding and thinning were done at 8, 25 and 45 DAS respectively. Jute hairy caterpillar was removed by hand picking and by pesticides use.

3.10 Growth analysis

3.10.1 Dry matter (DM) estimation and partitioning

Five randomly selected plants were uprooted from each unit plot in each sampling and sampling was done from 15 DAS to 120 DAS at 15 days interval. To avoid border effects plants were not sampled from edge of the plots.

For dry matter estimation the sampled plants were separated in to roots, sticks, barks and leaves. These parts were then dried in an oven at 70^0 C for 72 hours and then weighed. For Total Dry Matter (TDM) estimation weights individual plant parts were multiplied by total number of plant population.

3.11 Yield and yield components

3.11.1 Plant height (PH) and Base diameter (BD)

The plant height and base diameter were estimated of ten randomly selected plants from each plot at 15 days interval from 15 days after sowing (DAS) to 120 DAS.

3.11.2 Green weight

At maturity (at 120 DAS) whole area from each plot was harvested and weight of green plants including leaves were recorded and then converted to t/ha.

3.11.3 Dry fibre and stick yield

At maturity (120 DAS) whole area from each plot was harvested, tagged and kept for 4 days for shedding out the leaves from the plants. Then plants were dipped in water by the help of bamboo rake for 20 days. After proper retting of fibre, it was extracted from the jute sticks and allowed to dry in the sun. After proper drying the jute fibre and sticks weight were recorded per plot and then calculated in t ha^{-1}.

3.12 Collection of soil and plant samples

Soil samples were collected two times: (1) before sowing to observe the initial nutrient status of soil, (2) after harvest of plants to study the nutrient status of soil with different treatments in jute cultivation. Steel augar was used in 0-15 cm deep to collect soil samples. Plant samples were collected from individual plot at harvest stages of the crop for laboratory analysis. Five plants were randomly collected from each plot. The plant samples were washed first with tap water and then with distilled water several times .The plant samples were dried in the electric oven at 70^0 C for 48 hours. After that the samples were ground in an electric grinding machine and stored for chemical analysis. The plant samples were collected by avoiding the border area of the plots.

3.13 Analyses of Soil

3.13.1 Physical analysis

3.13.1.1 Particle-size analysis

Particle-size analysis of soil was done by Hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values for % sand, % silt and % clay to the "Marshall's Textural triangular coordinate" following the USDA system.

3.13.2 Chemical analysis

3.13.2.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter using soil water suspension of 1:2.5 as described by Jackson (1962).

3.13.2.2 Organic carbon

Organic carbon in soil was determined by wet oxidation method of Walkley and Black (1934). The underlying principle is to oxidize the organic carbon with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1N $FeSO_4$ solution. To obtain the organic matter content, the amount of organic carbon was multiplied by the Van Bemmelen factor, 1.73. The result was expressed in percentage.

3.13.2.3 Total nitrogen

Total nitrogen of soil was determined by micro Kjeldahl method where soil was digested with 30% H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selinium powder in the ratio of 100:10:1). Nitrogen in the digest was estimated by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Bremner and Mulvaney, 1982).

3.13.2.4 Available phosphorus

Available phosphorus was extracted from soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al.* 1954). The phosphorus in the extract was then determined by developing blue colour using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue colour was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.13.2.5 Exchangeable potassium

Exchangeable potassium was determined by 1N NH_4OAC (pH 7.0) extract of the soil by using flame photometer (Black, 1965).

3.13.2.6 Available sulphur

Available sulphur in soil was determined by extracting the soil samples with 0.15% $CaCl_2$ solution (Page *et al.* 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.14 Chemical analysis of the plant samples

3.14.1 Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5 g of sub-sample was taken into a dry clean 100 ml of Kjeldahl flask, 10 ml of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly to 200^0 C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6ml of 6N HCl were added to it. The content of the flask was boiled until they become clear and colourless. This digest was used for determining P, K and S.

3.14.2 Phosphorous

Phosphorous in the digest was determined by ascorbic acid blue color method (Murphy and Riley, 1962) with the help of a Spectrophotometer (LKB Novaspec, 4049).

3.14.3 Potassium

Potassium content in plant sample was determined by flame photometer.

3.14.4 Sulphur

Sulphur content in the digests were determined by turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspac, 4049)

3.14.5 Nitrogen

Plant samples were digested with 30% H_2O_2, conc. H_2SO_4 and a catalyst mixture (K_2SO_4 : $CuSO_4.5H_2O$: Selenium powder in the ratio 100 : 10 : 1 respectively) for the determination of total nitrogen by Micro-Kjelkal method. Nitrogen in the digests were determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01N H_2SO_4 (Jackson,1973).

3.15 Harvesting

The jute plants were harvested at early pod stage on 5 August 2005 after total growth duration of 120 days. After cutting at ground level, the jute plants were made into small bundles and kept standing on the ground for 4 days for sheding of leaves.

3.16 Retting of jute

After shedding of leaves, the jute bundles were steeped plotwise in pond water for retting. The retting process was completed in 21 days after steeping. In the retting process the fibre in the bark get loosened and separated from the woody stalk due to the removal of pectins, gums and other mucilaginous substances. This is usually caused by the combined action of water and microorganisms (Kundu, 1956).

3.17 Stripping, decortication, washing and drying

After proper retting the fibres were extracted by stripping and washed thoroughly in water. The extracted fibres were dried in sun plotwise on bamboo bars. After drying the fibres were weighed to get the fibre yield. After stripping the jute sticks were weighted to record the yield of sticks. Retting, decortication, washing and drying of the sample plants were done in the similar way.

3.18 Statistical Analysis

The recorded data on different parameters and various characters of the crop were subjected to statistical analysis. For this purpose, IRRISTAT, MICROSOFT EXCEL XP program were used. The difference between treatment means was compared by Least Significant Difference Test (LSD).

Chapter 4

Results and Discussion

Result and Discussion

This chapter comprises of the presentation and discussion of the results obtained due to application of different fertilizer doses on growth yield and nutrient uptake by Jute (BJC-370). Result of the studies such as plant height (PH), base diameter (BD), dry matter production of different plant parts, nutrient content, uptake by jute plant as well as yield attributes and stick yields and chemical characteristics of the soil at post harvest are discussed in this chapter.

4.1 Yield attributing characters

4.1.1 Plant height

Plant height is an important morphological character that acts as a indicator of availability of growth sources in its vicinity. The height of a plant depends on availability of nutrients. The effects of different treatments on plant height at four growth stages (30, 60, 90 and 120 DAS) were statistically significant except 30 DAS (Table 3). The maximum plant height (3.44 m) was attained in the treatment T_9 and the second highest plant height (3.39 m) was attained in the treatment T_{10} and the lowest plant height (2.84 m) of jute plant was displayed by T_1 treatment (at 120 DAS) (Table 3 and Appendix III). At 90 DAS, the highest and lowest plant height was also recorded in T_9 (2.87m) and T_1 (2.41m) treatments, respectively. Plants grown without fertilizer were consistently shorter compared to other treatments in all growth stages. This trend was similar to the result reported by Gupta and Sen (1975) in *olitorius* jute and Alam *et al.* (2000).

Table 3. Effect of NPK and S on Plant height of Jute (m) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	0.38	1.42	2.41	2.84
T_2	0.39	1.49	2.59	3.11
T_3	0.39	1.58	2.75	3.14
T_4	0.39	1.59	2.70	3.18
T_5	0.39	1.63	2.76	3.30
T_6	0.39	1.62	2.78	3.30
T_7	0.38	1.59	2.76	3.24
T_8	0.39	1.62	2.81	3.28
T_9	0.41	1.72	2.87	3.44
T_{10}	0.41	1.64	2.82	3.39
LSD (5%)	0.04	0.16	0.20	0.18
CV %	6.0	5.8	4.3	3.3
Level of significance	NS	*	*	**

NS = Non significant
** = Significant at 1% level of significance
* = Significant at 5% level of significance

$T_1 = N_0P_0K_0S_0$
$T_2 = N_{45}P_5K_{30}S_{10}$
$T_3 = N_{45}P_{10}K_{60}S_{20}$
$T_4 = N_{45}P_{15}K_{90}S_{30}$
$T_5 = N_{90}P_5K_{30}S_{10}$
$T_6 = N_{90}P_{10}K_{60}S_{20}$
$T_7 = N_{90}P_{15}K_{90}S_{30}$
$T_8 = N_{135}P_5K_{30}S_{10}$
$T_9 = N_{135}P_{10}K_{60}S_{20}$
$T_{10} = N_{135}P_{15}K_{90}S_{30}$

4.1.2 Base Diameter

Base Diameter, a yield contributing character of jute was significantly influenced by different doses of fertilizer combinations at different growth stages of the crop (Table 4 and Appendix IV). The maximum base diameter (10.22 mm) was produced by T_9 and minimum base diameter (9.72 mm) was produced by T_1 at 30 DAS. Similar trend was found at 60 DAS. At 90 DAS, the highest base diameter (20.99 mm) was found in the treatment T_8 which is statistically similar to T_5, T_6 and T_9 treatment. The lowest value (14.96 mm) was being recorded in T_1 treatment with 90 DAS. At 120 DAS the highest base diameter (24.81mm) was found in the treatment T_8 which is statistically similar to T_9, and T_{10} treatments. The lowest value (17.11 mm) was recorded in T_1 treatment. Similar trend of results were also reported by Ahamed *et al.* (1998) in jute.

Table 4. Effect of NPK and S on Base Diameter of Jute (mm) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	9.72	11.88	14.96	17.11
T_2	9.87	13.53	17.64	20.68
T_3	9.96	14.09	18.20	20.45
T_4	9.87	13.79	18.42	20.08
T_5	10.02	14.98	19.49	21.76
T_6	9.78	14.67	19.55	21.91
T_7	9.77	14.24	18.63	20.41
T_8	10.03	15.28	20.99	24.81
T_9	10.22	15.61	19.84	22.38
T_{10}	10.13	14.69	19.18	22.15
LSD (5%)	0.60	1.99	2.88	2.77
CV %	3.5	8.1	9.0	7.6
Level of significance	NS	*	*	**

NS = Non significant
** = Significant at 1% level of significance
* = Significant at 5% level of significance

$T_1 = N_0P_0K_0S_0$
$T_2 = N_{45}P_5K_{30}S_{10}$
$T_3 = N_{45}P_{10}K_{60}S_{20}$
$T_4 = N_{45}P_{15}K_{90}S_{30}$
$T_5 = N_{90}P_5K_{30}S_{10}$
$T_6 = N_{90}P_{10}K_{60}S_{20}$
$T_7 = N_{90}P_{15}K_{90}S_{30}$
$T_8 = N_{135}P_5K_{30}S_{10}$
$T_9 = N_{135}P_{10}K_{60}S_{20}$
$T_{10} = N_{135}P_{15}K_{90}S_{30}$

4.2 Dry matter accumulation

4.2.1 Total dry matter

Green material has been dried to get a constant weight for obtaining total dry mater. Total dry matter (TDM) production indicates the production ability of a crop. A high TDM production is the first prerequisite for high yield. TDM is the product of average crop growth rate (CGR) and growth duration (Tanaka, 1983).

The TDM production in jute plants over time was influenced significantly by different doses of fertilizers. Nitrogen fertilizer, accumulation of TDM in jute increased progressively from emergence to maturity (i.e. at harvest). The accumulation of TDM, however, varied depending on growth stages and NPK and S fertilizer. A rise in TDM production occurred from 30 to 90 DAS and these after the rate of increase was comparatively lower into maturity with all the treatments (Figure 4). Different treatment significantly influenced the TDM production in jute. In general, higher doses of different fertilizers increased the TDM accumulation in all growth stages. Alim (2003) reported similar trend of results.

4.2.2 Dry matter partitioning

Partitioning of accumulated dry matter into plant components is an important consideration in achieving desirable yield.

4.2.2.1 Dry Root weight

Different treatments of fertilizers showed significant variation in root dry weight (Table 5 and Appendix VIII). The highest root dry weight (18.33g $plant^{-1}$) was found with T_8 treatment and the lowest weight (9.33g $plant^{-1}$) recorded with T_1 treatment at 120DAS. Anonymous (1990) reported similar trends of results.

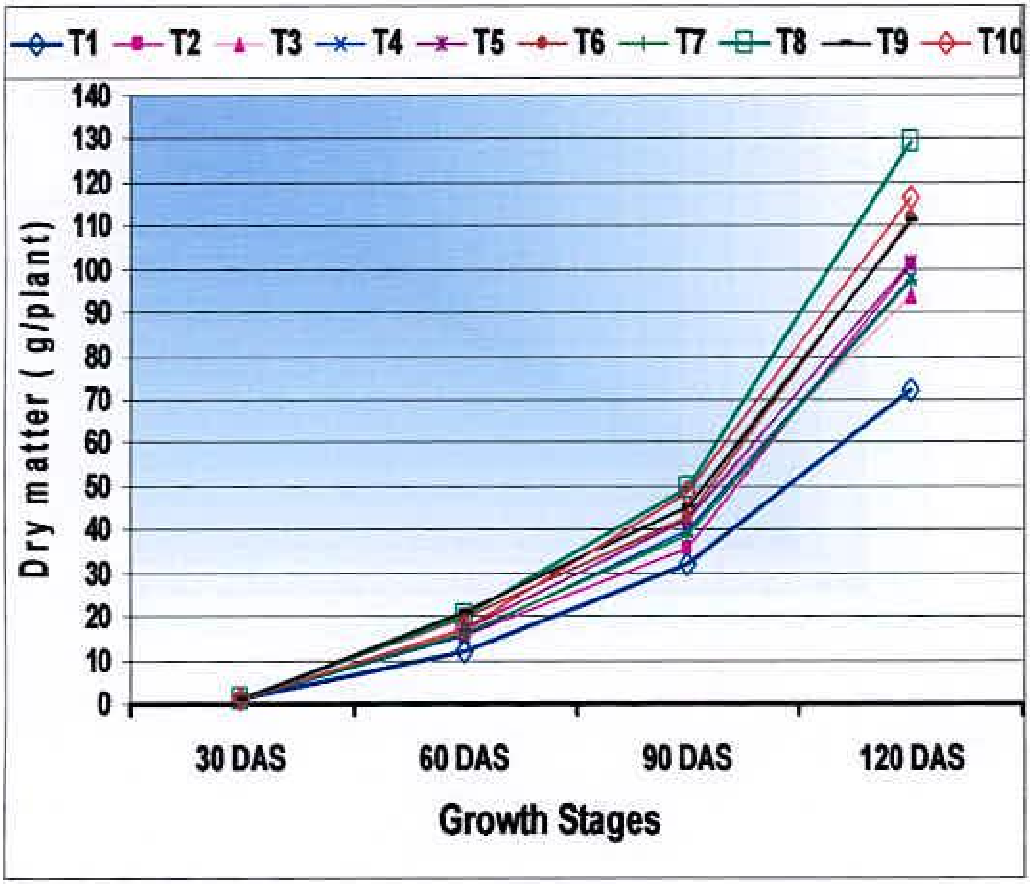

Figure 4. Total Dry matter production of Jute as influenced by different treatments at different growth stages

T_1 =	$N_0P_0K_0S_0$	T_6 =	$N_{90}P_{10}K_{60}S_{20}$
T_2 =	$N_{45}P_5K_{30}S_{10}$	T_7 =	$N_{90}P_{15}K_{90}S_{30}$
T_3 =	$N_{45}P_{10}K_{60}S_{20}$	T_8 =	$N_{135}P_5K_{30}S_{10}$
T_4 =	$N_{45}P_{15}K_{90}S_{30}$	T_9 =	$N_{135}P_{10}K_{60}S_{20}$
T_5 =	$N_{90}P_5K_{30}S_{10}$	T_{10} =	$N_{135}P_{15}K_{90}S_{30}$

4.2.2.2 Dry bark weight

The dry matter accumulation in bark of jute plant (Table 6 and Appendix V) showed that 60 DAS increased slowly up to maturity (at 120 DAS) at all treatments. At 30, 60, 90 and 120 DAS the maximum bark production 0.29, 5.93, 16.80 and 43.00 g plant^{-1} were achieved by the treatment T_7, T_9, T_8, and T_8 respectively. At harvest (120 DAS) the highest bark weight (43.00 g plant^{-1}) was recorded with treatment T_8 (135, 5, 30 and 10 kg NPK and S ha^{-1}respectively) and the lowest (22.80 g $plant^{-1}$) was recorded with treatment T_1 (0-0-0-0 kg NPK and S ha^{-1} respectively). Islam, *et al.* (1998) also found the highest bark production (26.95 g $plant^{-1}$) at 120 DAS in an experiment.

4.2.2.3 Dry stick weight

The effect of nitrogen, phosphorus, potassium and sulphur on dry stick weight of jute was statistically significant at 60 DAS, 90 DAS and 120 DAS. At 30, 60, 90 and 120 DAS the maximum stick production 0.23, 6.21, 18.87 and 62.00 g $plant^{-1}$ were achieved by the treatment T_5, T_9, T_8, and T_8 respectively. At harvest (120 DAS) the highest stick weight (62.00 g $plant^{-1}$) was recorded with treatment T_8 and the lowest (33.53 g $plant^{-1}$) was recorded with treatment T_1 (Table 7. and Appendix VI). During this period, stick dry weight dominated the TDM. This is recognized that the findings of Hossain *et al.* (1983). Islam *et al.* (1998) reported 35.56 g $plant^{-1}$ stick dry weight at 120 DAS in *Olitorius sp.* of jute.

4.2.2.4 Dry leaves Weight

Variation of leaf dry weight was observed in different combination of fertilizer (Table 8). The applied NPK and S fertilizer, the accumulation of dry matter in leaf continued up to 90 DAS and declined thereafter due to senescence and abscission of leaves (Appendix VII). The highest amount of leaf dry weight (7.80 g $plant^{-1}$) was recorded with T_{10} treatment at 90 DAS. The combination of leaf to the TDM was dominated up to 30 DAS. Similar report was presented by Hossain *et al.* (1983).

Table 5. Effect of NPK and S on Dry Root Weight of Jute/plant (g) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	0.10	1.37	5.00	9.33
T_2	0.10	2.13	5.53	17.67
T_3	0.10	1.83	6.53	11.33
T_4	0.11	1.63	6.33	12.33
T_5	0.10	1.74	7.20	12.07
T_6	0.12	2.55	6.40	14.33
T_7	0.11	1.87	6.20	13.33
T_8	0.13	2.53	6.20	18.33
T_9	0.12	2.75	6.93	13.67
T_{10}	0.13	2.83	6.73	14.67
LSD (5%)	0.02	0.57	2.95	5.20
CV %	9.9	15.6	27.3	22.1
Level of Significance	*	**	NS	*

NS = Non significant
** = Significant at 1% level of significance
* = Significant at 5% level of significance

$T_1 = N_0P_0K_0S_0$
$T_2 = N_{45}P_5K_{30}S_{10}$
$T_3 = N_{45}P_{10}K_{60}S_{20}$
$T_4 = N_{45}P_{15}K_{90}S_{30}$
$T_5 = N_{90}P_5K_{30}S_{10}$
$T_6 = N_{90}P_{10}K_{60}S_{20}$
$T_7 = N_{90}P_{15}K_{90}S_{30}$
$T_8 = N_{135}P_5K_{30}S_{10}$
$T_9 = N_{135}P_{10}K_{60}S_{20}$
$T_{10} = N_{135}P_{15}K_{90}S_{30}$

Table 6. Effect of NPK and S on Dry Bark Weight of Jute/plant (g) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	0.15	3.85	9.47	22.80
T_2	0.15	4.37	10.80	32.67
T_3	0.14	4.72	12.47	31.67
T_4	0.14	4.39	12.07	33.53
T_5	0.18	5.17	11.73	34.00
T_6	0.15	5.33	13.33	38.00
T_7	0.29	4.57	12.00	32.07
T_8	0.19	5.85	16.80	43.00
T_9	0.17	5.93	14.60	38.33
T_{10}	0.15	4.74	16.27	33.67
LSD (5%)	0.14	1.05	3.69	8.72
CV %	46.3	12.5	16.6	14.8
Level of significance	NS	*	*	*

NS = Non significant

* = Significant at 5% level of significance

$T_1 =$ $N_0P_0K_0S_0$

$T_2 =$ $N_{45}P_5K_{30}S_{10}$

$T_3 =$ $N_{45}P_{10}K_{60}S_{20}$

$T_4 =$ $N_{45}P_{15}K_{90}S_{30}$

$T_5 =$ $N_{90}P_5K_{30}S_{10}$

$T_6 =$ $N_{90}P_{10}K_{60}S_{20}$

$T_7 =$ $N_{90}P_{15}K_{90}S_{30}$

$T_8 =$ $N_{135}P_5K_{30}S_{10}$

$T_9 =$ $N_{135}P_{10}K_{60}S_{20}$

$T_{10} =$ $N_{135}P_{15}K_{90}S_{30}$

Table 7. Effect of NPK and S on Dry Stick Weight of Jute/plant (g) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	0.15	3.56	11.87	33.53
T_2	0.13	4.46	13.20	46.00
T_3	0.16	5.60	17.47	44.66
T_4	0.18	5.03	15.07	46.66
T_5	0.23	5.26	16.67	49.33
T_6	0.16	5.66	16.33	52.66
T_7	0.19	4.66	14.53	45.33
T_8	0.22	6.16	18.87	62.00
T_9	0.20	6.21	17.27	52.53
T_{10}	0.18	4.96	18.27	56.33
LSD (5%)	0.08	0.81	3.46	12.90
CV %	24.9	9.2	12.6	15.40
Level of significance	NS	**	**	*

NS = Non significant
** = Significant at 1% level of significance
* = Significant at 5% level of significance

$T_1 =$ $N_0P_0K_0S_0$
$T_2 =$ $N_{45}P_5K_{30}S_{10}$
$T_3 =$ $N_{45}P_{10}K_{60}S_{20}$
$T_4 =$ $N_{45}P_{15}K_{90}S_{30}$
$T_5 =$ $N_{90}P_5K_{30}S_{10}$
$T_6 =$ $N_{90}P_{10}K_{60}S_{20}$
$T_7 =$ $N_{90}P_{15}K_{90}S_{30}$
$T_8 =$ $N_{135}P_5K_{30}S_{10}$
$T_9 =$ $N_{135}P_{10}K_{60}S_{20}$
$T_{10} =$ $N_{135}P_{15}K_{90}S_{30}$

Table 8. Effect of NPK and S on Dry leaves Weight of Jute/plant (g) at different growth stages

Treatment	30 DAS	60 DAS	90 DAS	120 DAS
T_1	0.49	3.30	6.13	5.73
T_2	0.49	4.65	5.93	6.07
T_3	0.43	4.26	6.33	5.47
T_4	0.45	4.63	6.40	5.87
T_5	0.61	4.79	6.60	6.80
T_6	0.40	5.98	6.67	6.67
T_7	0.52	4.78	6.00	5.87
T_8	0.46	5.39	6.73	6.87
T_9	0.54	6.12	6.60	6.67
T_{10}	0.41	4.49	7.80	7.33
LSD (5%)	0.22	1.20	2.02	1.56
CV %	26.9	14.5	18.1	14.4
Level of significance	NS	*	NS	NS

NS = Non significant
* = Significant at 5% level of significance

T_1 = $N_0P_0K_0S_0$

T_2 = $N_{45}P_5K_{30}S_{10}$

T_3 = $N_{45}P_{10}K_{60}S_{20}$

T_4 = $N_{45}P_{15}K_{90}S_{30}$

T_5 = $N_{90}P_5K_{30}S_{10}$

T_6 = $N_{90}P_{10}K_{60}S_{20}$

T_7 = $N_{90}P_{15}K_{90}S_{30}$

T_8 = $N_{135}P_5K_{30}S_{10}$

T_9 = $N_{135}P_{10}K_{60}S_{20}$

T_{10} = $N_{135}P_{15}K_{90}S_{30}$

4.3 Fibre Yield

The total fibre yield of jute (BJC 370) varied significantly due to fertilizer application (Table 9. and Appendix I). The fibre yield varied from 1.39 to 3.70 t ha^{-1}. The highest yield (3.70 t ha^{-1}) was found in treatment T_8. Treatment eight was statistically similar to treatment T_9 and T_{10}. The lowest fibre yield was (1.39 t ha^{-1}) obtained in T_1 (control) treatment. The second highest yield (3.53 t ha^{-1}) was obtained from T_{10} treatment. Treatment T_8 produced 166.19% higher yield over control due to optimum fertilizer application. From the Table 9, it appears that there was a quantum jump in fibre yield with all the treated plots over control. As the soil was highly deficient in nitrogen, phosphorus, potassium and sulphur that resulted in a big yield difference between control and fertilized plots. Moreover, increase in yield of fibre under treatment T_8 might be due to production of taller plants with higher base diameter. Plant grown without fertilizer had the lowest fibre yield of jute. Fertilizer deficiency disturbed the balance of nutritional environment in plants which resulted in biological inactivation of life process of plants and had adverse effect on plant growth (Singh *et al.*, 1979).

4.4 Stick Yield

The effect of different treatments on the stick yield of jute was markedly influenced which is given in Table 9. and Appendix II. The stick yield varied from 3.56 to 8.14 t ha^{-1}. The highest stick yield (8.14 t ha^{-1}) was found in treatment T_8 which is followed by treatment T_{10}, T_9, T_6 and T_4. The second highest stick yield (8.08 t ha^{-1}) was obtained from T_{10} treatment. The lowest stick yield was (3.56 t ha^{-1}) obtained in T_1 (control) treatment. In producing stick yield, the treatment may be ranked in the order of $T_8 > T_{10} > T_9 > T_6 > T_4 > T_5 > T_3 > T_7 > T_2 > T_1$. Alim (2003) reported similar trend of results

4.5 Green weight of Jute with leaves

The effect of nitrogen, phosphorus, potassium and sulphur on green weight with leaves of jute was also statistically significant (Figure 5). Maximum green weight of jute (62.45 t/ha) was produced by T_8. The second highest stick yield (56.02 t ha^{-1}) was obtained from T_{10} treatment which was statistically similar to T_2, T_3, T_4, T_5, T_6, T_7 and T_9. The lowest green weight (35.30 t ha^{-1}) was produced by T_1 treatment. Similar trend of results were also reported by Gani *et al.* (1999) and Das *et al.* (1999) in jute.

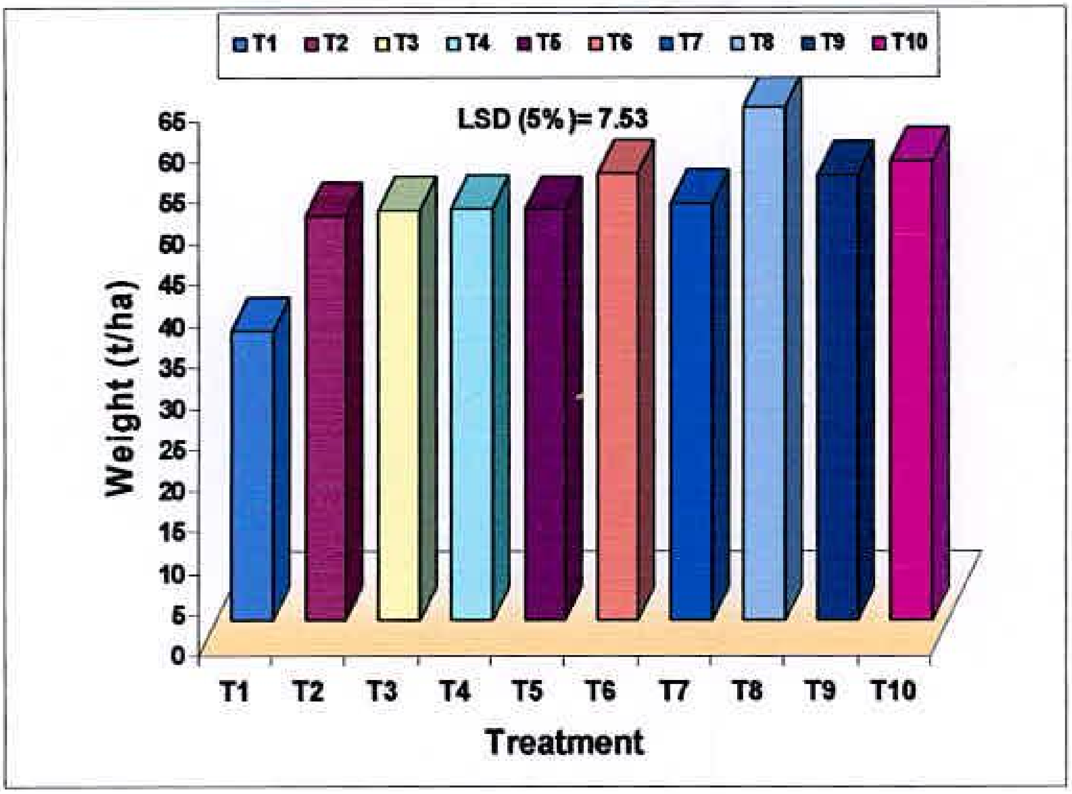

Figure 5. Effect of NPK and S on green weight of Jute with leaves

$T_1 = N_0P_0K_0S_0$

$T_2 = N_{45}P_5K_{30}S_{10}$

$T_3 = N_{45}P_{10}K_{60}S_{20}$

$T_4 = N_{45}P_{15}K_{90}S_{30}$

$T_5 = N_{90}P_5K_{30}S_{10}$

$T_6 = N_{90}P_{10}K_{60}S_{20}$

$T_7 = N_{90}P_{15}K_{90}S_{30}$

$T_8 = N_{135}P_5K_{30}S_{10}$

$T_9 = N_{135}P_{10}K_{60}S_{20}$

$T_{10} = N_{135}P_{15}K_{90}S_{30}$

Table 9. Effect of NPK and S on fibre and stick yield of Jute (t/ha)

Treatment	Fibre Yield	Stick Yield
T_1	1.39	3.56
T_2	2.58	5.40
T_3	2.79	6.51
T_4	2.95	6.67
T_5	2.87	6.53
T_6	3.07	6.81
T_7	2.90	6.41
T_8	3.70	8.14
T_9	3.46	7.94
T_{10}	3.53	8.08
LSD (5%)	0.50	1.55
CV %	10.0	13.7
Level of significance	**	**

** = Significant at 1% level of significance

$T_1 =$ $N_0P_0K_0S_0$

$T_2 =$ $N_{45}P_5K_{30}S_{10}$

$T_3 =$ $N_{45}P_{10}K_{60}S_{20}$

$T_4 =$ $N_{45}P_{15}K_{90}S_{30}$

$T_5 =$ $N_{90}P_5K_{30}S_{10}$

$T_6 =$ $N_{90}P_{10}K_{60}S_{20}$

$T_7 =$ $N_{90}P_{15}K_{90}S_{30}$

$T_8 =$ $N_{135}P_5K_{30}S_{10}$

$T_9 =$ $N_{135}P_{10}K_{60}S_{20}$

$T_{10} =$ $N_{135}P_{15}K_{90}S_{30}$

4.6 Nutrient content in jute plant

4.6.1 Nitrogen content

Nitrogen is the key factor in regulating the growth and yield of crop and its content in plant often has been used as an index of crop nitrogen requirement. Significant variation among the fertilizer combination in case of nitrogen content in jute plant was observed at different parts of jute (Table 10 and Appendix IX). Nitrogen content in roots, leaves, bark and stick increased with the increase of fertilizers doses. Among the treatments, T_{10} recorded the maximum nitrogen content (0.275 %) in root which was statistically similar to T_2, T_5, T_7, T_8 and T_9. The highest N content in bark (0.394%) was recorded T8 treatment and second value (0.388%) found from T_9 treatment. In case of leaves, T_9 recorded the maximum nitrogen content (1.733%). In stick, treatment T_8 recorded highest nitrogen content (0.364%) which was statistically similar to T_7, T_9 and T_{10}. Treatment T_1 recorded lowest nitrogen content 0.205%, 1.123%, 0.280% and 0.300% in roots, leaves, bark and stick respectively. This result is in good agreement with the findings of Ahad (1987a).

4.6.2 Phosphorus content

The effect of nitrogen, phosphorus, potassium and sulphur on phosphorus content in plant was statistically significant (Table 11 and Appendix X). The trend of phosphorus content of jute was, more or less, similar to that of nitrogen. Phosphorus content varied between 0.061% to 0.095% in root, 0.305% to 0.375% in leaves, 0.117% to 0.179% in bark and 0.064% to 0.087% in stick. The maximum value (0.095%) was noted in the treatment T_{10} in roots, which was statistically similar to T_7, T_8 and T_9. In case of leaves, T_{10} recorded the maximum phosphorus content (0.375%) which was statistically similar to T_7, T_8 and T_9. In bark, treatment T_{10} contributed highest phosphorus content (0.179%) which was statistically similar to T_4, T_7, T_8 and

T_9. But in stick, T_7 treatment recorded highest P content (0.087%). On the other hand, the lowest phosphorous content in all four parts of jute was produced by unfertilized control treatment T_1.

4.6.3 Potassium content

The content of potassium in leaf, root, bark and stick of jute exhibited marked variation due to various fertilizer doses (Table 12 and Appendix XI). The highest potassium content 0.569%, 1.614%, 1.650% and 0.778% in root, leaf, bark and stick, respectively. The lowest potassium content in all four parts of jute recorded in treatment T_1. Bark displayed the highest K content in the plant parts followed by root, stick and leaf. Potassium participates in physiological and biochemical processes within plant and finally stored in bark. Ali *et al.* (1980) observed positive correlation between K and NP.

4.6.4 Sulfur content

Sulfur content of the different plant parts (root, leaf, bark and stick) in jute varied significantly due to fertilization (Table 13 and Appendix XII). The range of sulphur contents in different parts of jute plants are 0.069% -0.089% in root, 0.152%-0.194% in leaf, in bark 0.065%-0.087% and 0.069%-0.090% in stick. The highest sulphur content (0.089%) in root was observed in treatment T_8, which was statistically similar to treatment T_7, and T_{10}. In leaf higher sulphur content (0.194%) was observed in treatment T_7. In bark highest S content (0.087%) was found in T_8 treatment, which was statistically similar to T_3, T_4, T_9 and T_{10} treatment. In stick maximum sulphur content (0.090%) was observed in treatment T_8, which was statistically similar to treatment T_4, T_6, T_7, T_9, and T_{10}. All parts of jute the lowest sulphur content was recorded in unfertilized control plot T_1.

Table 10. Nitrogen content (%) in different parts of jute plant as influenced by different treatments

Treatment	Nitrogen content (%)			
	Root	Leaf	Bark	Stick
T_1	0.205	1.123	0.280	0.300
T_2	0.270	1.673	0.367	0.312
T_3	0.260	1.643	0.363	0.311
T_4	0.255	1.627	0.363	0.311
T_5	0.266	1.720	0.372	0.324
T_6	0.260	1.707	0.374	0.334
T_7	0.271	1.710	0.385	0.354
T_8	0.274	1.720	0.394	0.364
T_9	0.270	1.733	0.388	0.356
T_{10}	0.275	1.730	0.387	0.338
LSD (5%)	0.009	0.177	0.027	0.026
CV %	2.0	6.3	4.3	4.6
Level of significance	**	**	**	**

** = Significant at 1% level of significance

T_1 = $N_0P_0K_0S_0$

T_2 = $N_{45}P_5K_{30}S_{10}$

T_3 = $N_{45}P_{10}K_{60}S_{20}$

T_4 = $N_{45}P_{15}K_{90}S_{30}$

T_5 = $N_{90}P_5K_{30}S_{10}$

T_6 = $N_{90}P_{10}K_{60}S_{20}$

T_7 = $N_{90}P_{15}K_{90}S_{30}$

T_8 = $N_{135}P_5K_{30}S_{10}$

T_9 = $N_{135}P_{10}K_{60}S_{20}$

T_{10} = $N_{135}P_{15}K_{90}S_{30}$

Table 11. Phosphorus content (%) in different parts of jute plant as influenced by different treatments

Treatment	Phosphorus content (%)			
	Root	Leaf	Bark	Stick
T_1	0.061	0.305	0.117	0.068
T_2	0.061	0.306	0.130	0.064
T_3	0.062	0.313	0.134	0.068
T_4	0.065	0.330	0.160	0.070
T_5	0.062	0.313	0.148	0.065
T_6	0.066	0.344	0.141	0.069
T_7	0.083	0.365	0.178	0.087
T_8	0.081	0.372	0.156	0.082
T_9	0.088	0.365	0.165	0.073
T_{10}	0.095	0.375	0.179	0.073
LSD (5%)	0.018	0.017	0.025	0.015
CV %	14.7	3.0	9.6	11.5
Level of significance	**	**	**	*

** = Significant at 1% level of significance
* = Significant at 5% level of significance

$T_1 = N_0P_0K_0S_0$
$T_2 = N_{45}P_5K_{30}S_{10}$
$T_3 = N_{45}P_{10}K_{60}S_{20}$
$T_4 = N_{45}P_{15}K_{90}S_{30}$
$T_5 = N_{90}P_5K_{30}S_{10}$
$T_6 = N_{90}P_{10}K_{60}S_{20}$
$T_7 = N_{90}P_{15}K_{90}S_{30}$
$T_8 = N_{135}P_5K_{30}S_{10}$
$T_9 = N_{135}P_{10}K_{60}S_{20}$
$T_{10} = N_{135}P_{15}K_{90}S_{30}$

Table 12. Potassium content (%) in different parts of jute plant as influenced by different treatments

Treatment	Potassium content (%)			
	Root	Leaf	Bark	Stick
T_1	0.405	1.409	1.487	0.732
T_2	0.452	1.496	1.506	0.737
T_3	0.494	1.456	1.581	0.742
T_4	0.511	1.577	1.634	0.753
T_5	0.454	1.452	1.574	0.740
T_6	0.460	1.523	1.528	0.757
T_7	0.550	1.614	1.650	0.768
T_8	0.565	1.571	1.593	0.759
T_9	0.568	1.535	1.633	0.778
T_{10}	0.569	1.540	1.615	0.771
LSD (5%)	0.053	0.153	0.119	0.174
CV %	6.1	5.9	4.4	1.3
Level of significance	**	NS	NS	**

NS = Non significant
** = Significant at 1% level of significance

T_1 = $N_0P_0K_0S_0$
T_2 = $N_{45}P_5K_{30}S_{10}$
T_3 = $N_{45}P_{10}K_{60}S_{20}$
T_4 = $N_{45}P_{15}K_{90}S_{30}$
T_5 = $N_{90}P_5K_{30}S_{10}$
T_6 = $N_{90}P_{10}K_{60}S_{20}$
T_7 = $N_{90}P_{15}K_{90}S_{30}$
T_8 = $N_{135}P_5K_{30}S_{10}$
T_9 = $N_{135}P_{10}K_{60}S_{20}$
T_{10} = $N_{135}P_{15}K_{90}S_{30}$

Table 13. Sulfur content (%) in different parts of jute plant as influenced by different treatments

Treatment	Sulfur content (%)			
	Root	Leaf	Bark	Stick
T_1	0.069	0.152	0.065	0.069
T_2	0.077	0.161	0.071	0.073
T_3	0.074	0.166	0.077	0.077
T_4	0.080	0.189	0.080	0.082
T_5	0.073	0.160	0.074	0.077
T_6	0.076	0.185	0.074	0.083
T_7	0.087	0.194	0.073	0.089
T_8	0.089	0.182	0.087	0.090
T_9	0.076	0.180	0.086	0.086
T_{10}	0.086	0.189	0.086	0.087
LSD (5%)	0.007	0.019	0.010	0.009
CV %	5.3	6.1	7.7	6.7
Level of significance	**	**	**	**

** = Significant at 1% level of significance

$T_1 = N_0P_0K_0S_0$

$T_2 = N_{45}P_5K_{30}S_{10}$

$T_3 = N_{45}P_{10}K_{60}S_{20}$

$T_4 = N_{45}P_{15}K_{90}S_{30}$

$T_5 = N_{90}P_5K_{30}S_{10}$

$T_6 = N_{90}P_{10}K_{60}S_{20}$

$T_7 = N_{90}P_{15}K_{90}S_{30}$

$T_8 = N_{135}P_5K_{30}S_{10}$

$T_9 = N_{135}P_{10}K_{60}S_{20}$

$T_{10} = N_{135}P_{15}K_{90}S_{30}$

4.7 Nutrient uptake by jute plant

4.7.1 Nitrogen uptake

Nutrient uptake of plants is important for determining the fertilizer requirement of crop as it is in established that there is a relation between the nutrient uptake and need of nutrient by the crop.

Uptake of nitrogen by the jute plant was computed by multiplying the DM weight with the nitrogen concentration in dry matter. The uptake of nitrogen by jute and its partitioning into leaf, bark, stick and root as influenced by applied fertilizers is shown in Table 14 and Appendix XIII . Nitrogen uptake increased with the increase of DM yield. Total uptake of nitrogen varied due to treatment variation. The highest amount of total nitrogen uptake (178.79 kg/ha) was recorded with T_8 treatment. The plant treated with T_8 treatment had the highest uptake of N 16.14 kg ha^{-1} in root and 52.10 kg N ha^{-1} in bark which was about 160.32% and 94.69% higher over control (T_1) and in leaves and stick the highest amount of N uptake 42.29 kg ha^{-1} and 71.99 kg ha^{-1}, was noted with T_{10} and T_9 treatments respectively which was 96.97% and 86.16% respectively higher over control. Stark *et al.* (1983) reported that total N uptake which was linearly related to N application, was less when the supply of N exceeds 300 kg ha^{-1}. Increasing removal of N was increasing N fertilizers by Alam *et al.* (1991). The uptake of N as had been reported by various other authors (Dargan, 1971; Lin, 1955 and PPIC. 1988) ranged between 40-84 kg N ha^{-1} depending upon rates of fertilizers.

4.7.2 Phosphorus uptake

Phosphorus uptake by the different component of jute plants followed the same pattern that of N uptake. The uptake of P increased with increasing supply of NPK and S fertilizers (Table 15 and Appendix XIII). The highest total P uptake (51.49 kg ha^{-1}) was recorded with T_{10} treatment. The plant treated with T_8 treatment had the highest uptake of P (4.77 kg ha^{-1}) in root, which was 159.24% higher over control. In leaf and bark the highest uptake of P (9.17 kg ha^{-1}) and (23.98 kg ha^{-1}) was recorded with T_{10} treatment which was 57.29% and 114.49% higher over control, respectively. In case of stick, the highest uptake of P (16.04 kg ha^{-1}) was recorded with T_8 treatment which was 83.11% higher over control. Besford (1979) reported that high levels of fertilizers increased the uptake of P. The range of P removal was between 7.81-28.22 kg ha^{-1} depending upon varieties, fertilizers and location, was reported by Alam *et al.* (1991).The range of P uptake was reported by various other authors (Dargon, 1971; Lin, 1955 and PPIC. 1988) ranged between 40-84 kg N ha^{-1} depending upon rates of fertilizers.

4.7.3 Potassium uptake

The uptake of K by different plant parts of jute was ranging from 12.24 to 33.27 kg ha^{-1} in root, 26.53 to 37.64 kg ha^{-1} in leaf, 142.09 to 216.41 kg ha^{-1} in bark and 94.35 to 157.33 kg ha^{-1} in stick. Uptake of K by root, leaf, bark and stick was increased by increasing application of fertilizers dose (Table 16 and Appendix XIII). The highest total K uptake (431.42 kg ha^{-1}) was recorded with T_9 treatment, which was 56.53% higher compared to control treatment. Massey and Winsor (1980) observed that total uptake of K increased with increasing rates of fertilizers. Of the plant parts the bark removed the highest amount of K than that of root, leaf and stick. Alam *et al.* (1991) and Mandal *et. al.* (1970) found the same trend of results.

4.7.4 Sulfur uptake

The uptake of S varied due to execution of different fertilizer treatments (Table 17 and Appendix XIII). Sulphur uptake by jute plants increased with increasing rate of NPK and S application. The uptake of sulphur by different plant parts of jute was ranging from 2.09 to 5.24 kg ha^{-1} in root, 2.90 to 4.62 kg ha^{-1} in leaf, 6.21 to 11.52 kg ha^{-1} in bark and 20.09 to 36.75 kg ha^{-1} in stick. The highest total S uptake (36.75 kg ha^{-1}) was recorded with T_{10} treatment, which was 82.93% higher compared to control treatment. Among the plant parts stick registered the highest uptake of S (17.40 kg ha^{-1}) at T_8 treatment due to its higher dry matter production in stick.

4.8 Soil Nutrient Status

4.8.1 pH

pH values of the post harvest soils ranged from 6.37 to 6.53. The variations of pH value among the treatments were insignificant (Table 18). The highest pH value (6.53) was recorded in T_2 treatment and the lowest pH value (6.37) was recorded from treatment ten. The decrease of pH may be the resultant effect of the formation of weak organic acids through litter fall and stubble decomposition and of formation of H^+ ions from hydrolysis of urea. Similar trend of results was reported by Ahad (1987b), Gani *et al.* (1999) in jute cultivation.

Table 14. Nitrogen uptake (kg/ha) by different parts of jute plant as influenced by different treatments

Treatment	Nitrogen uptake (kg/ha)				
	Root	Leaf	Bark	Stick	Total
T_1	6.20	21.47	26.76	38.67	93.1
T_2	11.40 (83.87)	33.84 (57.62)	40.78 (52.39)	50.61 (30.88)	136.63 (46.76)
T_3	9.59 (54.68)	29.94 (39.45)	38.32 (43.20)	46.30 (19.73)	124.15 (33.35)
T_4	9.92 (60.00)	31.82 (48.21)	40.58 (51.64)	48.38 (25.11)	130.7 (40.39)
T_5	10.11 (63.06)	38.99 (81.60)	42.16 (57.55)	53.28 (37.78)	144.54 (55.25)
T_6	11.27 (81.77)	37.93 (76.67)	47.37 (77.02)	58.64 (51.64)	155.21 (66.71)
T_7	11.44 (84.52)	33.44 (55.75)	41.15 (53.77)	53.49 (38.32)	139.52 (49.86)
T_8	16.14 (160.32)	39.37 (83.37)	52.10 (94.69)	71.18 (84.07)	178.79 (92.04)
T_9	12.30 (98.39)	38.51 (79.37)	50.87 (90.10)	71.99 (86.16)	173.67 (86.54)
T_{10}	12.71 (105.00)	42.29 (96.97)	51.86 (93.80)	64.60 (67.05)	171.46 (84.17)
Parenthesis indicates percent increase over control (Treatment T_1)					

$T_1 =$ $N_0P_0K_0S_0$

$T_2 =$ $N_{45}P_5K_{30}S_{10}$

$T_3 =$ $N_{45}P_{10}K_{60}S_{20}$

$T_4 =$ $N_{45}P_{15}K_{90}S_{30}$

$T_5 =$ $N_{90}P_5K_{30}S_{10}$

$T_6 =$ $N_{90}P_{10}K_{60}S_{20}$

$T_7 =$ $N_{90}P_{15}K_{90}S_{30}$

$T_8 =$ $N_{135}P_5K_{30}S_{10}$

$T_9 =$ $N_{135}P_{10}K_{60}S_{20}$

$T_{10} =$ $N_{135}P_{15}K_{90}S_{30}$

Table 15. Phosphorus uptake (kg/ha) by different parts of jute plant as influenced by different treatments

Treatment	Phosphorus uptake (kg/ha)				
	Root	Leaf	Bark	Stick	Total
T_1	1.84	5.83	11.18	8.76	27.61
T_2	2.58 (40.22)	6.19 (6.17)	14.44 (29.16)	10.38 (18.49)	33.59 (21.66)
T_3	2.29 (24.46)	5.70 (-2.23)	14.14 (26.48)	10.12 (15.53)	32.25 (16.81)
T_4	2.53 (37.5)	6.45 (10.63)	17.88 (59.93)	10.89 (24.32)	37.75 (36.73)
T_5	2.36 (28.26)	7.09 (21.61)	16.77 (50.0)	10.69 (22.03)	36.91 (33.68)
T_6	2.86 (55.43)	7.64 (31.05)	17.86 (59.75)	12.11 (38.24)	40.47 (46.58)
T_7	3.50 (90.22)	7.14 (22.47)	19.03 (70.21)	13.15 (50.11)	42.82 (55.09)
T_8	4.77 (159.24)	8.51 (45.97)	20.63 (84.53)	16.04 (83.11)	49.67 (79.90)
T_9	4.01 (117.93)	8.11 (39.11)	21.63 (93.47)	14.76 (68.49)	48.51 (75.70)
T_{10}	4.39 (138.59)	9.17 (57.29)	23.98 (114.49)	13.95 (59.25)	51.49 (86.49)
Parenthesis indicates percent increase over control (Treatment T_1)					

$T_1 = N_0P_0K_0S_0$

$T_2 = N_{45}P_5K_{30}S_{10}$

$T_3 = N_{45}P_{10}K_{60}S_{20}$

$T_4 = N_{45}P_{15}K_{90}S_{30}$

$T_5 = N_{90}P_5K_{30}S_{10}$

$T_6 = N_{90}P_{10}K_{60}S_{20}$

$T_7 = N_{90}P_{15}K_{90}S_{30}$

$T_8 = N_{135}P_5K_{30}S_{10}$

$T_9 = N_{135}P_{10}K_{60}S_{20}$

$T_{10} = N_{135}P_{15}K_{90}S_{30}$

Table 16. Potassium uptake (kg/ha) by different parts of jute plant as influenced by different treatments

Treatment	Potassium uptake (kg/ha)				
	Root	Leaf	Bark	Stick	Total
T_1	12.24	26.93	142.09	94.35	275.61
T_2	19.08 (55.88)	30.25 (12.33)	167.33 (17.76)	119.56 (26.72)	336.22 (21.99)
T_3	18.22 (48.86)	26.53 (-1.49)	166.88 (17.45)	110.48 (17.10)	321.91 (16.80)
T_4	19.87 (62.34)	30.84 (14.52)	182.65 (28.55)	117.13 (24.14)	350.49 (27.17)
T_5	17.25 (40.93)	32.91 (22.21)	178.39 (25.55)	121.69 (28.98)	350.24 (27.08)
T_6	19.93 (62.83)	33.84 (25.66)	193.55 (36.22)	132.90 (40.86)	380.22 (37.96)
T_7	23.22 (89.71)	31.56 (17.19)	176.37 (24.13)	116.05 (22.99)	347.2 (25.98)
T_8	33.27 (171.81)	35.96 (33.53)	210.63 (48.24)	148.45 (57.34)	428.31 (55.40)
T_9	25.88 (111.44)	34.11 (26.66)	214.10 (50.68)	157.33 (66.75)	431.42 (56.53)
T_{10}	26.30 (114.87)	37.64 (39.77)	216.41 (52.30)	147.35 (56.17)	427.7 (55.18)

Parenthesis indicates percent increase over control (Treatment T_1)

$T_1 =$ $N_0P_0K_0S_0$

$T_2 =$ $N_{45}P_5K_{30}S_{10}$

$T_3 =$ $N_{45}P_{10}K_{60}S_{20}$

$T_4 =$ $N_{45}P_{15}K_{90}S_{30}$

$T_5 =$ $N_{90}P_5K_{30}S_{10}$

$T_6 =$ $N_{90}P_{10}K_{60}S_{20}$

$T_7 =$ $N_{90}P_{15}K_{90}S_{30}$

$T_8 =$ $N_{135}P_5K_{30}S_{10}$

$T_9 =$ $N_{135}P_{10}K_{60}S_{20}$

$T_{10} =$ $N_{135}P_{15}K_{90}S_{30}$

Table 17. Sulfur uptake (kg/ha) by different parts of jute plant as influenced by different treatments

Treatment	Sulfur uptake (kg/ha)				
	Root	Leaf	Bark	Stick	Total
T_1	2.09	2.90	6.21	8.89	20.09
T_2	3.25 (55.50)	3.26 (12.41)	7.89 (27.05)	11.84 (33.18)	26.24 (30.61)
T_3	2.73 (30.62)	3.02 (4.14)	8.13 (30.92)	11.46 (28.91)	25.34 (26.13)
T_4	3.11 (48.80)	3.70 (27.59)	8.94 (43.96)	12.76 (43.53)	28.51 (41.91)
T_5	2.77 (32.54)	3.63 (25.17)	8.39 (35.10)	12.66 (42.41)	27.45 (36.64)
T_6	3.29 (57.42)	4.11 (41.72)	9.37 (50.89)	14.57 (63.89)	31.34 (55.99)
T_7	3.67 (75.59)	3.79 (30.69)	9.30 (49.76)	13.60 (52.98)	30.36 (51.12)
T_8	5.24 (150.72)	4.17 (43.79)	9.65 (55.39)	17.40 (95.73)	36.46 (81.48)
T_9	3.46 (65.55)	4.00 (37.93)	11.27 (81.48)	17.39 (95.61)	36.12 (79.79)
T_{10}	3.98 (90.43)	4.62 (59.31)	11.52 (85.51)	16.63 (87.06)	36.75 (82.93)
Parenthesis indicates percent increase over control (Treatment T_1)					

$T_1 = N_0P_0K_0S_0$

$T_2 = N_{45}P_5K_{30}S_{10}$

$T_3 = N_{45}P_{10}K_{60}S_{20}$

$T_4 = N_{45}P_{15}K_{90}S_{30}$

$T_5 = N_{90}P_5K_{30}S_{10}$

$T_6 = N_{90}P_{10}K_{60}S_{20}$

$T_7 = N_{90}P_{15}K_{90}S_{30}$

$T_8 = N_{135}P_5K_{30}S_{10}$

$T_9 = N_{135}P_{10}K_{60}S_{20}$

$T_{10} = N_{135}P_{15}K_{90}S_{30}$

4.8.2 Organic Matter:

Organic matter content among the ten treatments was found to be statistically insignificant in all treatments used in the experiment. The organic matter content of the post harvest soil ranged from 1.26% to 1.55% (Table 18). The maximum organic matter content (1.55%) was obtained in treatment ten (T_{10}) and the minimum organic matter content (1.26%) was obtained in the treatmentT_1, T_2 and T_6

4.8.3 Total Nitrogen

The total N content of the post harvest soil ranged from 0.07% to 0.09% (Table 18). The highest total N content was observed in T_{10}, because in T_{10} maximum doses of NPK and S was applied for this reason the amount of leftover biomass and shedding of jute leaves during growth period as jute leaves contains substantial amounts of nutrients. The results are in agreement with the findings of Rahman *et al.* (2000) in wheat and Ahad (1987b), Singh and Ghosh (1999) and Alam *et al.* (2000) in jute. The second highest total N content was found in T_3, T_4, T_5, T_7, T_8 and T_9 treatments.

4.8.4 Available phosphorus

Soils of the experimental site were more sandy (70% sand) and pH was 6 to 7, for this reason phosphorus concentration was very low. The phosphorus content in post harvest soils ranged from 4.37 to 5.99 ppm. The highest phosphorus content was recorded in the treatment T_3 (5.99 ppm) followed by T_2 (5.95 ppm), T_4 (5.80 ppm) and T_7 (5.54 ppm). The lowest phosphorus content was found in treatment T_8 (Table 18).

4.8.5 Exchangeable potassium

The potassium content of post harvest soils ranged from 0.11 to 0.13 meq/100g soil (Table 18). The highest potassium content was observed in T_6, T_7 and T_{10} treatment which was statistically similar to other treatments and the lowest potassium content was recorded in T_2 and T_8 treatment.

4.8.6 Available sulphur

The effect of combined application of different doses of fertilizer showed no significant differences in respect of sulphur content of soil after jute harvest (Table 18). However, the lowest sulphur content of crop-harvested soil (1.77 ppm) was recorded in the treatment T_1 and the highest sulphur content (2.92 ppm) was recorded in T_2 treatment.

4.9 Economic analysis

The analysis was done in order to find out the most profitable treatment based on cost and benefit of various treatments. Net benefit was calculated by subtracting the total input cost from the gross field income. Gross field income was calculated as the total market value of fibre and stick yield of jute. The input cost was calculated as the total market value of fertilizers, and other material and non-material cost. The results of economic analysis of jute (cv. BJC-370) showed that the highest net benefit of Tk. 78444 ha^{-1} was obtained in T_8 treatment followed by Tk. 71451ha^{-1}, Tk. 71120 ha^{-1}, Tk 61909 ha^{-1} and Tk 56813 ha^{-1}, Tk 56109 ha^{-1}, Tk 54200 ha^{-1}, Tk 53713 ha^{-1}, Tk 48292 ha^{-1} and Tk 19625 in T_{10}, T_9 , T_6 ,T_5 ,T_4 ,T_7 ,T_3 ,T_2 and T_1 treatments respectively (Table 19).

Table 18. Effect of NPK and S on chemical properties of surface soil (0-15 cm)

Status	pH	% OM	% N	P (ppm)	K (meq/100g soil)	S (ppm)
Initial Soil Nutrient	6.1	0.78	0.06	4.05	0.10	1.52
After Harvest Soil Nutrient						
T_1	6.50	0.76	0.07	4.88	0.12	1.77
T_2	6.53	0.76	0.07	5.95	0.11	2.92
T_3	6.53	0.82	0.08	5.99	0.12	1.97
T_4	6.50	0.82	0.08	5.80	0.12	1.98
T_5	6.53	0.82	0.08	4.67	0.12	2.38
T_6	6.37	0.76	0.07	4.86	0.13	2.85
T_7	6.47	0.88	0.08	5.54	0.13	2.24
T_8	6.40	0.88	0.08	4.37	0.11	1.93
T_9	6.47	0.88	0.08	4.89	0.12	2.37
T_{10}	6.37	0.85	0.09	4.76	0.13	2.10
LSD (5%)	0.19	0.19	0.02	1.47	0.02	1.63
CV %	1.7	13.3	13.3	16.5	10.0	42.3
Level of Significance	NS	NS	NS	NS	NS	NS

NS = Non significant

$T_1 = N_0P_0K_0S_0$

$T_2 = N_{45}P_5K_{30}S_{10}$

$T_3 = N_{45}P_{10}K_{60}S_{20}$

$T_4 = N_{45}P_{15}K_{90}S_{30}$

$T_5 = N_{90}P_5K_{30}S_{10}$

$T_6 = N_{90}P_{10}K_{60}S_{20}$

$T_7 = N_{90}P_{15}K_{90}S_{30}$

$T_8 = N_{135}P_5K_{30}S_{10}$

$T_9 = N_{135}P_{10}K_{60}S_{20}$

$T_{10} = N_{135}P_{15}K_{90}S_{30}$

Table 19. Economics for fertilizer use in production of white jute (cv. BJC-370) during kharif-I season (2005)

Treatment	Gross return (Tk ha^{-1})			Total Variable cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
	Fibre	Stick	Total			
T_1	31275	7120	38395	18770	19625	2.046
T_2	58050	10800	68850	20558	48292	3.349
T_3	62775	13020	75795	22082	53713	3.432
T_4	66375	13340	79715	23606	56109	3.377
T_5	64575	13060	77635	20822	56813	3.729
T_6	69075	15180	84255	22346	61909	3.770
T_7	65250	12820	78070	23870	54200	3.271
T_8	83250	16280	99530	21086	78444	4.720
T_9	77850	15880	93730	22610	71120	4.146
T_{10}	79425	16160	95585	24134	71451	3.961

Input cost : Urea @ 6.00 per kg, TSP @ 16.00 per kg, MOP @ 16.00 per kg, Gypsum @ 6.00 per kg, Jute seed @ 80 per kg, Pesticide- 220 Tk., Per Labour @ 70 Tk.

Output cost: Fibre @ 22.50 Tk per kg, Stick @ 2 Tk per kg

Chapter 5

Summary and conclusion

SUMMARY AND CONCLUSION

The field experiment was conducted at the research field in Central Research Station, Manikganj under Bangladesh Jute Research Institute, during kharif-I season in 2005 to study the effect of NPK and S fertilizer on growth and yield of white Jute BJC-370 under Young Brahmaputra and Jamuna Floodplain (AEZ-8).

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The treatments used were T_1 control (0 kg NPK & S ha^{-1}), T_2 (45, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_3 (45, 10, 60, 20 kg ha^{-1} NPK & S respectively), T_4 (45, 15, 90, 30 kg ha^{-1} NPK & S respectively), T_5 (90, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_6 (90, 10, 60, 20 kg ha^{-1} NPK & S respectively), T_7 (90, 15, 90, 30 kg ha^{-1} NPK & S respectively), T_8 (135, 5, 30, 10 kg ha^{-1} NPK & S respectively), T_9 (135, 10, 60, 20 kg ha^{-1} NPK & S respectively) and T_{10} (135, 15, 90, 300 kg ha^{-1} NPK & S respectively).

Different combinations of N, P, K and S exhibited significant variation in respect of most of the characters namely plant height, base diameter, and dry matter production at different growth stages, nutrient contents in plants & post harvest soil and fibre & stick yield of jute. The highest fibre yield (3.70 t ha^{-1}) was obtained from the combinations of 135-5-30-10 kg N-P-K-S ha^{-1} (T_8) which was followed by 135-15-90-30 kg N-P-K-S ha^{-1} (T_{10}). As expected, the lowest fibre yield (1.39 t ha^{-1}) was obtained from the treatment receiving no fertilizer (control). The highest stick yield (8.14 t ha^{-1}) and second highest stick yield (8.08 t ha^{-1}) were obtained from T_8 and T_{10} treatments respectively. The lowest stick yield (3.56 t ha^{-1}) found from control treatment. The highest plant height (3.39 m) and base diameter (24.81mm) at 120 DAS were found with T_9 and T_8 treatment respectably. Different combinations of fertilizer significantly influenced the dry matter partitioning of roots, leaves, barks and sticks at different stages. The highest root dry weight (18.33g plant^{-1}), bark dry weight (43.00 g plant^{-1}) and stick dry weight (60.67 g plant^{-1}) were recorded with treatment T_8 at 120 DAS. The lowest dry weight value was found with control treatment in all cases. Leaf dry weight continued to increase upto 90 DAS and then declined. Different combinations of NPK and S fertilizer exhibited significant variation in respect of nutrient contents and uptake in roots, leaves, barks and sticks. At harvest the highest concentration of nitrogen (0.275% in root, 1.733% in leaf, 0.394% in bark and 0.364% in stick), phosphorus (0.095% in roots, 0.375% in leaves, 0.179% in bark and 0.087% in sticks), potassium (0.569% in roots, 1.614% leaves, 1.650% in barks and 0.778% in sticks) and sulphur (0.089% in roots, 0.194% leaves, 0.087% in barks and 0.090% in sticks) were recorded with different treatments. The highest total uptake of nitrogen (178.79 kg ha^{-1}), phosphorus (51.49 kg ha^{-1}), potassium (431.42 kg ha^{-1}) and sulphur (36.75 kg ha^{-1}) were recorded with treatment T_8, T_{10}, T_9 and T_{10} respectively. Application of different doses of fertilizers showed considerable influence on the properties of the post harvest soils such as pH, OM, total N, available P, exchangeable K and available S. The pH value of post harvest soils range varied from 6.37 to 6.53. The organic matter content of the post harvest soils ranged from 1.26 to 1.55. The N, P, K and S content of the post harvest soils ranged from 0.07 to 0.09%, 4.37 to 5.99 ppm, 0.11 to 0.13 meq 100 g^{-1} soil and 1.77 to 2.92 ppm, respectively.

The results of economic analysis showed that the highest net benefit of Tk.78444 ha^{-1} was obtained in T_8 treatment and the lowest net benefit of Tk.19625 ha^{-1} was found in control.

It may be concluded that growth, fibre yield, stick yield and yield attributes of white Jute BJC-370 were greatly influenced by the application chemical fertilizers. The application of 135 kg N, 5 kg P, 30 kg K and 10 kg S ha^{-1} was found appropriate for proved to higher production of white Jute BJC-370. The present results can be used as a prime source for the development of future research program on similar aspects. Introduction of newer fertilizer recommendation should be encouraged; it would maximize the option of white Jute growers. However, further studies are suggested with the present recommendation in different agro-ecological zones of Bangladesh for validation and to make present findings acceptable nation wide.

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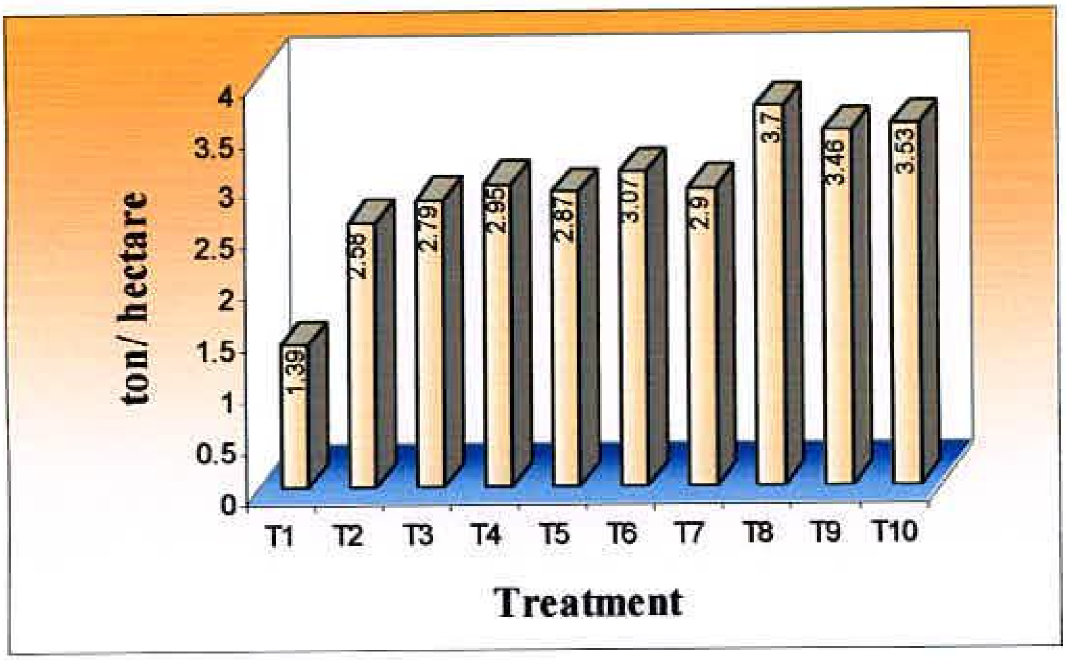
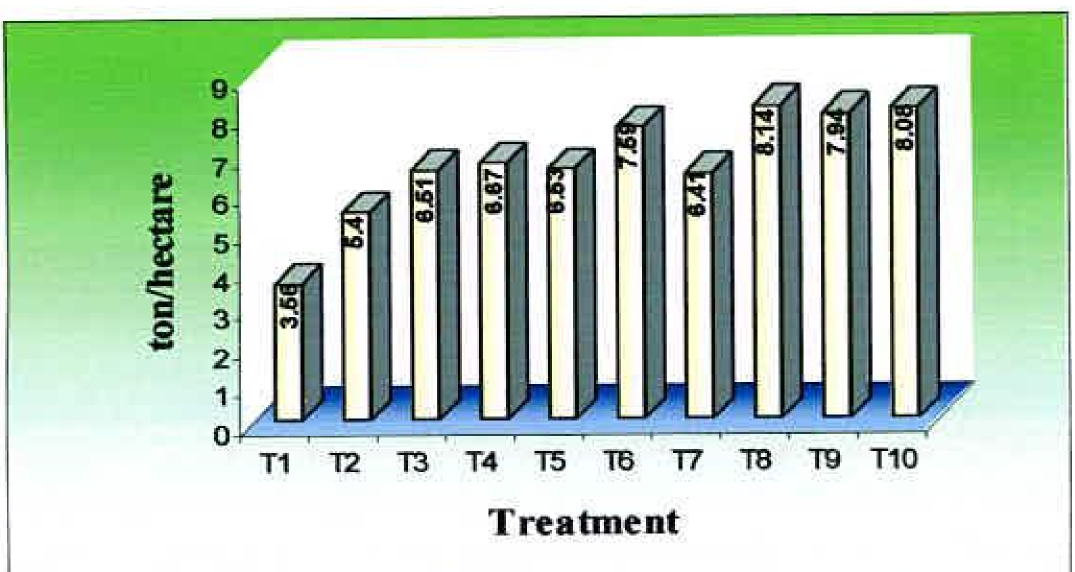
Appendices

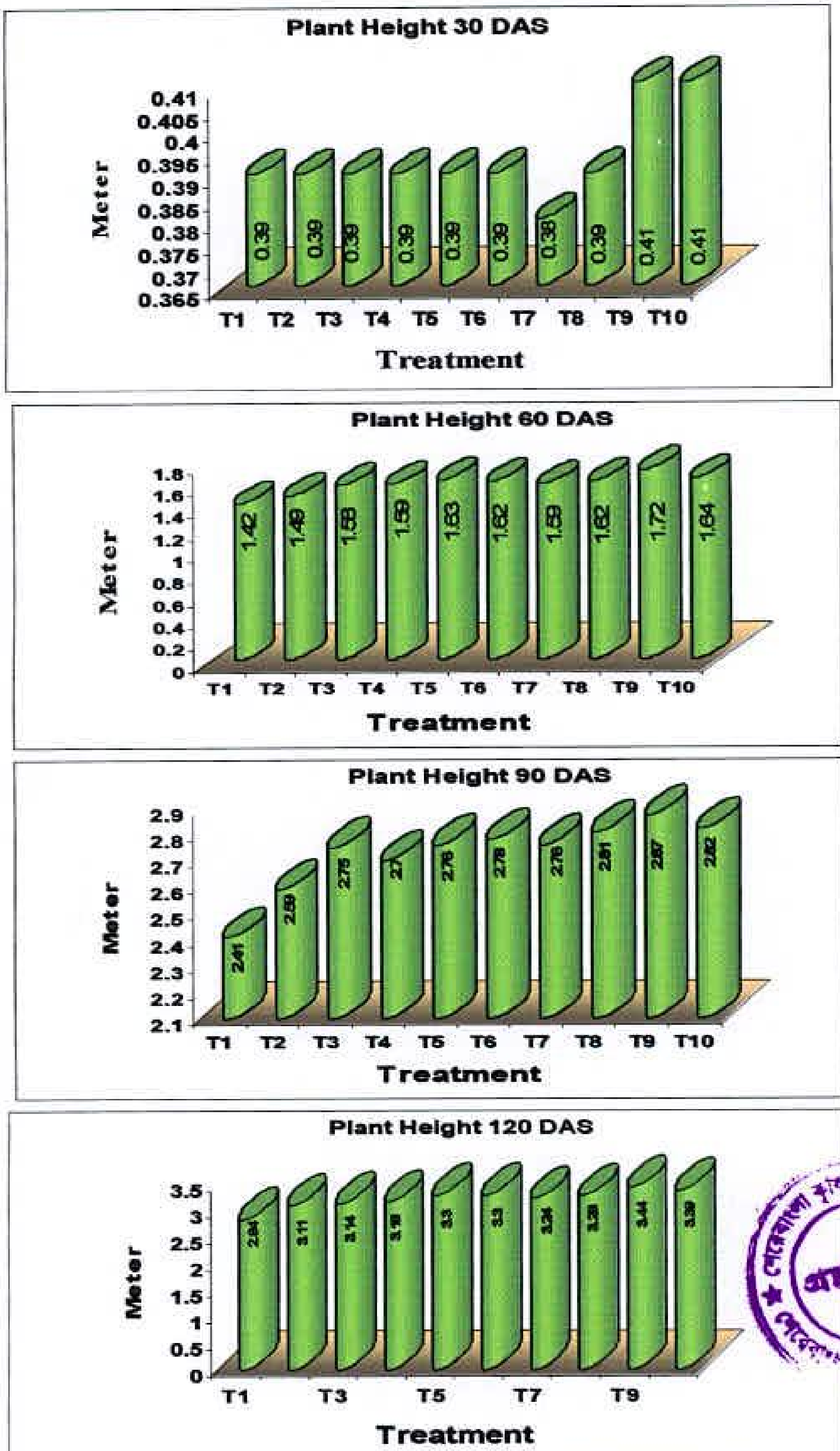
APPENDICES



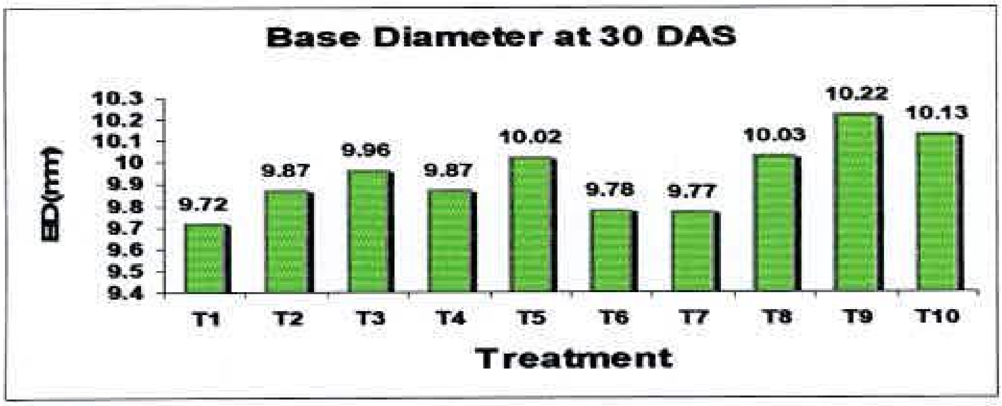
Appendix I. Effect of NPK and S on fibre yield of Jute

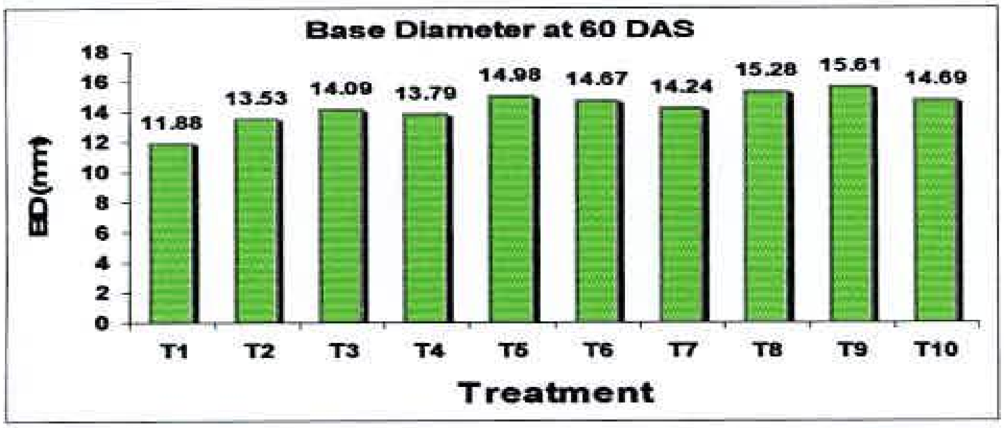


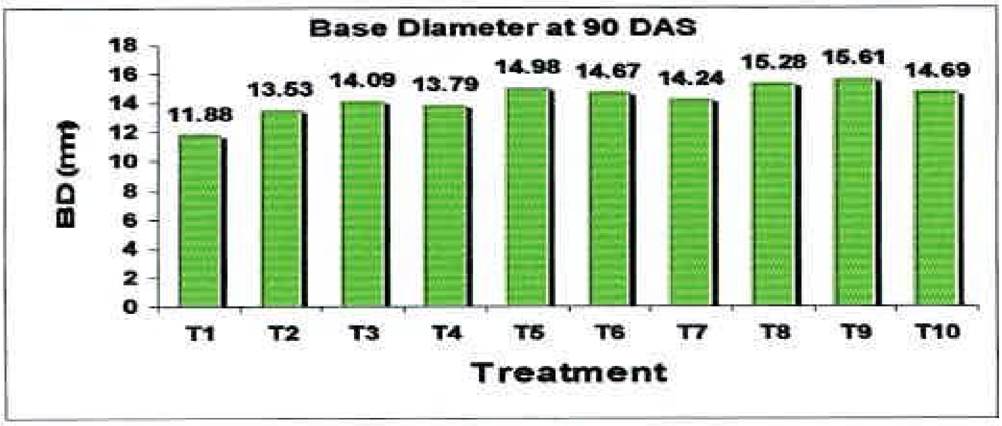
Appendix II. Effect of NPK and S on stick yield of Jute

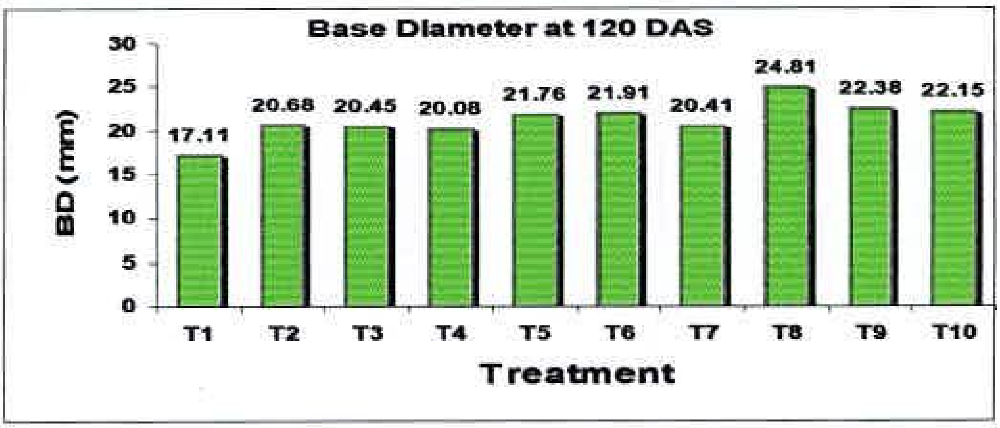


Appendix III. Effect of NPK and S on Plant height of Jute (m) at different growth stages

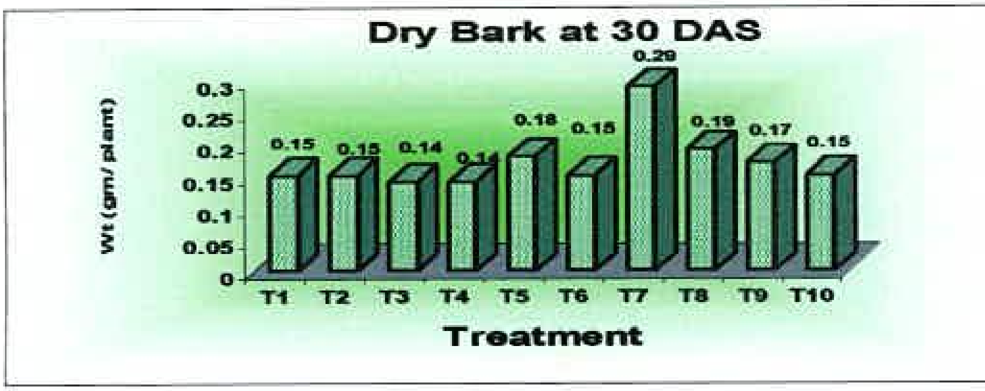


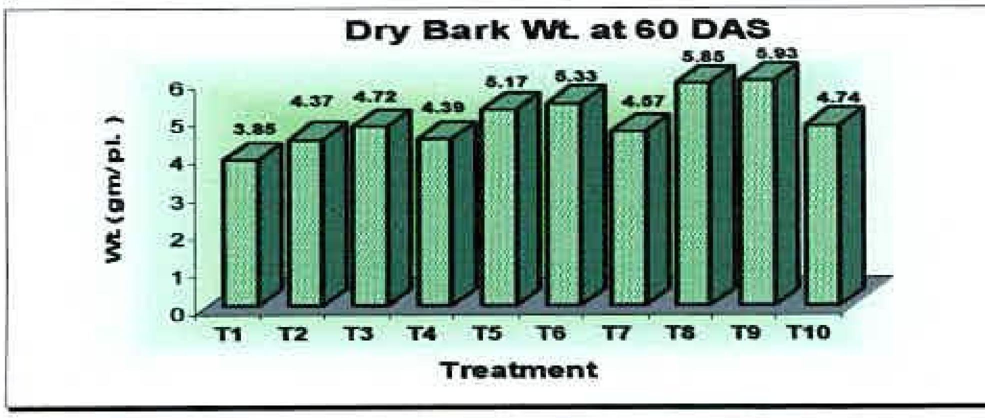


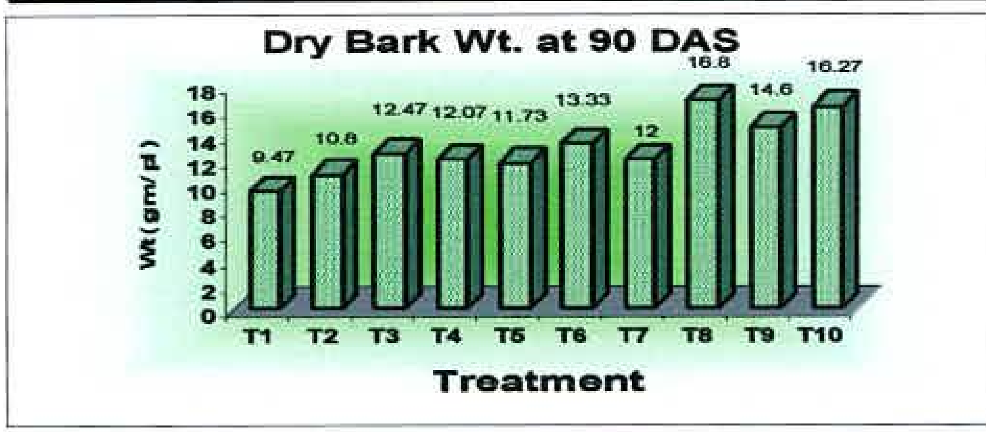


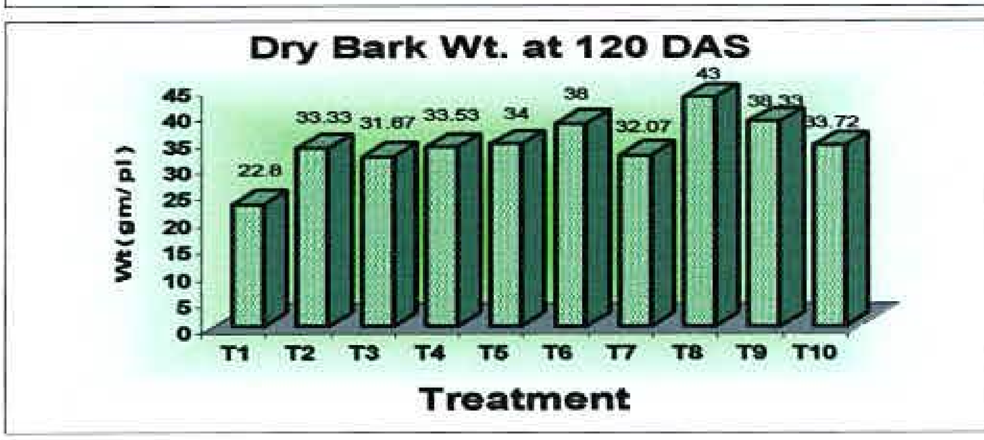


Appendix IV. Effect of NPK and S on Base Diameter of Jute (mm) at different growth stages

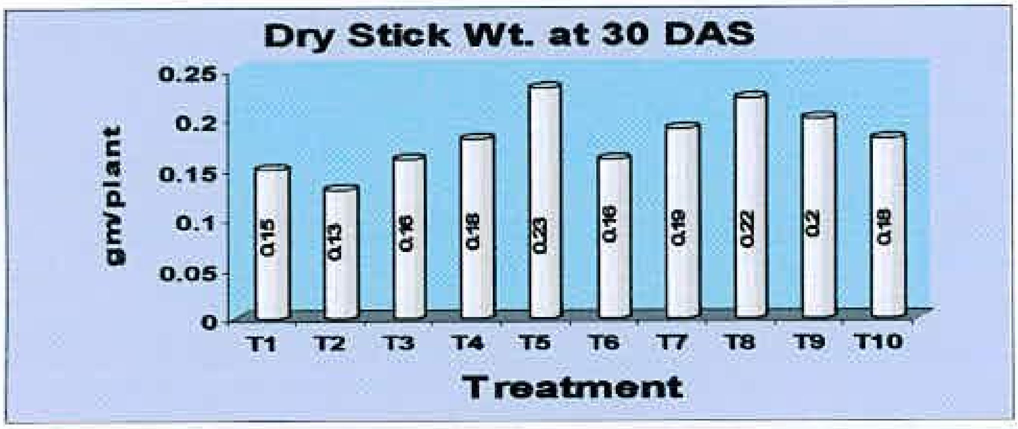


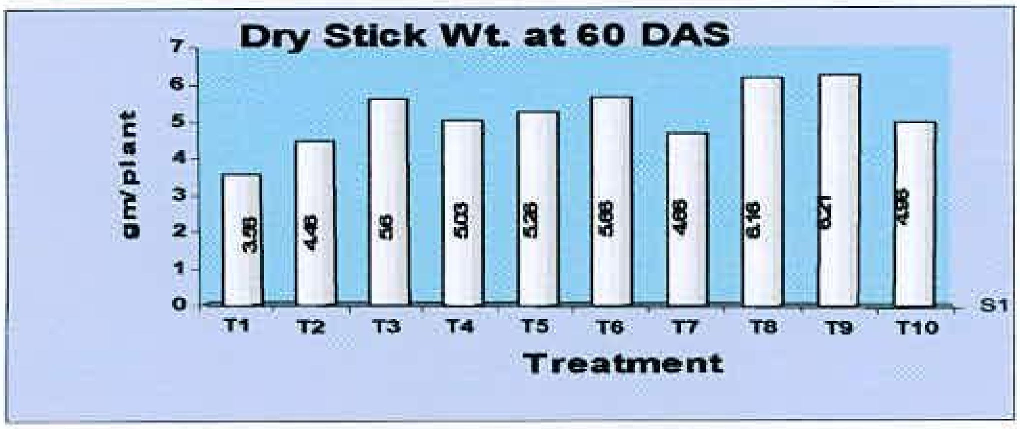


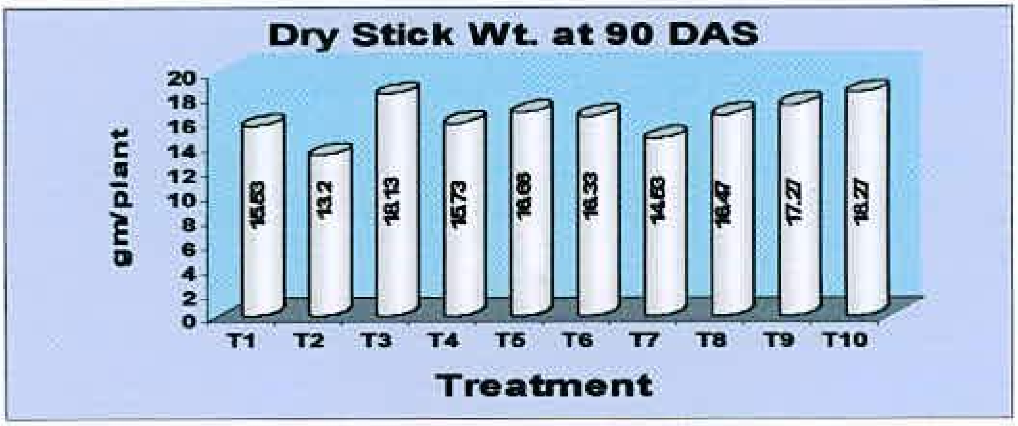




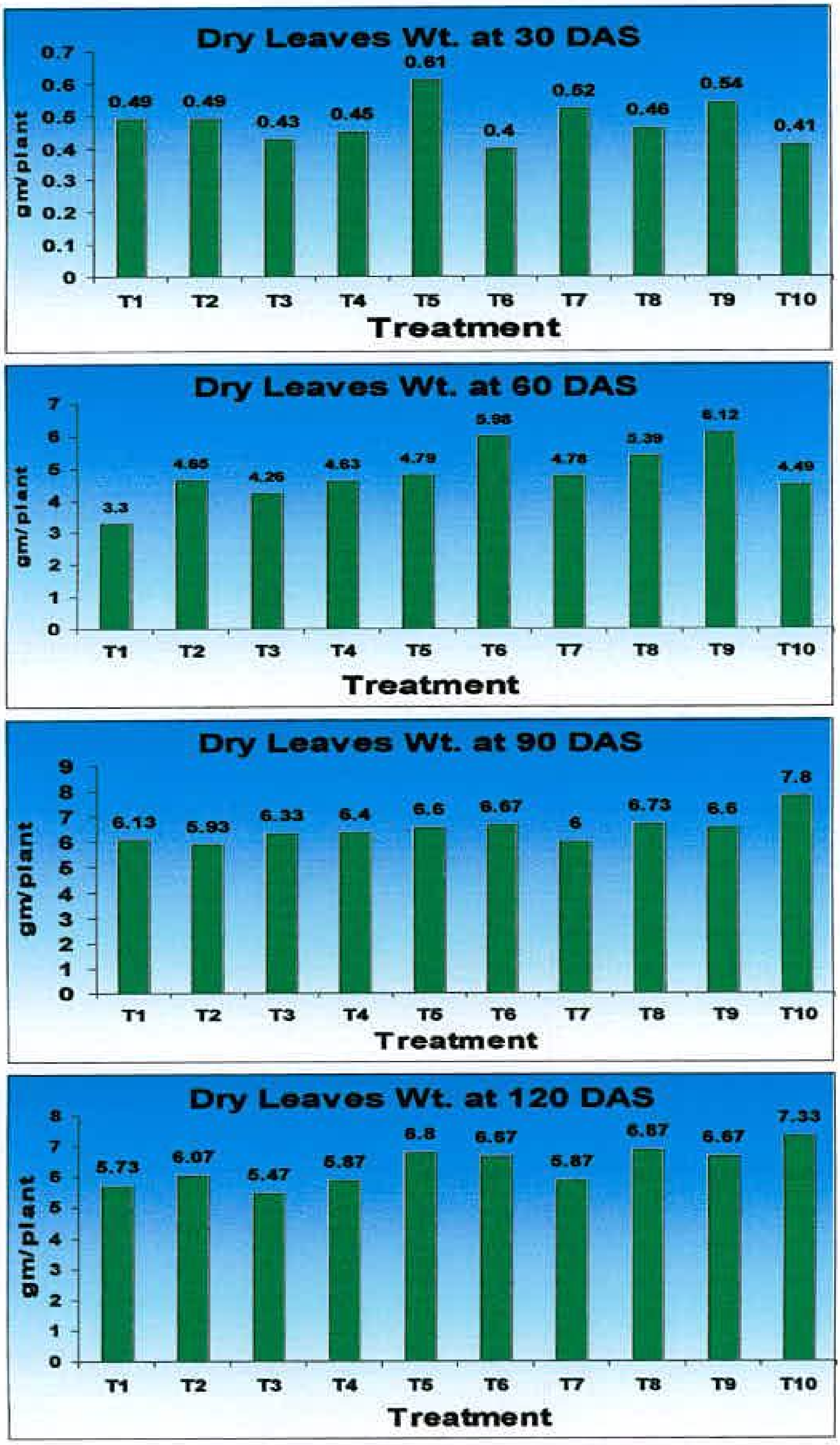
Appendix V. Effect of NPK and S on Dry Bark Weight of Jute/plant (g) at different growth stages



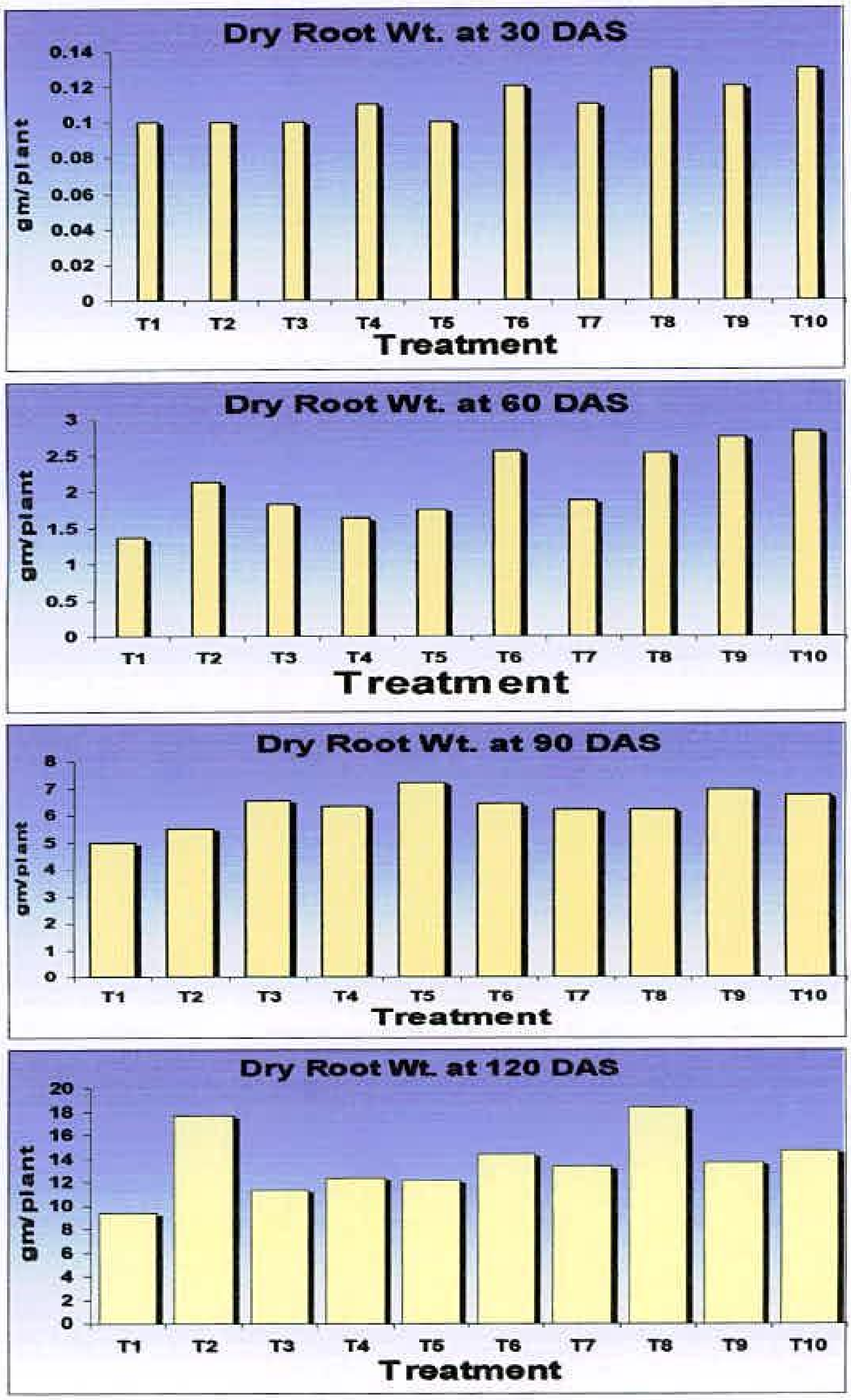




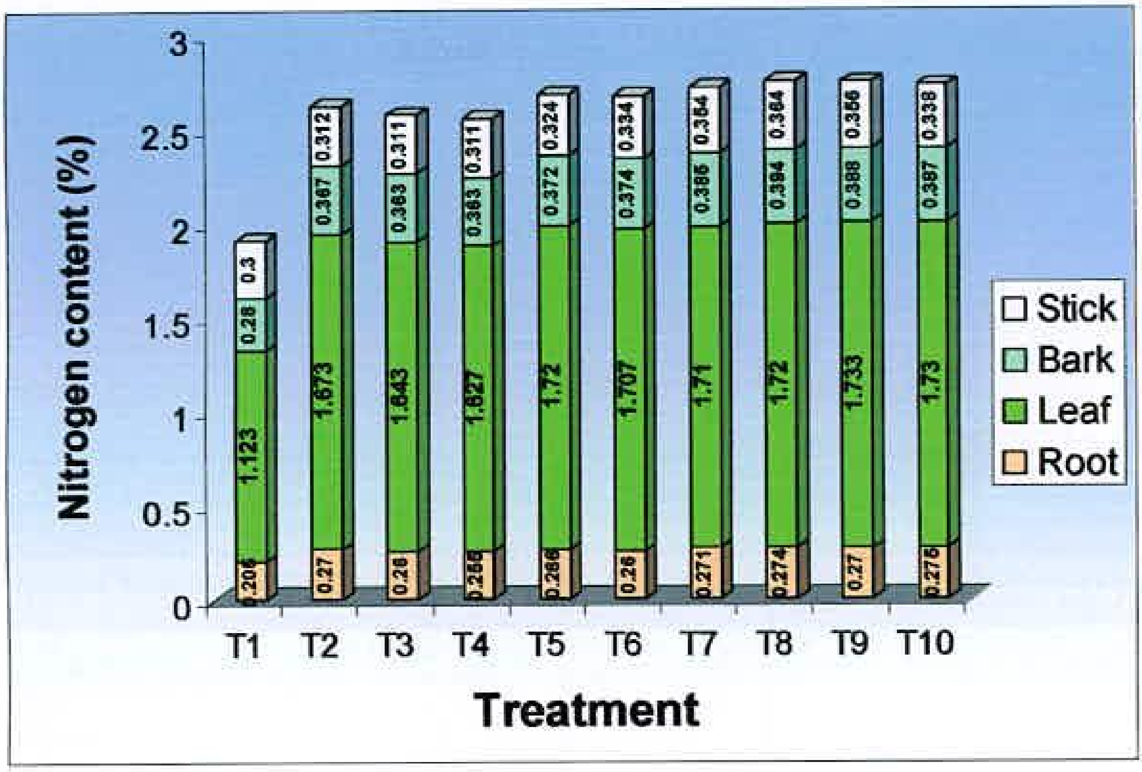
Appendix VI. Effect of NPK and S on Dry Stick Weight of Jute/plant (g) at different growth stages



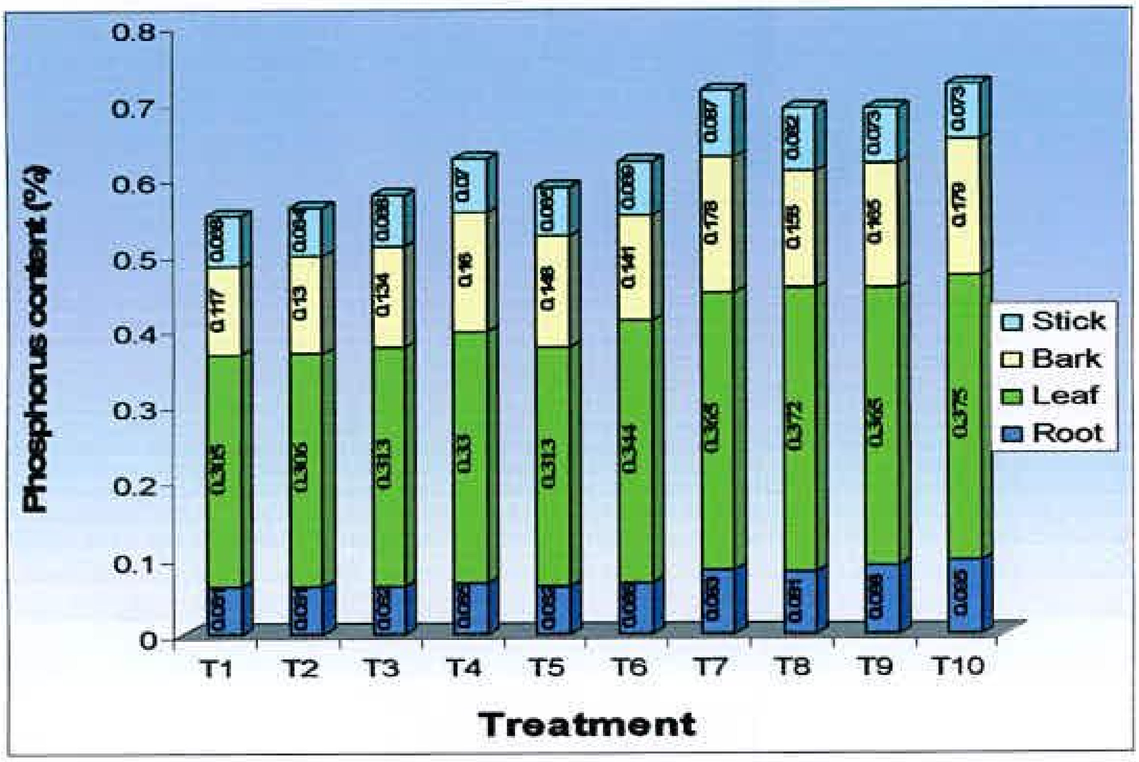
Appendix VII. Effect of NPK and S on Dry Leaves Weight of Jute/plant (g) at different growth stages



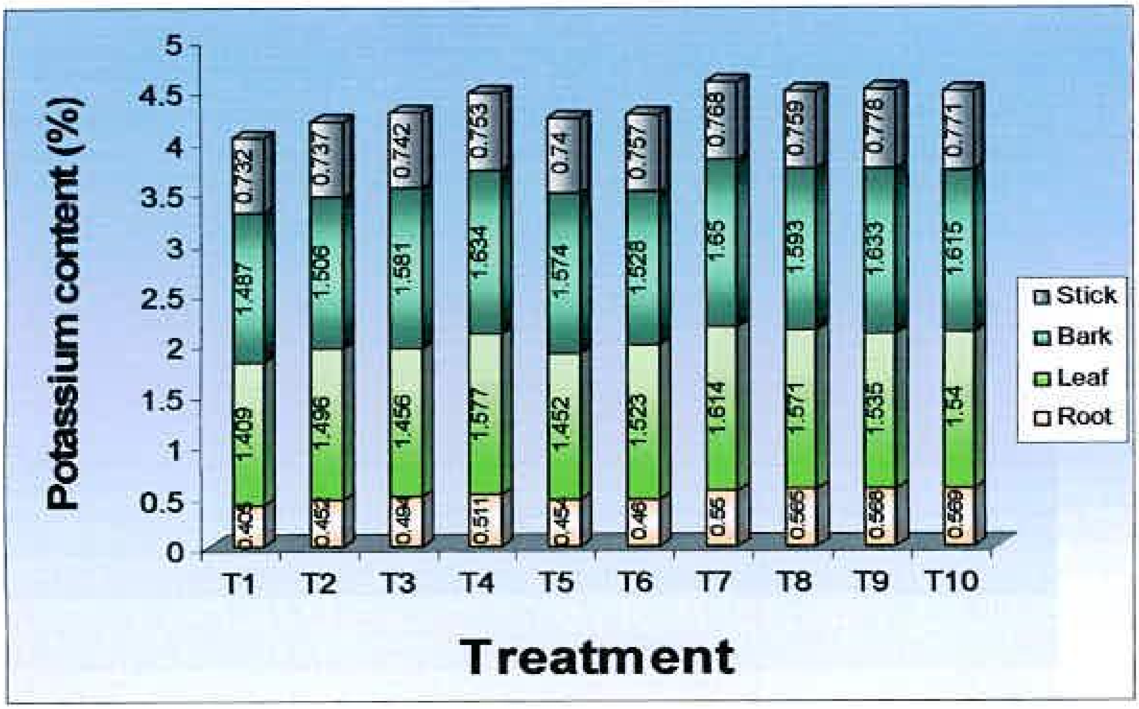
Appendix VIII. Effect of NPK and S on Dry Root Weight of Jute/plant (g) at different growth stages



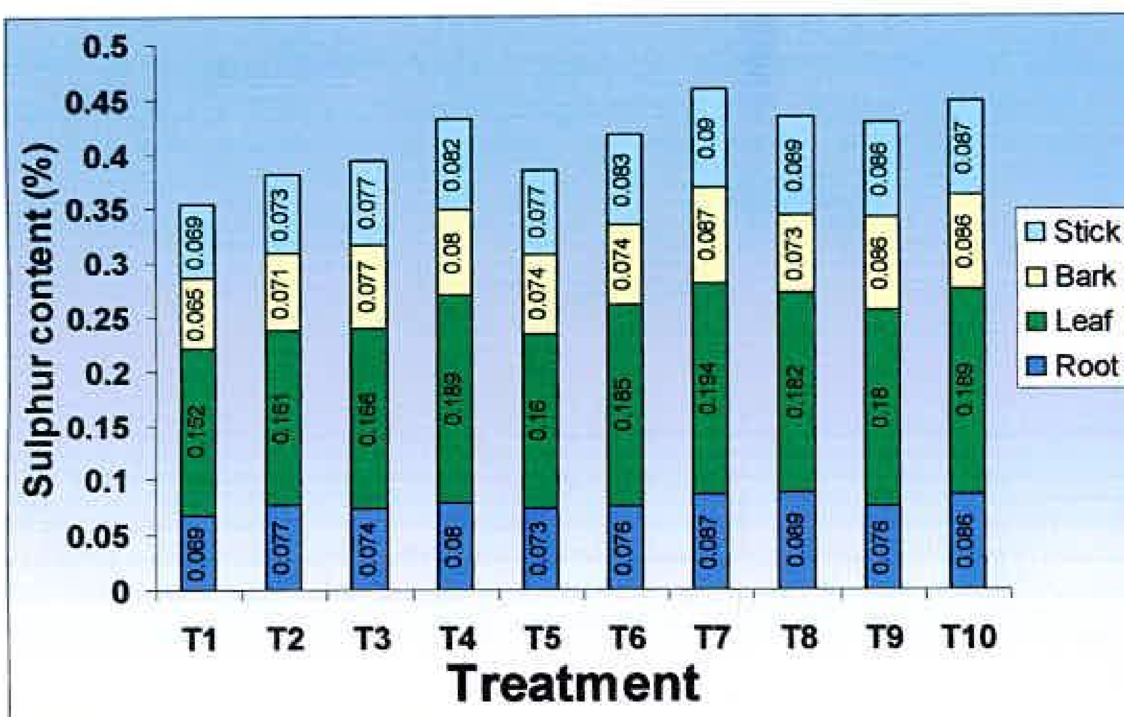
Appendix IX. Nitrogen content (%) in different parts of jute plant as influenced by different treatments



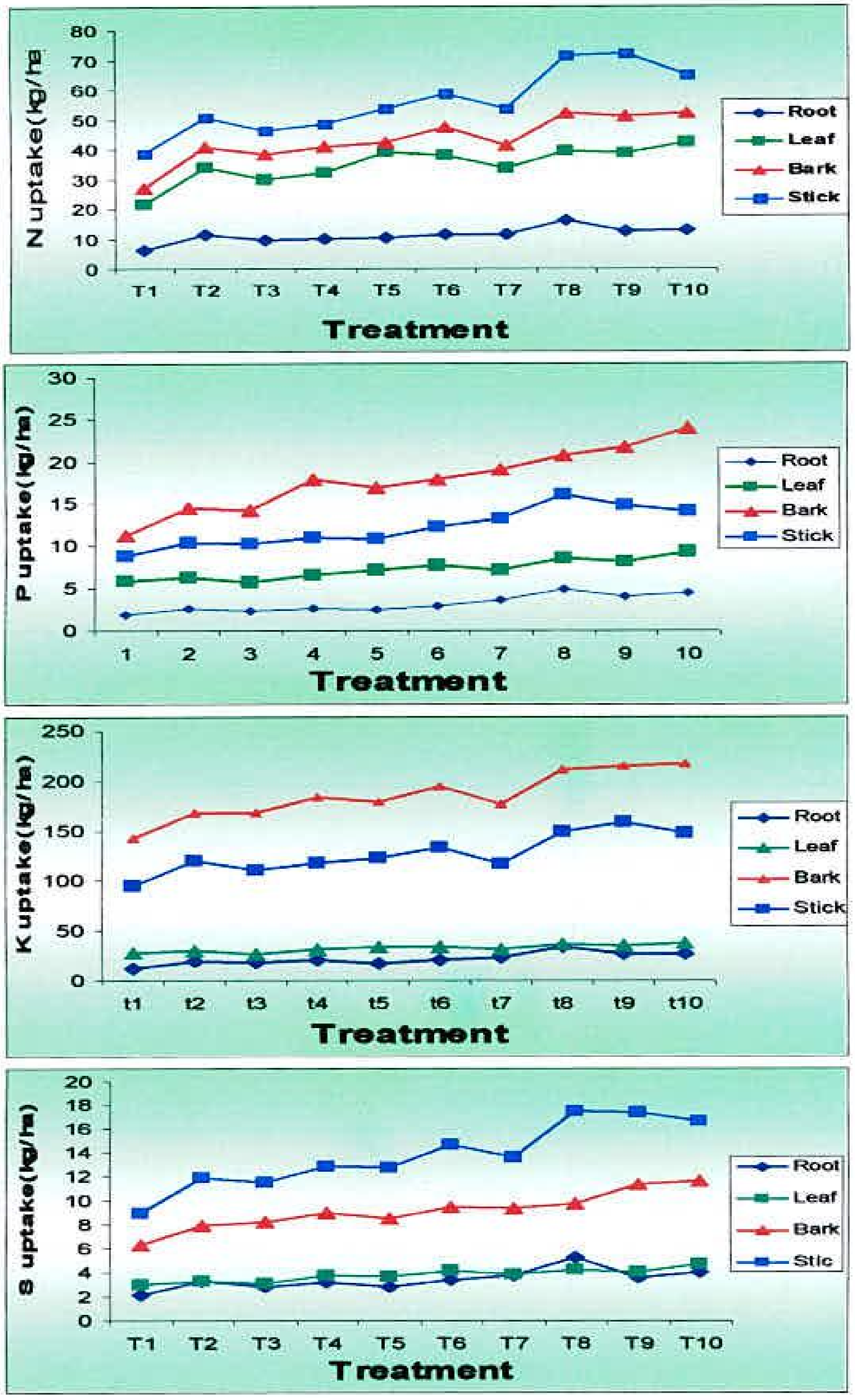
Appendix X. Phosphorus content (%) in different parts of jute plant as influenced by different treatments



Appendix XI. Potassium content (%) in different parts of jute plant as influenced by different treatments



Appendix XII. Sulfur content (%) in different parts of jute plant as influenced by different treatments



Appendix XIII. Nitrogen, phosphorus, potassium and sulphur uptake (kg/ha) by different parts of jute plant as influenced by different treatments

Appendix XIV. Meteorological data of Manikganj area during the period of April 2005 to August 2005

Month	Air temperature		Mean relative Humidity (%)	Rainfall (mm)
	Min. (°C)	Max. (°C)		
April, 05	24.1	34.4	66.50	91
May, 05	24.2	33.2	74.60	298
June, 05	26.8	33.4	78.60	260
July, 05	26.1	31.1	80.78	542
August, 05	26.7	32.0	83.22	361

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.