INFLUENCE OF NITROGEN AND WEED MANAGEMENT ON TOSSA JUTE AND THEIR TREATMENT EFFECT ON BLACKGRAM

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By

SANKAR SAHA

DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
MOHANPUR, NADIA, WEST BENGAL

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Dedicated
to my
Beloved Parents

BIDHAN CHANDRA KRISHI VISWAVIDYALAYA
FACULTY OF AGRICULTURE
Department of Agronomy

APPROVAL OF EXAMINERS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURE (AGRONOMY)

We, the undersigned, having been satisfied with the performance of Sri Sankar Saha, in the VIVA-VOCE Examination, conducted today, the First December, 2009 recommended that the thesis be accepted for the award of the Degree of Doctor of Philosophy.

Name		Signature
1. Prof. R.K.Ghosh	Chairman, Advisory Committee	01/12/09
2. Dr. B. Maji, Principal Scientist, CRIJAF, ICAR	External Examiner	01/12/09
3. Prof. S. S. Mondal	Member, Advisory Committee	01/12/09
4. Prof. S. P. Bhattacharya	Member, Advisory Committee	S.P. Bhattacharya 01.12.09
5. Dr. N. Mandal	Member, Advisory Committee	N. Mandal 01.12.09
6. Prof. A. Zaman	Head, Department of Agronomy	1.12.09
7. Prof. P. Bandyapadhyay	Teachers' Nominee	Bandyopadhyay 01/12/09

BIDHAN CHANDRA KRISHI VISWAVIDYALAYA

Faculty of Agriculture

Department of Agronomy

From : Dr. R. K. Ghosh , Ph.D
Professor in Agronomy

P.O.- Krishi Viswavidyalya
Mohanpur, Dist. Nadia, W.B.

Ref. No. :.........................

Date : 20th August, 2007

Certificate

This is to certify that the work recorded in the thesis entitled **"Influence of Nitrogen and Weed Management on Tossa Jute and their treatment effect on Blackgram"** submitted by **Sri Sankar Saha** in partial fulfillment of the requirements of the award of Degree of Doctor of Philosophy in Agriculture (Agronomy) of the Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, is a faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis, have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

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(R. K. Ghosh)
Chairman, Advisory Committee

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Sankar Saha

(Sankar Saha)

LIST OF ABBREVIATIONS

^{0}C	=	Degree of centigrade	RH	=	Relative humidity
mm	=	Millimeter	g	=	Gram
N	=	Nitrogen	DAS	=	Days after sowing
P	=	Phosphorus	B:C	=	Benefit Cost Ratio
K	=	Potassium	WCE	=	Weed Control Efficiency
ha	=	Hectare	CD	=	Critical difference
m	=	Meter	@	=	At the rate of
kg	=	Kilogram	*et al.*	=	And others
t	=	Tonne	cm	=	Centimeter
FYM	=	Farm Yard Manure	m^{-2}	=	Per square meter
HW	=	Hand Weeding	gm^{-1}	=	Per gram
DAS	=	Days After Sowing	SSP	=	Single super phosphate
CGR	=	Crop Growth Rate	MOP	=	Muriate of potash
ha^{-1}	=	per hectare	POE	=	Post Emergence
%	=	Percentage	PE	=	Pre Emergence
&	=	And	Rs	=	Rupees
Fig.	=	Figure	LAI	=	Leaf Area Index

CONTENTS

List of Tables

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

A field experiment on "Influence of Nitrogen and Weed Management on Tossa Jute and their treatment effect on Blackgram" was conducted at 'C' Block Farm, Kalyani (23.5°N latitude, 89°E longitude and 9.75 m AMSL) of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, during *pre-kharif* and *kharif* seasons of 2003 and 2004 to study the effect of different weed management practices, effect of skipping basal nitrogen on the weed crop competition, yield of jute and also their interaction effect on growth and yield of jute . The experiment was laid out in split plot design with N management in the main plots (two) and both chemical and mechanical methods either solely or in combination in the sub plots (seven), replicated thrice.

During both the year, jute was infested by all categories of weeds viz. grass, sedge and broad leaved weeds but among them grasses and sedges were the dominant weed flora in the experimental field.

Pooled data showed higher fibre and stick yield from the treatment where nitrogen was applied at 10 DAS without basal nitrogen than the treatment received nitrogen as basal dose. This was due to higher growth and yield attributing characters like plant height, basal diameter, LAI, etc. resulted from lower crop-weed competition and higher availability of nitrogen after emergence of the crop. Application of quizalofop ethyl at 15 DAS coupled with one hand weeding at 35 DAS although produced lower fibre and stick yield than the tedious method of two hand weeding or weed free condition but produced higher fibre and stick yield than the application of pendimethalin alone or in combination with one hand weeding.

All the weed management treatments did not show any harmful or adverse effect on the yield of the following crop blackgram.

Influence of pendimethalin on α-amylase activity during germination of seeds in laboratory condition showed that the maximum reduction of α-amylase activity in seeds of *Echinochloa colona* at 48 hours after treatment, whereas the minimum inhibition was recorded in tubers of *Cyperus rotundus*. Jute seeds also recorded reduction of α-amylase activity (18.55 %) at 48 hours after treatment, which hampered the hydrolysis of starch to maltose.

Thus, application of nitrogenous fertilizer at 10 DAS of jute by skipping the basal nitrogen followed by application of quizalofop ethyl @ 50 g ha^{-1} at 15 DAS coupled with one hand weeding at 35 DAS can effectively manage the most problematic grass and sedge weeds of jute and increase the fibre and stick yield with higher net return per rupee investment. In spite of the fact that weed free treatment gave highest fibre and stick yield followed by hand weeding twice treatment (at 15 and 35 DAS), but considering the economic factor the best weed management method in tossa (olitorius) jute was application of quizalofop ethyl along with one hand weeding (W_6).

Therefore, skipping of basal nitrogen and application of 50 % N at 10 DAS and remaining part in two equal splits at 20 and 40 DAS along with application of quizalofop ethyl @ 50 g ha^{-1} at 15 DAS coupled with one hand weeding at 35 DAS proved best amongst all the treatments used in this experiment and can be safely recommended for this Gangetic alluvial plains of West Bengal.

Chapter-1

INTRODUCTION

Since the dawn of civilization man has been hunted down by three basic needs of livelihood, food, cloth and shelter. Though other things were at hand to fulfill these demands yet they were insufficient and incomplete too without the genuine aid of plants. As far clothing is concerned, the skins and hides were not sufficient and henceforth calls for the demand of plant fibres.

Cultivation of jute was known from ancient time. According to Royle (1855), the ancient Greeks used to call a pot herb as *"Korkhorus"*, from which the generic name of *"Corchorus"*, is derived. Flax was considered one of the important fibre crops prior to the end of 18th century. It was the Europeans who identified jute as a cheapest substitute of fibre.

The alarming ecological degradation is becoming one of the paramount concerns of mankind and therefore, the world is trying to explore different solutions and in the process rediscovering the virtues in the natural fibre like jute shows the ray of hope. It seems to be an important biodegradable bast fibre which is also environment friendly and renewal source of lingo-cellulose. Jute fibre is the outcome of the vegetative part, so fibre yield is dependant on the vegetative growth of the plant. On the other hand maximization of fibre production along with its quality depends largely on the species of jute, soil type, cultivation techniques and micro ecosystem. However, it was once considered as a low fibre meant for packaging purpose only and now is emerging as a versatile raw material for diverse applications. The twin properties of jute in terms of its bio-degradability and as an annually renewable resource are the main planks on which the revival is being carried forward (Prasad, 1998). Jute is extensively used in multifarious facets like manufacture of packing materials of hessians and sacking, linoleum backing, as mixed materials with cotton for making carpets, decorative cloths, curtains and upholstery, raw materials for paper industry and other agricultural uses.

In a number of Asian countries India, Bangladesh, Nepal, Thailand and China are the major producer of jute that plays a pivotal role in their economy. In India 0.8 million ha is covered annually by this crop with an annual average production of 1.5 million tones of fibre (Mahapatra and Saha, 1999). Unfortunately, such an important crop jute shares hardly 1.4%

of the total cropped area in the eastern and northeastern part of the country. Furthermore, the area under jute remained static for the last couple of decades and the increase in production and productivity is the contributions of high yielding varieties grown under improved crop husbandry (Das and Hazra, 2002). In spite of that, the more concerning fact is the potential yield gap of around 2.0 t ha^{-1} between the experimental plot and actual farmers' field (Siddiq, 1999). India produces more than 40 percent of the world's raw jute. Importance of this crop to India's socio-economy is also well known as it involves 4 million farm families and generates employment to the tune of 10 million paid man days (Saha, 1996). On the other hand, the energy ratio of fibre and by-products of jute is the highest (41.56 MJ ha^{-1}) amongst major agricultural crops grown in India (Borkar *et al.*, 1999).

It is important to raise the productivity and improve the quality of jute fibre for competing in the international market (Pathak and Sinha, 2000).

The major constraints in quality jute production may have arisen from improper crop management practices. Regarding crop management practices, weed management is of no less than any other factors as it affects not only the crop growth adversely but also results in heavy losses in fibre yield, henceforth calls upon a higher input cost in jute cultivation on the production system. Manual weeding (543 MJ ha^{-1}) requires 4.56 times greater energy than that required for land preparation (Borkar *et al.*, 1999). About 35% of the total cost of cultivation of jute goes to weeding alone if done manually as per report of Saraswat (1980). In jute 50-80% fibre yield loss may occur due to presence of weeds during the critical period of 30-45 days of sowing (Mishra, 1997).

Weeds interfere with the growth of jute in the following ways.

1. Competing with the jute plant for growth resources like moisture, mineral nutrient, light and space.
2. During the initial critical growth phase jute being a C_3 plant can not compete the C_4 weeds (Palit and Bhattacharyya, 1984; Elmore and Paul, 1983). Although during the later phase of crop growth jute takes upper hand when competing with weeds due to its higher genetical potential of growth.
3. Secreting some toxic root exudates or leaf leachets.
4. Acting as alternate host of insect, diseases and other pests.

To find out a suitable, economically sound and ecologically viable method of weed management in jute, number of investigators worked for decades on different aspects of weed management encompassing chemical, cultural, mechanical and other methods solely or in combination. Unfortunately, excepting a few, most of the methods either single or in cluster could prove successful in this crop. This might be attributed to the inherent weaknesses of jute besides the typical edapho-climatic factors of jute growing environment favouring excessive weed growth.

Besides weed problem, the nutritional problem is largely associated with growth, yield and quality of fibre. Balanced plant nutrition enhanced the functioning of all inputs to the crop efficiently which essentially calls upon the optimum utilization of fertilizer at proper time, rate and methods. Among different nutrients nitrogen is most important and its application has been found to give best response. Timely application of nitrogen checks the weed growth, increases the availability of nutrient at growth stages when jute crop starts growing faster. Besides timely and adequate availability, split application also prevents losses of nitrogen through leaching and others.

The common indulgence of the farmers' are found to practicing injudicious manurial application which essentially appraises enhanced weed competition thereby lowering crop yield, quality and marketability. Further reliance on few herbicides year after year for controlling weeds in particular crop may lead to multiplication & spread of resistant weed populations as has been observed in case of many other crops. Therefore, under such situations it becomes apparent to have new herbicide for an efficient weed management on long term basis. Therefore, considering all the above concerned points, an attempt had been made to find out suitable weed management along with appropriate time of application of nitrogenous fertilizer with the following objectives.

i) To study the effect of different weed management practices on the weed crop competition and its effect on growth and fibre yield of jute.
ii) To find out the effect of skipping basal nitrogen on the weed crop competition and its effect on jute fibre yield.
iii) To study the interaction effect between N application and weed management practices on growth and fibre yield of jute.
iv) To study the economics involved in different weed management practices in jute.
v) To study the seed yield in the following black gram crop.

Chapter-2

REVIEW OF LITERATURE

Jute is one of the most important fibre crops of West Bengal during *pre-kharif* season. This crop is badly affected by different categories of weeds during the early growth stages of the crop which is responsible for heavy reduction in yield and fibre. The weed flora associated with jute includes all categories of weeds, viz. grasses, sedges and broadleaved. Grasses and sedges are the main competing flora as compared to broadleaved weeds which pose comparatively less competition.

2.1 Associated weeds of jute and its ecology

Saraswat, 1999 reported that hot and humid climate with frequent rainfall during April – September (jute growing season) encourages profuse growth of weeds in jute field.

From an extensive survey on *pre-kharif* weeds of West Bengal, Das *et al.*, 1997a, reported that the jute crop of West Bengal is mainly infested by weeds like *Cyperus rotundus, Cynodon dactylon, Cleome viscosa, Phyllanthus niruri, Corchorus acutangulus, Cassia tora, Melochia corchorifolia, Digitaria sanguinalis, Physalis minima, Euphorbia hirta, Croton sparciflorus, Scoparia dulcis, Eclipta alba* etc.

Weed problem in jute is too severe at the early crop growth stages and at the later stage the crop itself acts as smother crop to some extent (Dasgupta, 1968).

From a field experiment at CRIJAF, Barrackpore, West Bengal during 2002, Ghorai *et. al.*, 2004 reported that among different weed flora, grassy weeds accounted for 93 % of the total weed population whereas, sedge and broadleaf weeds were 5 % and 2 % respectively.

Saraswat, 1980 made a detailed study of the occurrence of weeds in jute fields from the time of land preparation to harvest of the crop for fibre or seed under various agroclimatic and edaphic conditions. The predominant weeds were annual grasses namely *Eleusine indica, Digitaria sanguinalis, Echinochloa colona, Axonipous compressus, Brachiaria ramosa, , Cynodon dactylon, Dactyloctenium aegyptium, ,Eragrostis tenella, Imperata cylindrica, Leptochloa chinensis, Panicum repens, Paspalum scrobiculatum, Setaria glauca* and *Sporobolus diander*; sedges were *Cyperus alulatus, Cyperus rotundus, Cuperus iria, Fimristylis aestivalis, Fimbristylis dichotoma* and broadleaved weeds were *Eclipta alba, Euphorbia hirta, Launea sarmentosa, Portulaca oleracea, Phyllanthus niruri, Tridax procumbens.*

Among these weed flora, grass spp. *Echinochloa colona, Eleusine indica, Cynodon dactylon* and sedge spp. *Cuperus* sp., *Fimristylis* sp. were found to be dominant and most difficult to control. The author also reported that broad-leaved weeds pose minimum problem in jute as compared to grasses and sedges.

Kundu, 1980, made a massive survey of weed flora over five jute growing states of India namely West Bengal, Assam, Orissa, Bihar and Uttar Pradesh to find a comprehensive list of jute weeds. It was found that there were 190 different species of weeds belong to 37 families. The important families were Poaceae (*Cynodon dactylon, Echinochloa colona, Eleusine indica, Paspalum scrobiculatum, Brachiaria reptans, Imperata cylindrica*), Cyperaceae (*Cyperus rotundus, Kyllinga monocephalla, Fimbristylis diphyla*), Compositae (*Eclipta alba*), Leguminosae (*Cassia tora*), Amaranthaceae (*Amaranthus viridis, Amaranthus spinosus*), Solanaceae (*Solanum nigram*), Capparaceae (*Cleome viscosa*), Commelinaceae (*Commelina benghalensis*), Euphorbiaceae (*Croton sparsiflorus, Phyllanthus niruri*), Labiateae (*Leucas linifolia*), Chenopodiaceae (*Chenopodium album*), Stercultaceae (*Melocia corchorifolia*) and Tiliaceae (*Corchorus acutangulus*).

Biswas and Das, 1993 reported for continuous monocropping of jute for consecutive 3 years, *Cyperus rotundus* and *Fimbristylis dichotoma* established themselves as predominant weeds. From the 4^{th} year onwards broadleaved dicots gradually began to establish during early crop growth stage.

According to Elmore and Paul, 1983; Palit and Bhattacharya, 1984, jute is a C_3 plant and most of the weeds that infest jute fields are C_4 species. As C_4 weeds grow faster, they become more competitive to the C_3 jute plant especially under high temperature and high light intensity condition.

Saraswat and Mukherjee, 1983 studied the habitat of weeds in jute, and found a wide variation not only in the habitat but also in the life span of different weed species. It was also reported that *Cyperus rotundus* was prevalent in all jute growing areas, present abundantly in light-textured upland soils, but rare in heavy low land soils.

From a multilocation trial Saraswat, 1973a and 1973b, reported that *Eleusine indica, Dactyloctenium aegyptiacum, Echinochloa colonum* and *Cyperus rotundus* were dominant weeds in almost all places except the lowlands of the JARI (at present CRIJAF) farm, Barrackpore. He further reported that 126 weed species; the most dominant were annual grasses and sedges which outnumbered the broadleaved weeds.

Among the weeds associated with *C. olitorius* cv. JRO 632 *Borreria articularis* and *Cyperus compressus* were the most dominant weeds in *Corchorus olitorius* on highlands of Tripura state (Datta and Chakraborti, 1983; Chakraborti, 1983; Chakraborti, 1985).

Hayder Talukder and Kasem Ali, 1976 reported that so far as the associated weeds of jute in Bangladesh are concerned *Cyperus rotundus* and *Cynodon dactylon* were causing maximum damage to the crop.

2.2 Critical period of crop-weed competition and Losses caused by weeds in jute

According to Gogoi and Kalita, 1992, the critical period of crop-weed competition in capsularis jute ranges between 15 and 60 days after sowing.

The critical period of crop weed competition for jute ranges between 30-45 DAS and if the weed population is not kept under the threshold limit it may reduce the fibre yield of white jute (*Corchorus capsularis*) by 77 % (Mukhopadhyay *et.al.*,1973) whereas a loss of 56% has been reported by Saraswat and Ray, 1985 in case of tossa jute (*Corchorus olitorius*).

Biswas and Das, 1987 studied the correlation of weed biomass with the growth and yield of *olitorius* jute and found that the weed biomass (g m^{-2}) at 30 days after sowing had significant negative correlation with plant height (r= -0.24), fibre weight on single plant basis (r= -0.35), stick weight (after retting) on single plant basis (r= -0.34) and total fibre yield of jute (r= - 0.68). Weed biomass at 45 DAS had significant positive correlation with leaf dry matter (r=0.25), bark dry matter (r=0.34) and wood dry matter (r=0.44).

Weed infestation, as evidenced by population data and nutrient uptake, caused enormous competition to the jute crop reported by Datta and Chakraborti, 1983.

The yield losses of jute crop due to weeds have been worked by several workers. A loss of 5-80% has been estimated by Pathak and Saikai, 1983 whereas 33 % loss was reported by Mukhopadhyay and Dasgupta, 1971. Mandal *et.al.*, 1971 worked out the losses in yield of jute to the extend of 85.3% caused due to weed infestation whereas Mukhopadhyay *et.al.*, 1973 reported that loss in yield of jute might be upto 77.4%.

Saraswat and Mishra, 1977 reported that 40 % Of total cost of cultivation was incurred due to manual weeding only. They also stated that critical period for weed competition in jute is the first 6 weeks after sowing.

Mishra, 1997 reported that the weed infestation in jute is maximum upto 6 weeks crop age and fibre yield showed a loss of 50-80% due to presence of weeds during this period.

From an exhaustive study Sahoo and Saraswat, 1988, reported that 75.5% of fibre yield may be lost in jute due to presence of weeds (un-weeded) as compared to the yield obtained from weed free condition. They also estimated the loss of fibre yield (due to weeds) in production terms amounting to 700.9 thousand tonnes of jute fibre annually due to weeds only which is a huge loss to in the national exchequer.

Datta and Chakraborti, 1983, studied the losses due to the presence of weeds in jute field and reported that yield loss due to weed was 63.15% in *olitorius* (JRO 632) and 51.92% in *capsularis* (JRC 212) jute.

Mishra and Mishra, 1996 reported that weed infestation during the critical period of 30-45 DAS may cause a yield reduction to the extent of 50-80%. The result was again confirmed by Mishra, 1997.

The yield reduction due to competition from weeds in jute was quantified by Biswas and Das, 1987. The regression equation between the weed dry weight (X) at 30 DAS and the fibre yield (Y) was, Y= 3038.77 – 8.52 X, which showed that at 30 DAS rise of every kilogram of weed dry weight reduced the fibre yield by 85.22 kg ha^{-1}. The same equation for 45 DAS was Y= 2563.29 – 0.057 X, proving thereby the yield reduction was only 0.57 kg ha^{-1} due to increase of every kilogram of weed biomass. Therefore, the critical period of jute-weed competition lies within 45 DAS.

2.3 Cost involved in the weeding of jute

The maximum cost of cultivation in jute involved in thinning and weeding, which is clear from the following statements of different investigators. The manual weeding in jute is not only tedious and time consuming but also it is a costly affair and accounts for as much as 30% of the total cost of cultivation was earlier reported by ICAR (Anonymous 1987).

Das and Hazra, 2002 reported that the maximum share in the operation wise cost to the tune of 37% was on weeding and thinning in jute as per an estimate made during 1999.

About 32% of the total cost of cultivation was due to the expenses on manual weeding in jute cultivation as reported by Saraswat, 1975.

It was reported by Saraswat, 1974, that for weeding in one hectare jute field about 120 labourers are required which is a very costly affair. He further reported that about 35% of the total cost of cultivation of jute goes to weeding alone if done manually (Saraswat, 1980).

2.4 Weed management in jute

2.4.1 Mechanical weed management in jute

Hand weeding twice at 21 and 35 DAS in jute field, produced the lowest weed population (m^{-2}) and weed biomass (g m^{-2}) among all other treatments as observed by Bhattacharya *et. al.,* 2004.

Das *et.al.,* 1997 reported that manual weedings at 21 and 35 DAS resulted in minimum number of weeds.

Guha, 1999 reported from a field experiment at Shilonganj that manual weeding in jute cv. JRO – 524 at 3 and 4 weeks after sowing resulted in the lowest number and dry weight of weeds and the highest fibre yield and net return per hectare, followed by manual weedings at 3 weeks after sowing.

One hand weeding after death of grassy weeds by the application of quizalofop-ethyl is a necessity to remove the sedge and broadleaved weeds from the jute field as suggested by Ghorai *et. al.,* 2004.

Instead of hoeing several times, a single manual weeding treatment at 3 weeks after sowing could give good fibre yield and a higher return from jute as reported by Guha and Das, 1998. Yields and returns could be further increased by 2 manual weeding treatments at 3 and 4 weeks after sowing.

Mishra and Nayek, 1995 clearly stated that plant height and basal diameter significantly increased with hoeing and manual weeding treatment as compared to unweeded control.

The plots received two hand weedings recorded maximum plant height, basal diameter and green plant weight in both years as observed by Asokaraja and Jayaraman, 1995.

From Mymensingh, Bangladesh, Rahman and Gaffer, 1990, reported that raking twice (15 and 25 days after sowing) and hand weeding once (25 DAS) resulted in fibre yield of *capsularis* jute (cv. CC 45) comparable to those obtained by raking once and hand weeding twice reducing the labour requirement by 23 man-days for a ha.

Sarkar, 2006 stated that although highest fibre and stick yields were recorded from hand weeded plots but due to high cost of manual labour, the net return per rupee invested was lower (1.36) in this treatment .

Acording to Tosh, 1982 in cultivation of JRC-212, hand weedings at 7 days intervals throughout the crop period, weed free conditions upto 35 and 42 days after sowing showed better results than Dalapon.

2.4.2 Chemical weed management in jute

2.4.2.1 Pre-emergence chemical weed management in jute

Asokaraja and Jayaraman, 1995 stated that Basalin @ 1 kg a.i. ha-1 applied as pre-plant spray at 3 DBS followed by one hand weeding at 35 DAS recorded the comparable yield with hand weeding twice.

Bhattacharya *et. al.,* 2004, recorded fibre and stick yield of 2.37 and 6.16 t ha^{-1} respectively, by the application of pendimethalin @ 0.75 kg ha^{-1} at 1 DBS along with one hand weeding at 35 DAS.

Borgohain, 1990 reported that Pendimethalin @ 0.75 kg ha^{-1} applied 1 DAS controlled the weeds more effectively than hand weeding twice.

Biswas, 1987 opined that pre-emargence application of Pendimethalin @ 0.75 kg a.i. per hectare increased fibre yield to the tune of 39.95 q ha^{-1}.

It was shown (Biswas *et al.*, 1995), that Fluchloralin at 2 kg ha^{-1} in association with FYM (15 t ha^{-1}) provided higher fibre yield of olitorius (2717 kg ha^{-1}) and *capsularis* (2643 kg ha^{-1}) jute.

Grasses constitute the dominant weed flora in jute fields and its management using pre-emergence herbicide like Trifluralin is possible as opined by Sarkar *et. al.,* 2005.

From a field experiment on weed management of jute (var. JRO – 524) Santhi and Ponnuswamy, 1998 found that Fluchloralin @ 1 kg a.i. ha -1 applied as pre-emergence followed by 1 hand weeding at 4 weeks after sowing recorded the lowest dry weight of weeds.

Saraswat and Ray, 1981 reported that Tetrapion at 2-4 kg ha^{-1} incorporated 7 days before sowing jute controlled all grasses and 30-40% nutsedge and left no residual effect on succeeding crops of oats or wheat. It was further reported that Fluchoralin at 1-1.5 kg ha^{-1} as pre-sowing or pre-emergence gave good control of all grasses but nutsedge was not affected.

Tetrapion at 3 kg a.i. ha^{-1} applied before sowing jute largely suppressed grassy weeds (Saraswat and Ray, 1980).

Bhattacharya *et al.*, 2001, found that Napropamide at 1.0-2.5 kg a.i ha^{-1} as pre-emergence application could effectively control broad spectrum of weeds (except *Cyperus rotundus*) in jute but at the same time it caused not only poor germination but also showed phytotoxicity to the crop resulting low fibre yield.

Biswas,1990 reported that JRO – 7835 variety of jute recorded higher fibre yield (3.73 t ha^{-1}) with pre-emergence application of Fluchloralin @ 1 kg a.i ha $^{-1}$ followed by one hoeing at 21 DAS.

Datta and Chakraborty, 1985 observed that application of 1.5 l Basalin ha-1 kept the weeds under control resulting the highest fibre yield of jute.

Mukhopadhyay and Ghosh, 1978 in field trials found that, Fluchloralin (as *Basalin*) at 1.5 or 2 litres ha^{-1} was effective in controlling weeds of jute which recorded a fibre yield of 2600 kg ha^{-1}, as compared with the un-weeded control treatment (1760 kg ha^{-1}) and hand weeded plot (2913 kg ha^{-1}).

Pre-emergence application of Fluchloralin at lower dose viz 1.0 and 1.5 l ha^{-1} though kept weeds under control for 7 days they started reappearing afterwards as reported by Bhattacharya, 1976. The author also reported that at higher rates of 2.0 and 2.5 l ha^{-1} of fluchloralin gave a much better and more persistent control of all categories of weeds other than the sedge *Cyperus rotundus*. Under completely weed free condition through repeated weedings the highest fibre yield of 2020 kg ha^{-1} was obtained which was closely followed by fluchloralin at 2.5 l ha^{-1} yielding 1900 kg of fibre per hectare.

In moist but not wet soils pre-sowing application of Tetrapion (sodium 2,2,3,3-tetrafluoropropionic acid) can control almost all types of weeds if used in jute consecutively for 2-3 years and was safe on jute as reported by Saraswat and Mitra, 1977.

From a weed management experiment in olitorius jute, Saraswat, 1975, reported that promising herbicides for control of weeds in jute field were Ansar 519 (MSMA), Deconate (MSMA + wetter), Ansar 529P (DSMA), Dowpon (Dalapon) and Ansar 529 + Dowpon.

In another experiment Biswas and Saraswat, 1977, observed that the nutsedge (*Cyperus rotundus*) and grass population were reduced by 50% and 70 to 90% respectively in plots treated with Tetrapion.

Saraswat and Ray, 1973 tried seventeen herbicides and their combinations before sowing or post-emergence for weed management in olitorius jute. Nitralin in combination with Daconate [MSMA 35% + wetter] gave promising control of weeds and crop damage was tolerable. Sirmate [Dichlormate] at 3-4 kg ha^{-1} gave good control of germinating grasses and was completely safe to jute but nutsedge [*Cyperus rotundus*] and established *Cynodon dactylon* remained unaffected. TFP [2,2,3,3-tetrafluoropropionic acid] was clearly selective to jute and gave 100% and 40-50% control of grasses and nutsedges when applied at 3-4 kg ha^{-1}, 10 days before sowing .

Application of 4 kg TFP [Tetrapion] ha^{-1} as pre-sowing incorporation to *olitorius* jute gave the most effective control of weeds and resulted in fibre yields of 2.42 t ha^{-1}, compared with 2.51 t with 2 hand weedings and 1.32 t with un-weeded control treatment as reported by Pathak *et* al., 1984. Application of 4.5 kg MSMA or 6 kg dalapon ha^{-1} as post-emergence gave slight reductions in dry weight of weeds especially of *Cyperus rotundus, C. iria* and other sedges where the yields ranged between 2.28 and 2.32 t ha^{-1}.

Tiwari and Singh, 1977, reported that, Frenock A (sodium 2,2,3,3-tetrafluoropropionate [30%]) at 4 litres [product]/ha was applied 10 days before sowing in trials in 1975-76 and Ansar 529 [MSMA 35%] 7.5-12.5 l ha^{-1} was applied as a post-emergence directed spray with shielded nozzles in a 3-week-old crop. Ansar 529 at 5 litres + Dowpon [dalapon-sodium 85%] 4 kg ha^{-1} gave more or less the same fibre yield as hand weeding.

Field trials as reported by Singh *et al.*, 1994, on sandy loam soil at Bahraich conducted during 1988-89 and 1989-90 to study the relative efficiency of herbicides (1.0 and 1.5 kg ha^{-1} fluchloralin) applied 3 or 1 d before sowing, or just after sowing for the control of weeds (mainly *Cynodon dactylon, Cyperus rotundus, Euphorbia hirta* and *Echinochloa colona*) in jute cv. UPC 94, and the effects of these herbicides on jute yield revealed that the herbicides resulted in weed densities of 52.0-165.0 and 46.0-105.5, 40.0-97.0 and 30.0-102.5, and 18.5-60.5 and 15.5-84.0 plants m^{-2} for 4 and 6 weeks after sowing and at harvest respectively. The dry mass of weeds was 25.0-52.0 and 18.5-48.0, 24.0-58.5 and 17.0-57.5, and 9.5-47.0 and 10.5-56.0 g m^{-2} for 4 and 6 weeks after sowing and at harvest in 1988-89 and 1989-90, respectively.

Biswas, 1986, in a screening trial of some herbicides for jute found that Diuron at 0.62 to 1.87 kg ha^{-1} as pre-plant, pre-emergence was harmful to jute. In the same experiment it was found that Pendimethalin at 0.75 to 2.0 kg ha^{-1} as pre-emergence had also detrimental effect on jute plant. Though the lower dose of Oxyfluorfen as pre-plant application was tolerable to jute, higher dose at 0.62 kg a.i ha^{-1} had a detrimental effect on the crop itself.

On a moderately fertile clay loam soil application of Basalin [fluchloralin] at 1.0 and 1.5 kg a.i. ha^{-1} 1 or 3 days before sowing (pre-emergence) produced the highest fibre yield to the tune of 2.8 t ha^{-1} which was an improvement of 48.10% over the un-weeded control as reported by Mishra *et al.*, 1989.

Saraswat, 1975, reported that promising herbicides for control of weeds in jute field were Ansar 519 (MSMA), Deconate (MSMA + wetter), Ansar 529P (DSMA), Dowpon (Dalapon) and Ansar 529+Dowpon

2.4.2.2 Post-emergence chemical weed management in jute

From one field experiment during 2003, Bhattacharya *et. al.,* 2004 opined that statistically at par fibre and stick yield were obtained from the treatment received application of quizalofop-ethyl as post emergence herbicide at 15 DAS along with one hand weeding at 35 DAS and the treatment received hand weeding twice at 21 and 35 DAS.

Application of Targa Super (quizalofop-ethyl 5 %) @ 1.5 – 2.0 ml per lit of water yielded 24-25 q ha^{-1} raw fibre, whereas, 24-26 q ha^{-1} raw fibre yield was recorded from two manual weeding treatment, as reported by Ghorai *et. al.,* 2004.

Use of post emergence herbicides like cyhalofop butyl, quizalofop ethyl and fenoxaprop-p-ethyl, which control weeds in broadleaved field crops like sunflower, soyabean and potato (Ito *et. al.,*1998 ; Bedmar, 1997) holds promise in jute field also as opined by Sarkar, 2006. He also found 78.97 % WCE from the treatment received quizalofop ethyl @ 50 g ha^{-1}.

Sarkar, 2006 reported that post emergence application of fenoxaprop-p-ethyl @ 75 g ha^{-1} or quizalofop ethyl @ 50 g ha^{-1} at 21 DAS effectively controlled the grass weeds giving higher jute fibre yield and net return per rupee invested (2.0 and 1.87 respectively).

Singh *et al.*, 1994, reported from field trials conducted during 1988-89 and 1989-90 on sandy loam soil at Bahraich that greatest weed control was obtained due to Fluazifop-butyl at 0.6 kg ha^{-1} and the fibre yields as a result of the herbicide treatment were 1.396 and 1.940 t ha^{-1} in 1988-89 and 1989-80 respectively as compared to the highest fibre yield obtained with manual weeding (2.035 and 2.288 t ha^{-1}) in 1988-89 and 1989-90, respectively.

Saraswat and Ray, 1976 screened a number of herbicides for weed control in tossa jute (*Corchorus olitorius*) and it was found that MSMA at 2 kg, Dalapon 6 kg and MSMA 2 kg + Dalapon 3 kg ha^{-1} were also satisfactory when applied as post-emergence directed application in a 3 week old crop.

Sarkar, 2006 conducted an experiment at CRIJAF, Barrackpore and observed that significantly higher plant height and basal diameter of jute were recorded by the application of quizalofop ethyl @ 50 g ha^{-1} than unweeded control treatment but there was no significant difference with hand weeding twice treatment.

Mishra *et al.*, 1989, reported that the fibre yield of jute cv. JRC 212 from application of Fusilade [Fluazifop butyl] at 0.4 or 0.6 kg a.i. ha^{-1} applied 21 days after sowing was not better than the yield obtained from treatments of Basalin [Fluchloralin] at 1.0 and 1.5 kg a.i. ha^{-1} applied 1 or 3 days before sowing. Highest yield (2.8 t) was recorded with Basalin 1 kg applied 1 day before sowing, which gave an improvement 19.59% over Fusilade at 0.6 kg.

Studies conducted by Mustafee and Ray, 1975a, indicated that spraying of Ansar 529 (MSMA 34.8%) applied at 10 litres product ha^{-1} in 3 to 4 weeks old jute crop not only gave effective control of the weed flora, but also directly influenced the growth of the olitorius jute resulting an increase in yield over the control treatment.

Biswas, 1986, found that Diuron at 0.62 to 1.87 kg ha^{-1} as post-emergence was harmful to jute plant. He also found that Pendimethalin at 0.75 to 2.0 kg ha^{-1} as post-emergence had detrimental effect on jute plant.

Ghorai *et. al.,* 2004 observed from an experiment during 2002 that Quizalofop-ethyl did not show any phytotoxicity on jute crop and left no residual effect on the following crop mustard. They opined that this chemical can be applied safely and satisfactorily in jute field.

Directed sprays in jute (*Corchorus olitorius*) infested with *Cyperus rotundus, Digitaria sanguinalis, Echinochloa colonum, Dactyloctanium aegyptium* and *Cynodon dactylon,* 4 kg MSMA ha^{-1} gave complete weed control and resulted in the highest fibre yield increases (Saraswat, 1983).

Jain *et al.,* 1966, reported that *Dowpon* (Dalapon sodium 85%) at up to 10 kg ha^{-1} applied to jute (*olitorius,* cv. JRO 632) three weeks after sowing could keep the dense infestation of grassy weeds under control up to 4 weeks and at doses optimum for fibre and seed crops, 7.5 and 10 kg ha^{-1}, respectively, caused only temporary injury to the jute.

The post-emergence directed spray of 5 litre Ansar 529 + 4 kg Dowpon [Dalapon] ha^{-1} in jute was effective against weeds and gave fibre yields of 1.73 t ha^{-1}, compared with 1.58 t with 2 hand-weedings (Tiwari and Singh, 1977).

Mustafee and Ray, 1975b, opined that weeding and thinning of jute seedlings (*Corchorus capsularis*) at the early stages are essential for good crop growth. Increasing cost of hand labour promotes interest in chemical weed control. In a field trial with the vars. JRC212, D154 and JRC321, Ansar 529 (MSMA [34.8%]) at 4 kg a.i. ha^{-1} in 8 litres water applied between the rows using hooded nozzles at the crop aged 14-22 days, gave 84-96% control of weeds. This treatment proved considerably cheaper than hand labour.

Studies conducted by Mustafee and Ray, 1975a, under the varied agro-climatic conditions in various districts of W. Bengal, indicated that spraying of Ansar 529 (MSMA 34.8%) *10 litres product ha^{-1} in 500 litres water) at 3 to 4 week old jute crop not only gave effective control of the weed flora associated in jute, but also directly influenced the growth of the crop resulting an increase in yield over the hand-weeded control treatment.

2.4.3 Integrated weed management in jute

Ghorai *et. al.,* 2004 obtained about 97 % WCE of the treatment received quizalofop-ethyl as post emergence herbicide along with one hand weeding and thus can effectively solved weed problem in jute field.

Mishra and Mishra, 1996 reported that farmers' practice although recorded the highest yield giving 153.46 % more yield over control, chemical plus mechanical methods of weed control recorded the highest net return per rupee investment.

Application of Basalin @ 1 kg a.i. ha-1 at 3 DBS supplemented with one hand weeding at 4 WAS recorded the lowest weed density, weed dry weight and nitrogen uptake resulting more fibre yield, net monetary return and benefit cost ratio, as reported by Rayput, 2000.

Das *et al.*, 1994 found that manual weed control in jute alone showed best result in controlling weed, fibre yields (3.30 and 2.35 t ha^{-1} in 1987 and 1989, respectively) compared with the untreated control values of 0.94 and 0.75 t in 1987 and 1989 respectively. Of the herbicide treatments, Pendimethalin + hand weeding proved to be the best treatment in controlling weeds, fibre yields (2.96 and 2.13 t in 1987 and 1989, respectively) with a net return per rupee invested (Rs 1.62 and 0.92 in 1987 and 1989, respectively).

Bhattacharya *et. al.,* 2004, from West Bengal reported that the highest weed control was observed with two hand weeding treatment closely followed by application of quizalofop-ethyl 5 % EC (Targa Super) @ 2 ml per l of water at 15 DAS along with one hand weeding at 35 DAS.

Mishra and Bhol, 1996 reported that application of Basalin @ 1 kg a.i. ha-1 at 3 DBS followed by one hand weeding at 35 DAS reduced the weed dry matter, increased plant height and fibre yield significantly over other herbicidal schedules and fetched maximum net profit.

Mishra and Nayak, 1995, found that weed control efficiency was the highest (95.4%) with hoeing + hand weeding 21 and 35 days after sowing (DAS), followed by hoeing + hand weeding 42 DAS (90.4%). Fibre yield was the maximum (2.73 t ha^{-1}) with 1 kg ha^{-1} Fluchloralin pre-emergence + hoeing 35 DAS, followed by hoeing + hand weeding 21 and 35 DAS (2.62 t ha^{-1}). Net profit was the highest (Rs.10908/ha) with 1 kg ha^{-1} Fluchloralin pre-emergence + hoeing 35 DAS, followed by 0.43 kg/ha Fluazifop-p-butyl post-emergence + hoeing 35 DAS (Rs.9038 ha^{-1}).

In 4 years trials on sandy loam medium fertile and neutral soil, cultural practices were compared with Fluazifop-butyl at 1.6 l ha^{-1} applied 7 days after sowing for use in jute. Various regimes of weeding or weeding + hoeing significantly increased jute yield and successfully controlled all types of weeds. Neither mulching nor Fluazifop-butyl increased the yield during first year, but did so in the subsequent 3 years. Although mulching gave good initial control, grasses emerged later in the season. Fluazifop-butyl was effective against grasses, but not against *Cyperus sp.* and broadleaved weeds (Roy *et al.*, 1988).

Biswas and Das, 1993, conducted field trials to evaluate the control of *Echinochloa colona [E. colonum]*, *Cyperus rotundus* and broadleaved weeds. The herbicides used were Tetrapion [flupropanate] at 4 kg ha^{-1} 7 d before sowing, Butachlor at 1.5 kg, 5 d after sowing (DAS), Nitrofen at 1.25 kg at 1 DAS, Alachlor at 1.75 kg at 1 DAS and Atrazine at 1 kg at 1 DAS. The results revealed that repeated applications of Tetrapion-Butachlor-Nitrofen/Alachlor/Atrazine in jute-rice-wheat/potato/maize, respectively, induced a shift in the composition of the weed flora in jute from annuals to perennials (such as *Cyperus rotundus*). However, the interaction of the jute-rice-potato rotation and the direct effect of Flupropanate in the jute crop-weed community caused a shift in the population balance in favour of jute. The maximum weed density was observed in jute rotated with wheat or maize. There was a small increase in the numbers of broadleaved weeds in jute when potatoes were included in the rotation.

Gogoi *et al.*, 1992, reported that the highest weed control efficiency, better crop growth and the maximum fibre yield was observed under hand weedings done at 21 and 42 days after sowing and this treatment was significantly superior to all other treatments except Fluazifop-p-butyl at 0.4 and 0.6 kg a.i ha^{-1}. Fluchloralin significantly reduced weed growth and increased fibre yield and there was no significant difference among Fluchloralin at 1.0 and 1.5 kg a.i ha^{-1} applied as pre-plant incorporation or pre-emergence application whereas Fluazifop at 400 g ha^{-1} applied 21 days after sowing (DAS) + 1 hand-weeding (HW) 35 DAS gave more effective control of weeds of jute cv. JRC 212 than 600 g of Fluazifop applied 2 DAS + 1 HW, Fluchloralin at 1.0 kg ha^{-1} applied 3 or 7 DAS + 1 HW and Pendimethalin at 0.75 kg ha^{-1} applied 1 day before sowing. All treatments gave more effective control of weeds than 2 HW only. The best fibre yield was recorded with the 400 or 600 g Fluazifop treatments (Borgohain *et al.*, 1990).

Datta and Chakraborty, 1985, reported that among the herbicides tested, best-weed control in jute and highest fibre yields were obtained through the application of 1 kg *Basalin* [Fluchloralin] or 1.5 kg *Lasso* [Alachlor] ha^{-1} as pre-sowing on highlands and 5 kg *Ansar 529* [MSMA] or 4 kg *Ansar 529* + 5 kg Dalapon ha^{-1} post-emergence on medium highlands, with each treatment followed by hand pulling of broadleaved weeds.

Fluchloralin at 1 kg a.i. ha^{-1} pre-em. + 1 hand weeding, Tetrapion at 4 kg a.i. ha^{-1} incorporated presowing + 1 hand weeding or MSMA at 5.62 kg a.i. ha^{-1} post-emergence effectively controlled grass weeds and nutsedge [*Cyperus rotundus*] in jute and gave more or less similar fibre yields as was obtained with 2 hand weedings. Whereas fluchloralin alone was not effective against *C. rotundus*. Diphenamid at 4-6 kg a.i. ha^{-1} uses as pre-sowing incorporated or applied as pre-emergence though effectively controlled grassy weeds and decreased *C. rotundus* populations, it was toxic to the crop (Saraswat and Sharma, 1983).

Saraswat, 1984 reported that overall sprays of 1.0-1.5 l Fluazifop-butyl (125 g l^{-1} + 25% wetter) ha^{-1} at 2-3 weeks after sowing of jute followed by one hoeing at 7 days after the application of herbicide could effectively suppress *Cyperus rotundus* and surviving broadleaved weeds.

Effective weed control and high fibre yields (2.82 t ha^{-1}) of jute were obtained with 2 litres *Basalin* (fluchloralin) ha^{-1} as pre-emergence application, followed by hand weeding at 20 days after sowing (DAS). Fibre yields of 2.30, 2.16, 1.87 and 1.72 t ha^{-1} were achieved with hand weeding at 20, 40 and 60 DAS and hoeing on the same dates (Sarkar *et al.*, 1987).

Field trials conducted by Gaffer and Rahaman, 1988, with jute cv. D-145, both broadcast and line-sown at 11 and 9 kg seeds ha^{-1}, respectively, on silty loam, to compare the use of Nitralin (soil-incorporated prior to sowing at 8.5 or 13.0 kg ha^{-1}) and Dalapon (applied 20 d after sowing at 0.75 and 1.15 kg) with manual weeding at 15, 15 and 28 or at 15, 28 and 35 d after sowing clearly revealed that Dalapon at 13 kg killed 100% of the most common weeds, comprising mainly of *Echinochloa spp., Cyperus rotundus, Eleusine indica* and *Scirpus mucronatus* (39.82, 18.45, 12.25 and 10.28%, respectively, of the total weed vegetation). Dalapon at 8.5 kg resulted in 80-96% control of eight of the most common weeds, but only 68% control of *Commelina diffusa*. Nitralin was less effective than Dalapon, resulting in 74-98 and 58-79% weed control at 1.15 and 0.75 kg, respectively. In each case *C. diffusa* was least controlled. All weed control treatments enhanced jute height and diameter, and also increased yields from un-weeded control values of 0.144 kg m^{-2} to 0.18-0.26 kg m^{-2}. Dalapon at 13 kg was slightly phytotoxic to jute, whereas the higher rate of Dalapon resulted in the highest crop yield (0.26 kg m^{-2}), with the exception of that from plots that were manually weeded thrice.

Biswas, 1981, reported that application of 0.188 kg Fusilade [Fluazifop-butyl] ha^{-1} at 20 days after sowing (DAS) + 2 hoeings to jute sown in rows gave the highest fibre yield (3.13 t ha^{-1}) which was closely followed by Fusilade (0.125 kg) at 20 DAS + Fusilade (0.188 kg) at 40 DAS for broadcast-sown jute with a yield of 3.12 t ha^{-1}. Fusilade alone at 0.125 kg ha^{-1} at 20 DAS produced 2.67 t fibre which was superior to the twice hand-weeded control (2.47 t ha^{-1}) when broadcast-sown. Fusilade was not only safe for jute and was effective against *Echinochloa colonum*, *Eleusine indica* and *Leptochloa*, the dominant weeds of jute fields.

Pathak and Saikia, 1983, reported that 2 hand weedings or wheel hoeings or 1 kg Fluchloralin ha^{-1} pre-emergence + 1 hand weeding gave effective control of weeds in Capsularis jute and resulted in fibre yields of 3.13-3.44 t ha^{-1}, compared to 1.65 t in untreated control treatment. Yields with 2 kg Fluchloralin ha^{-1} as pre-emmergence or 1.5 kg Alachlor pre-emergence + 1.5 kg Dalapon post-emergence/ha was 2.76 t ha^{-1}.

Field experiments conducted for two years at the Tamil Nadu Rice Research Institute at Aduthurai revealed that pre-emergence application of fluchloralin at 1.0 kg ha^{-1} followed by one light hand weeding at 4 weeks after sowing (WAS) plus mechanical hoeing twice at 3 and 5 WAS resulted in the greatest crop plant height, stem girth, green and fibre yield, and the lowest weed dry weight (Santhi and Ponnuswamy, 1998).

Experiments conducted in the summer seasons of 1987-88 at Coimbatore, Tamil Nadu, India, to find out suitable weed management practices for olitorius jute cv. JRO 524, herbicides (Fluchloralin, Fluazifop-P-butyl and Pendimethalin) were compared with a conventional method of hand weeding twice at 21 and 35 days after sowing, and an un-weeded control plot. The plots that were hand weeded twice recorded the lowest weed dry matter and higher plant height, basal stem diameter and green plant weight in both years. Among the herbicides, Fluchloralin (1.0 kg ha^{-1}) applied as pre-plant spray at three days before sowing, combined with hand weeding at 35 days after sowing resulted in yields comparable to those in plots that were hand-weeded twice. The herbicide, Pendimethalin was the least effective in both years (Asokaraja and Jeyaraman, 1995).

From a field trials Biswas, 1990 found that average weed control efficiency at 50 DAS varied between 4.7% with PPI of Oxyfluorfen to 85.6% with manual weeding + hoeing. Fluazifop-P-butyl was the best herbicide treatment, resulting in an average of 56.3% weed control efficiency when used together with hoeing. It was further reported that mean jute fibre yields were reduced from average control values of 2325 kg ha^{-1} by Isoproturon and Oxyfluorfen treatments. However, all other treatments increased average fibre yields from 2443 to 3895 kg, the maximum yield was obtained with manual weeding + hoeing. Fluchloralin was the best herbicide treatment for high yields, resulting in 3735 kg fibres when the chemical treatment was followed by one hoeing .

In an experiment on weed management in *olitorius* jute where *Cyperus rotundus* and *Echnochloa colona* were predominant weed species, Mukhopadhyay *et al.*, 1978, reported that MSMA controlled weeds effectively particularly *Cyperus rotundus* as directed spray at 7.5 or 10 l ha^{-1}. Dalapon showed temporary check in growth of jute plants but killed the grassy weeds effectively. Combination of Dalapon at 5 kg ha^{-1} with hand weeding or MSMA at 5 l ha^{-1} recorded more yield than Dalapon alone because all categories of weeds were checked due to this treatment. Paraquat at 2 l ha^{-1} showed quick top kill of all categories of weeds but there was rapid regeneration of weeds. In other part of the experiment where *Cyperus rotundus* was not present but grassy weeds were dominant, pre-emergence application of fluchloralin (Basalin) at 1.5 kg ha^{-1} showed the highest yield of jute fibre when compared with other herbicides like Frencock AC 60. Nitrofen and kerb was almost at par with hand weeding twice but Nitrafen caused severe mortality of jute crop.

Prusty *et al.*, 1988, reported from a experiment with JRC 212 that hoeing at 15 DAS and 2 weedings in the 3 and 5 week gave best jute fibre yield (2.54 t ha^{-1}) and best stick yield (4.98 t ha^{-1}). Benthiocarb (0.75 kg ha^{-1}) pre-emergence, Oxyfluorfen (0.25 kg ha^{-1}) pre-emergence, Fluazifop-butyl (0.25 kg ha^{-1}) post emergence and Fluchloralin (0.9 kg ha^{-1}) pre-sowing incorporation gave an increase in fibre yields with increasing N rate; at 90 kg N, fibre and stick yields were 2.54 t ha^{-1} and 4.59 t ha^{-1} respectively.

Weed control with fluchloralin as pre-sowing and Benthiocarb [Thiobencarb] and Oxyfluorfen as pre-emergence was compared with conventional practice (1 hoeing + 1 hand weeding) and an un-weeded control in lowland jute. The conventional practice gave effective control of weeds and the highest yield, 68.77% greater than the un-weeded control. Benthiocarb, Fluchloralin and Oxyfluorfen gave 59.02%, 53.53% and 50.97%, respectively, higher yields than the un-weeded control (Tosh and Acharya, 1985).

Among fluchloralin, pendimethalin and quizalofop-ethyl, the most effective one in controlling grassy weeds was quizalofop-ethyl, as reported by Bhattacharya *et. al.,* 2004.

2.5 Nitrogen nutrition of jute

The effect of nitrogen is more evident because jute is a bast fibre crop where yields depend directly on the development of the vegetative parts (Das and Dua, 1964). Under rainfed condition yield of jute can be increased with nitrogenous fertilizers by about 8-16 times per unit of nitrogen. The excess dose of N may invite some deleterious effects such as tendency to lodge, greater susceptibility to pathogenic fungi and production of coarse fibre (Sengupta, 1963; Kundu, 1956 and Pandey *et.al.,* 1959). Ammonium nitrogen was better than nitrate nitrogen for production of green matter and fibre as reported by Sengupta, 1953.

Saha *et.al.,* 1967 reported that foliar application of 16.8 kg N ha^{-1} as urea was as effective as soil application of 44.8 kg N ha^{-1}.

Singh *et.al.,* 1979 reported that response of jute to nitrogenous fertilizer in terai region where fibre yield increased from 1.68 to 2.29 t ha^{-1} with increase in N from 0 to 80 kg ha^{-1}.

N rates upto 100 kg ha^{-1} gave significantly the best fibre qualities like fibre fineness, fibre tenacity, yearn tenacity and yearn regularity as reported by Gupta *et. al.,*1979.

Bhattacharya *et.al.,* 1983 worked on effect and efficiency of foliar and soil application of urea and iron on fibre yield and quality of jute and recorded 13 % higher fibre yield under the application of 40 kg N and 10 kg $FeSO4$ ha $^{-1}$ as basal and 10 kg N ha $^{-1}$ in two foliar spray than those obtained with Fe and 50 N ha $^{-1}$ to soil and 47 % higher than those obtained without N or Fe.

Islam *et.al.,* 1992 conducted a field experiment at Maymensingh, jute was grown on silty loam soil and given 0, 22.5, 45 and 67.5 kg N ha $^{-1}$. Fibre yield increased with N rate from 2.26 (without N) to 3.80 t ha $^{-1}$ (with 67.5 kg N). This was related to an increase in plant height and stem diameter.

Roy and Choudhury, 1991 summarized that the fibre yield increased progressively in case of *Capsularis* jute cv. UPC 94 and JRC 632 from 1.24 t (without N) to 1.94 t ha $^{-1}$ with 60 kg N ha $^{-1}$. Application of further 20 kg N increased fibre yield but not significantly.

According to Jayaraman and Asokaraja, 1995 the highest yield was obtained from JRO – 524 with application of 60 kg N ha $^{-1}$ and harvesting at 100 DAS. Whereas, Das and Choudhury, reported that fibre yield and stick yield increased significantly with upto 40 kg N ha $^{-1}$.

Nayek *et. al..,*1996 reported that the mean dry matter yield was highest (2.7 t ha -1) with 60 kg N ha $^{-1}$.

Utilization of phosphorus is affected by N. Choudhury and Roy, 1998 opined that dry matter yield and phosphate uptake incraesd with increasing N rate and with upto 40 kg N ha^{-1}.

Maity *et.al.,* 1989 reported that increasing N rate increased fibre yields but the difference between 40 and 60 kg N rates was not significant in *C. olitorius*. Whereas, Pnadey *et.al.,* 1967 opined that higher levels of N adversely affected the quality of the fibre in *Olitorius* jute.

Chapter-3

MATERIALS AND METHODS

3.1 Experimental site

The field experiment was conducted at the 'C' Block Farm, Kalyani of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India. It is located very close to the tropic of cancer. The farm is situated at 23.5°N latitude, 89°E longitude and with an altitude of 9.75 m above the mean sea level.

3.2 Experimental Soil

The soil of the experimental field was typical Gangetic alluvium (Inceptisol) and sandy loam in texture with good drainage facility. The physico-chemical properties of the soil sample determined from composite soil samples collected from 0-30 cm depth of the experimental field are presented in the following Table 3.1.

Table 3.1 Physico-chemical properties of the experimental soil

A. Mechanical composition of soil

Particulars	Value	Method followed
Textural class	Sandy loam (USDA)	International Pipette Method (Pipper, 1966)
Sand	56.4%	
Silt	24.0%	
Clay	19.6%	

B. Chemical composition of soil

Particulars	Value	Method followed
pH	6.8	Systronics Digital pH Meter (Jackson, 1973).
Organic carbon	0.62%	Walkley and Black method (Jackson, 1973)
Total nitrogen	0.059%	Modified Kjeldahl method (Jackson, 1973)
Available P	14.43 kg ha^{-1}	Olsen's method (Jackson, 1973)
Available K	96.85 kg ha^{-1}	Flame photometer method (Jackson, 1973)

3.3 Climatic condition

The experimental situation comes under sub-tropical humid condition. The meteorological data pertaining to the experimental periods are presented in Table 3.2.

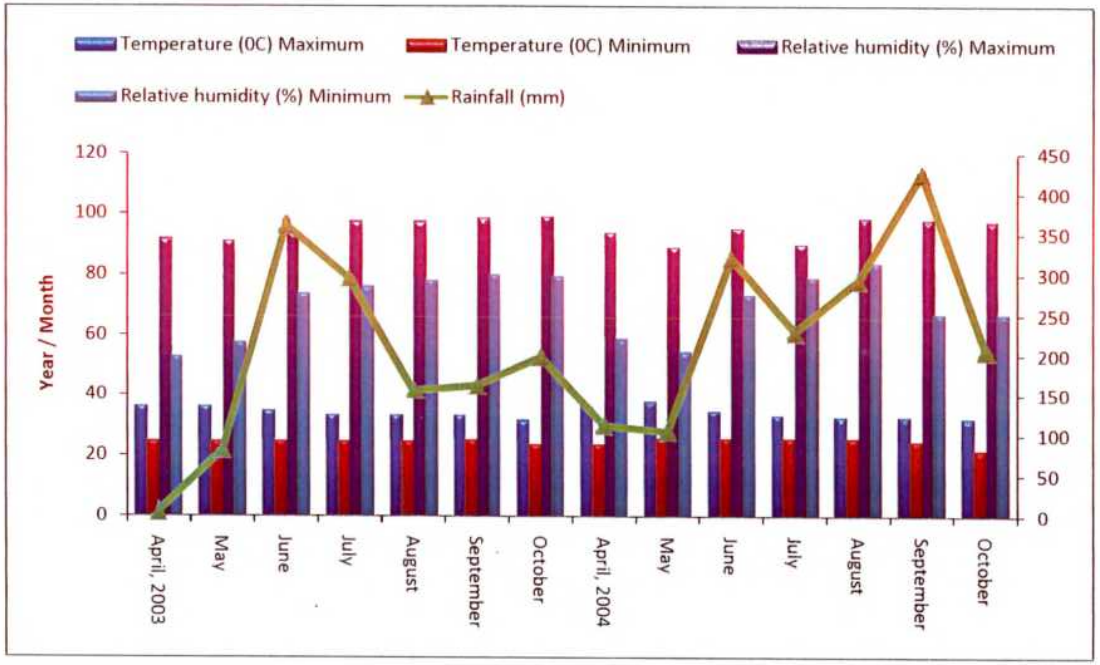


Fig. 1. Meteorological observations during the experimental period 2003 & 2004

Table 3.2 Meteorological data

Year/Month	Temperature (^0C)		Rainfall (mm)	Relative humidity (%)	
	Maximum	Minimum		Maximum	Minimum
April, 2003	36.5	24.7	6.0	92.03	53.33
May	36.5	24.9	81.4	91.29	57.71
June	34.8	24.9	361.3	93.43	73.87
July	33.4	25.0	295.2	97.35	76.16
August	33.4	25.0	155.7	97.65	78.26
September	33.4	25.6	162.0	98.53	80.47
October	31.87	23.87	197.9	99.03	79.52
April, 2004	36.18	24.00	112.0	93.70	58.73
May	37.67	25.73	104.6	89.26	54.74
June	34.67	25.77	320.5	95.33	73.50
July	33.45	25.69	229.9	90.14	79.39
August	32.93	25.66	293.5	98.52	83.71
September	32.75	24.83	425.3	98.07	67.32
October	32.02	21.78	206.3	97.74	67.32

Source : Meteorological station, BCKV, Kalyani, Nadia, W.B.

3.3.1 Temperature

The temperature in this region begins to rise from middle of February and reaches to its highest value during May. The mean maximum and minimum temperature showed a wide range fluctuation. The maximum temperatures were 36.50 and 37.67 °C in 2003 and 2004, respectively. The minimum temperature during the crop growth period was 24.7 and 24.0 °C in the 1^{st} and 2^{nd} year of the experiment.

3.3.2 Rainfall

The average total annual rainfall in the experimental area is 1457 mm of which the maximum amount is received during the monsoon months of June to August. 8-10^{th} June normally the monsoon breaks in this area and rain continues upto September. During the pre-monsoon months March-April small amount of rainfall is received which is essential for sowing of jute.

3.3.3 Humidity

The maximum relative humidity (RH) were 97.35 and 90.14% and the minimum RH were 53.33 and 54.74% during the 1^{st} and 2^{nd} year of the experiment.

3.4 Previous cropping history of the experimental field

The last 3 years cropping history of the experimental field prior to the experimentation was as under:

Table 3.3 Cropping history

Year	*Pre-kharif*	*Kharif*	*Rabi*
2000	Jute	Rice	Lentil
2001	Jute	Rice	Fallow
2002	Sesame	Rice	Mustard

3.5 Experimental Methods

3.5.1 Experimental details

Table 3.4 Experimental details

Design of the experiment	:	Split plot design
Number of replication	:	Three (3)
Number of main plot treatment	:	Two (2)
Number of subplot treatment	:	Seven (7)
Total number of plots	:	Forty-two (42)
Individual plot size	:	5 x 4 m^2
Width of irrigation channel	:	1.5 m
Width between main plots	:	1.5 m
Variety used	:	JRO - 524 (Navin)
Spacing	:	25 x 10 cm

3.5.2 Particulars of the crop and variety

Jute belongs to the family Tiliaceae and is located in the Malvales order. Mitha or Tossa jute (*Corchorus olitorius* L.) and Tita or white jute (*Corchorus capsularis* L.) are the two important cultivated species of jute, which are distinct in morphology with basic chromosome number n = 7. Both the species of jute are predominantly self pollinated crops. Average cross-pollination of capsularis is only about 1.38% and that of olitorius jute is about 10.5% which primarily depends upon the pressure of pollinating agents and weather condition (Kumar *et al.*, 2003). Jute is primarily a rainfed crop, thriving best on warm, humid and rich loamy or alluvial soils where annual rainfall ranges between 150 and 200 cm; with an average temperature from 17 to 38 °C and a relative humidity around 70-90%.

JRO- 524 : It is popularly known as Navin. *This Olitorius* jute with parentage Sudan green x JRO - 632 is higher yielder than JRO- 878 and JRO-7835 with added qualities of fine fibre and quick in retting. It is resistant to root rot and yellow mite. Plants are 3-4 m in height with pigmented stems. Pods are non shattering. Time of sowing ranges from middle of March to end of April. It is recommended for medium to high lands of West Bengal, Assam, Bihar, eastern U.P, Tripura and Orissa.

3.5.3 Treatments

The nutrient N management were placed in the main plots while both chemical and mechanical methods were considered either solely or in combination in the sub plots. The treatment combinations are as follows :

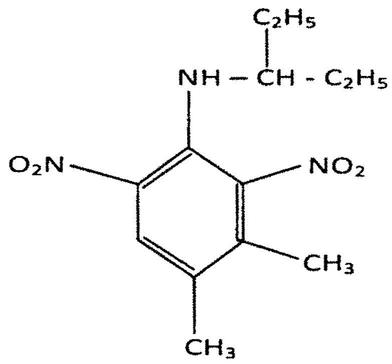
Table 3.5 Treatment Details

❖	**Main plot treatments**
N_1	50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS
N_2	50% N basal +25% N at 20 DAS +25% 40 DAS
	Sub-plot treatments
W_1	Unweeded Control
W_2	Weed free
W_3	Hand weeding twice at 15 and 35 DAS
W_4	Quizalofop ethyl 5% @ 50 g / ha at 15 DAS
W_5	Pendimethalin @ 750 g /ha at 1 DAS
W_6	Quizalofop ethyl 5% @ 50 g / ha at 15 DAS + hand weeding at 35 DAS
W_7	Pendimethalin @ 750 g /ha at 1 DAS + hand weeding at 35 DAS

DAS = days after sowing

3.5.3.1 Details of the herbicides used

3.5.3.1.1 Pendimethalin



IUPAC Name: N (1- ethyl propyl) -3, 4- dimethyl-2,6-dinitrobenzenamine

PHYSICO-CHEMICAL PROPERTIES

Molecular formula :

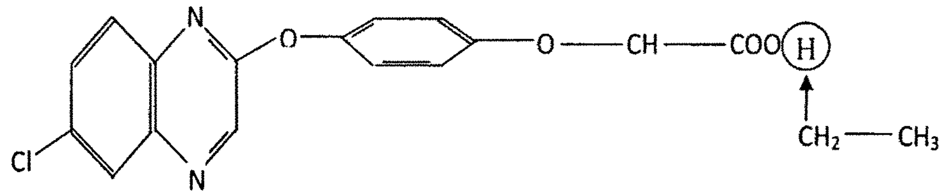
Molecular weight	: 268
Melting point	: 56-57 ^{0}C
Solubility	: Soluble in water (3 ppm in water at 20 ^{0}C)
Formulation	: 30 % EC and 3 % G
Type of herbicide	: Selective herbicide
Time of application	: Pre-plant incorporation, pre-emergence
Stability	: Stable to alkaline and acidic condition
Corrosiveness	: Non-corrosive
Toxicity LD_{50}	: Acute or rat 2930 Dermal; rabbit 6870

COMMERCIAL INFORMATION

Trade Name	: Stomp
General Dose	: 0.5 – 2 kg a.i. / ha
Manufacturer	: Cyanamid Agro Limited
Price	: Rs. 445.00 per lit.

MODE OF ACTION : With the pre-emergence application, the chemicals control weeds by inhibiting seeds germination and seedling development

3.5.3.1.2 Quizalofop ethyl



IUPAC Name: ethyl(RS)-2[4-(6-chloroquinoxalin -2-yloxy) phenoxy] propionate

PHYSICO-CHEMICAL PROPERTIES

Molecular formula	: $C_{19} H_{17}ClN_2O_4$
Molecular weight	: 372.8
Melting point	: 91.7 - 92.1 ^{0}C
Solubility	: Soluble in water (0.3 mg/l water at 20^{0}C)
Formulation	: 5 % EC
Type of herbicide	: Selective herbicide
Time of application	: Post-emergence
Stability	: Stable to alkaline and acidic condition
Corrosiveness	: Non-corrosive
Toxicity LD_{50}	: Acute oral for male rat 1670 and female rat 1430

COMMERCIAL INFORMATION

Trade Name	: Targa super, Targa, Pilot, Assure, Tolan
General Dose	: 50- 75 g a.i. / ha
Manufacturer	: Nissan Chemical Industries
Price	: Rs. 160.00 per 100 ml

MODE OF ACTION : Absorbed from the leaf surface, with translocation throughout the plant, moving in both xylem and phloem and accumulated in the meristametic tissue. Acetyl CoA carboxylase inhibitor and inhibit fatty acid biosynthesis.

3.6 Layout

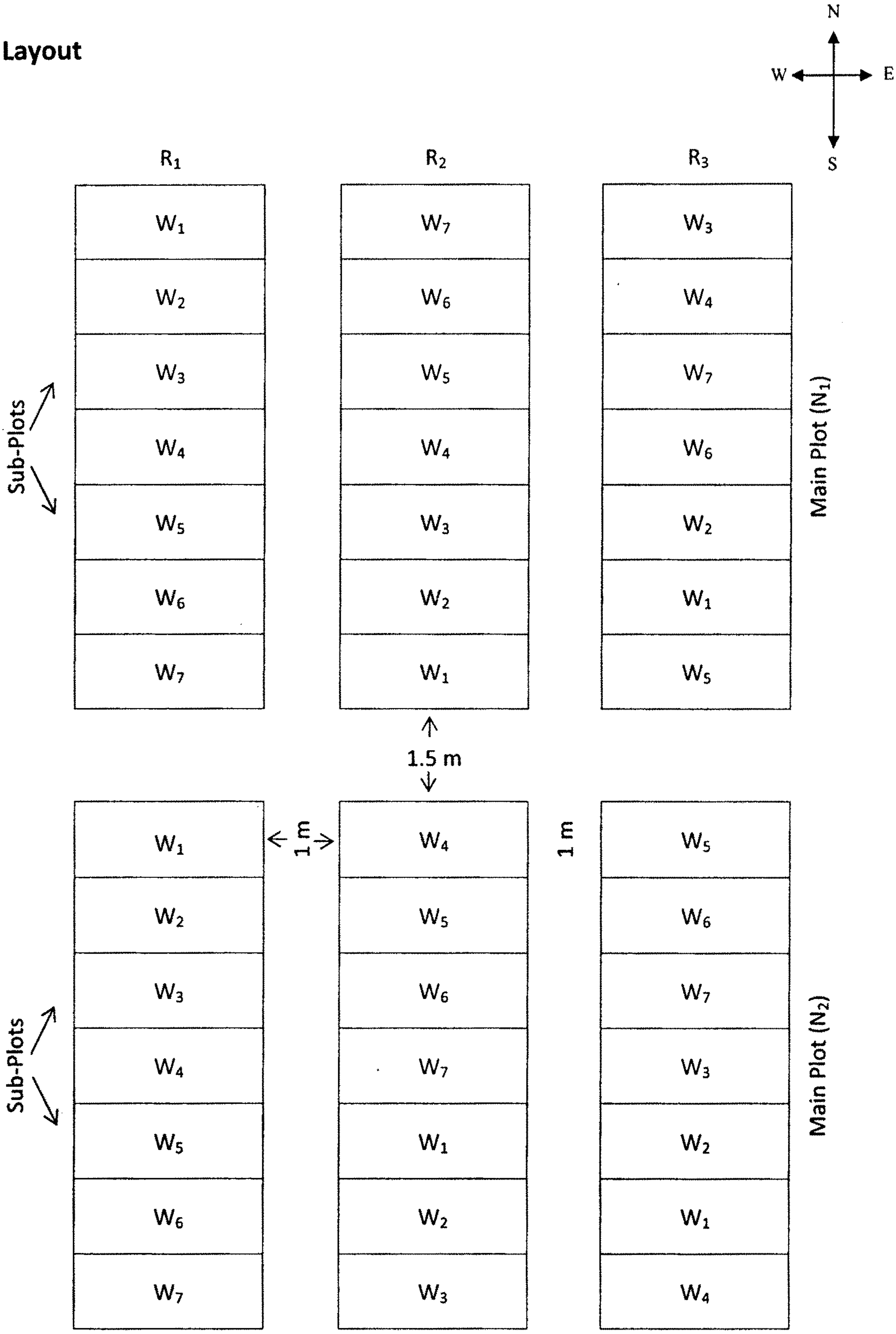


Fig. 2 : Layout of the experiments

3.7 Methodology of treatment application

3.7.1 Herbicide application

The amount of herbicides required for each plot was calculated on the basis of the following formula:

$$Q = \frac{10.\ R.\ A}{P}$$

Where, Q = Quantity of herbicide required in g or ml

A = Area in m^2

R = Rate of application in kg a.i. ha^{-1}

P = Percentage of active ingredient in the formulation

The required quantity of commercial formulation of the herbicides used in this experiment was measured with the help of graduated measuring cylinder. Using manual knapsack sprayer fitted with flat fan nozzle the herbicides were applied in the treatment plots. About 500 litre ha^{-1} of water was used for the spraying.

3.7.2 Hand weeding treatment

At 15 and 35 DAS two hand weedings were given with the help of *khurpi/ nirani* in the specified plots.

3.8 Agronomic management practices adopted

Table 3.6 Calendar of operations

Operation	Dates	
	2003	2004
Land preparation	11 April	8 April
Layout of the experiment	16 April	10 April
Basal application of fertilizers	17 April	11 April
Seed treatment and seed sowing	17 April	11 April
Pre-emergence application of herbicides	18 April	12 April
First weeding and thinning	2 May	26April
Post-emergence application of herbicides	2 May	26April
Top dressing of nitrogenous fertiliser	27 April , 7 May & 27 May	21April , 1 May & 21 May
Second weeding	22 May	16 May
Plant protection measures	4 June & 28 June	30 May & 22 June
Harvesting	15 August	8 August
Retting started	18 August	11August
Retting completed and Fibre Extraction	1 September	25 August

3.8.1 Land preparation

The land was thoroughly ploughed twice by a tractor drawn disc plough when the soil moisture was optimum and then by a power tiller for getting fine tilth. All the stubbles were removed manually from the field. Proper levelling was done through the use of wooden plank fitted with tractor. Then as per the treatments and replications the layout was done.

3.8.2 Application of fertilizers

Nitrogen (N) @ 40 kg ha $^{-1}$ in the form of Urea, phosphate (P_2O_5) @ 30 kg ha^{-1} in the form of Single Super Phosphate and potash (K_2O) @ 30 kg ha^{-1} in the form of Muriate of Potash were applied in both the years. The full amount of phosphate and potas were applied as basal at the time of final land preparation and N was applied as per the treatment.

3.8.3 Layout

The whole experimental field was divided into 3 replications. Then each replication was divided into two equal main plots. Each main plot was divided into seven sub-plots. Then treatments were placed randomly in each plot.

3.8.4 Time of sowing, seed rate, spacing and method of sowing

The seeds were sown in line on 17 April in 2003 and on 11 April in 2004 at the rate of 5 kg ha^{-1}. The row to row spacing was 25 cm and the spacing of plants within a row was maintained at 10 cm during thinning.

3.8.5 Thinning and weeding

According to treatment combination first weeding and thinning was done at 15 DAS and the second weeding was done at 35 DAS. In all the plots, irrespective of treatments followed, thinning operation was done at 15 DAS to maintain plant to plant spacing (within a row) .

3.8.6 Irrigation

One pre-sowing irrigation was given before the final land preparation during the first year (2003) and during second year (2004) no irrigation was applied. .

3.8.7 Plant protection measures

Prophylactic plant protection measures against insects and diseases were taken by spraying insecticide like Endosulfan 0.075% twice at 45 and 65 DAS and fungicide

Carbendazim 0.1% concentration once at 60 DAS. It may be mentioned that the seeds were treated with Mancozeb @ 3 g kg^{-1} of seed before sowing.

3.8.8 Harvesting

Harvesting of jute was done at 120 days of crop age, by using sharp country sickles and cutting the green plants close to the ground. The harvested plants were then bundled into convenient size of 10 plants and kept in the field itself for 3 days for shedding of all leaves.

3.8.9 Retting and extraction

After complete leaf shedding the bundles were taken to the retting tank just beside the experimental plot of the Viswavidyalaya 'C' Block and kept standing in 40 cm deep water for another 3 days for softening the hard basal portion. Then the bundles were laid side by side in water and tied together to form *'jak'* and thereafter the bundles were submerged under water by putting coconut leaves, water hyacinth and some concrete blocks so that the *jak* remained 15 cm below the water surface. After 12 days from the *jak* which remained in that condition one reed was at first pulled out from the bundle and found that the fibre was loosen enough for extraction. The fibre then was extracted by following single plant extraction method after 14 day of retting. After extraction the fibre was cleaned in water through repeated washing and then put over a bamboo structure for sun drying for 5 days. The sticks also were sun dried in the upright condition for 7 days.

3.8.10 Final yield

The final yield of fibre and sticks were taken plot-wise after complete drying of fibre and sticks and then converted to 'yield per hectare' for each treatment.

3.9 Recording of biometrical observations

3.9.1 Observation on weeds

3.9.1.1 Weed flora present in the experimental plots

Regular and timely observations were undertaken for identifying different weed species category wise in the experimental plots from the beginning of the experiment to the harvest of the crop.

3.9.1.2 Weed density

A quadrate of size 0.5 m x 0.5 m was placed randomly at four places in each plot to count the weed population per square metre for each treatment. Different categories of weeds like grass, sedge and broadleaf were then counted separately for each plot. Weed population counts were taken at 30, 60 and 90 DAS of the jute crop.

3.9.1.3 Weed biomass (Dry weight of weeds)

Weeds belonging to three different categories obtained during population count at 30, 60 and 90 DAS were separated, washed thoroughly with clean water, kept in brown paper packet with proper labelling and dried in hot-air oven at a temperature of 60^0 C till constant weight was obtained. Then the dry matter weight of the weeds was recorded separately.

3.9.1.4 Weed control efficiency (WCE)

It denotes the efficiency of the applied herbicide or an herbicidal treatment, for comparison purpose it may be calculated by using the following formula:

$$\text{WCE} = \frac{\text{Dry matter of weeds in control plot} - \text{Dry matter of weeds in treated plot}}{\text{Dry matter of weeds in control plot}} \times 100$$

3.9.2 Observation on jute crop

3.9.2.1 Crop toxicity rating

To record herbicide toxicity on crop stand and growth, visual assessment of response of herbicide on jute was rated at 30 days after sowing by following the European Weed Research Council Rating System in Form No. 'B' with a 1-9 scale as shown in Table 3.7.

Table 3.7 Qualitative description of treatment effects on crop in the visual scoring scale of 1 to 9.

FORM No. B		
Rating	Crop response	Verbal description
1	0-1.0	No reduction or injury
2	1.0-3.5	Very slight discolouration
3	3.5-7.0	More severe but not lasting
4	7.0-12.5	Moderate and more lasting
5	12.5-20.0	Medium and lasting
6	20.0-30.0	Heavy injury
7	30.0-50.0	Very heavy injury
8	50.0-90.0	Nearly destroyed
9	100.0	Completely destroyed

3.9.2.2 Plant height and basal diameter

Ten plants from each plot were randomly chosen and labelled with aluminium tags. Observations of plant height and basal girth were taken at 25, 50, 75, and 100 DAS from the same labelled plants.

3.9.2.3 Total biomass accumulation

Randomly chosen five plants from each plot were uprooted in each date of observation. The samples were then oven dried at 70°C for 12 hours till a constant weight is reached. Then it was weighed and converted to t ha^{-1}.

3.9.2.4 Leaf area index

Leaf area index is the ratio between the area of the surface of green leaves and ground area covered. It can be expressed as follows :

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Ground area}}$$

For calculation of leaf area, 10 plants from each plot and in each date of observation were selected. Thirty leaves, one each from top, middle and lower portion of the stem of 10 jute plants were removed and the leaf area of each leaf was demarcated in mm`graph paper. The collected 30 leaves were dried in the hot air oven. Thus a relation between the leaf area and dry weight of leaves was established for each plot and for each date of observation. Using this relation by converting the total leaf dry weight into the leaf area and thereafter the LAI was calculated.

3.9.2.5 Crop growth rate

Crop growth rate (CGR) represents dry weight gained by a unit area of crop in a unit time expressed as g d^{-1} m^{-2}. The CGR was calculated from the following equation:

$$\text{CGR} = \frac{w_2 - w_1}{t_2 - t_1}$$

where, w_1 = plant dry weight from unit area at time t_1 and

w_2 = plant dry weight from unit area at time t_2

3.9.2.6 Yield

Main economic yield components of jute are fibre and sticks. So both were measured for yield analysis.

3.9.2.6.1 Fibre yield

Harvesting of crops was done on net plot basis. Harvested jute plants are then retted for getting the fibre yield from the plot area, which was then converted in terms of hectare yield.

3.9.2.6.2 Stick yield

The same procedure followed in the fibre yield estimation was followed in estimating the stick yield.

3.10 Soil analysis

Before final land preparation composite soil samples were collected from the experimental field for analysis of the initial status of the chemical and physical properties of soil by following the procedure as mentioned in Table 3.1.

3.11 Economic analysis

The cost of various inputs and crop management practices employed for crop production and value of crop yield in Rupees were estimated as per the available market information. For each treatment cost of production and net return of crop were calculated and then net return per rupee investment was obtained. Cost of production included common cost and treatment cost (added cost of the respective treatment). Common costs included the cost of land preparation, seed materials, sowing, manures and fertilizers, plant protection measures, harvesting and post harvest techniques (retting, drying and bundling). The costs were worked out as presented in Table 3.8 and in Table 3.9.

3.12 Statistical analysis

The data so obtained as described earlier were subjected to statistical analysis by the analysis of variance method (Panse and Sukhatme, 1978) and the significance of different sources of variations were tested by Error Mean square by Fisher and Snedecor's 'F' test at probability level 0.05. For the determination of critical difference at 5% level of significance, Fisher and Yate's tables were consulted. The value of critical difference to compare the difference between means have been provided in the tables of results.

Table 3.8 Calculation of Common Cost for One Hectare

Cost item	Quantity required	Unit cost (Rs)	Sub-total (Rs)	Total (Rs)
1. LAND PREPARATION				
i) Ploughing by tractor	3 times	200.00	600.00	
ii) Ploughing by power tiller	2 times	110.00	220.00	
iii) Levelling	1 time	170.00	170.00	
iv) Number of labourers	8 mandays	62.10	496.80	
TOTAL : Land Preparation				**1486.80**
2. FERTILISERS				
i) Urea	87 kg	5.03	437.61	
ii) SSP	187.5 kg	3.85	721.88	
iii) MOP	50 kg	4.45	222.50	
iv) Application cost	2 mandays	62.10	124.20	
TOTAL : Fertiliser				**1506.19**
3. SEED AND SEED TREATMENT				
i) Seed	5 kg	40.00	200.00	
ii) Seed treatment (Dithane M-45)	15 g	0.25	3.75	
iii) Labour for seed sowing	7 mandays	62.10	434.70	
TOTAL : Seed and sowing				**638.45**
4. PLANT PROTECTION MEASURES				
i) Thiodan	750 ml	0.30	225.00	
ii) Bavistin	800 g	0.55	440.00	
iii) Application cost	8 mandays	62.10	496.80	
TOTAL : Plant protection measures				**1161.80**
5. HARVESTING				
i) Labourers for harvesting	20 mandays	62.10	1142.00	
TOTAL : Harvesting				**1142.00**
6. POST HARVEST OPERATION				
i) Retting and Extraction	30 mandays	62.10	1863.00	
ii) Drying and bundling	15 mandays	62.10	931.50	
TOTAL : Post harvest operation				**2794.50**
GRAND TOTAL				**8829.75**

3.13 Blackgram

After harvesting of jute, blackgram was sown on the same plots as previous treatment to find out whether the treatment had any harmful effect or not on the next crop. Finally the grain yield of blackgram was recorded for this purpose.

Table 3.9 Calculation of Treatment Cost for one hectare

Treatments	Dose	Quantity of formulation/ number of labourers required	Unit cost of formulation/ labourers	Cost of the chemical/ labourers	Herbicide application cost	Total Treatment Cost
A	B	C	D	E	F	G (E+F)
T_1 : Un-weeded control	-	-	-	-	-	0
T_2 : Weed free	All the time	160 man-days	Rs. 62.10/man-day	Rs. 9936.00	-	Rs. 9936.00
T_3 : HW twice 15+35 DAS	Twice	80 man-days	Rs. 62.10/man-day	Rs. 4968.00	-	Rs. 4968.00
T_4 : Quzalofop-ethyl	50 g a.i. ha^{-1}	1 kg ha^{-1}	Rs. 160 /100 ml container	Rs. 1600.00	Rs. 248.40 (Rs 62.10 x 4 man-days)	Rs. 1848.40
T_5 : Pendimethalin	750 g a.i ha^{-1}	2.5 kg ha^{-1}	Rs. 445 /lit.	Rs. 1112.50	Rs. 248.40	Rs. 1360.90
T_6 : T_4 + HW 35 DAS	50 g a.i ha^{-1} + once	1 kg ha^{-1} + 20 man-days	Rs. 160 /100 ml + Rs. 62.10/man-day	Rs. 1600.00 + Rs. 1242.00	Rs. 248.40	Rs. 3090.40
T_7 : T_5 + HW 35 DAS	750 g a.i ha^{-1} + once	2.5 kg ha^{-1} + 30 man-days	Rs. 445.00/lit. + Rs. 62.10/man-day	Rs. 1112.50 + Rs. 1863.00	Rs. 248.40	Rs. 3223.90

3.14 Influence of pendimethalin on α-amylase activity of jute seed and different weed seeds

Influence of pendimethalin on α-amylase activity during germination of crop (jute) and dominant weed seeds was studied in laboratory condition at different intervals.

3.14.1 Procedure of α- amylase enzyme test

This α-amylase test was conducted at Weed Science Laboratory, Depatment of Agronomy of Bidhan Chandra Krishi Viswavidyalaya under controlled conditions in BOD incubator at 35 $\pm$ 2^0C . Seeds of crop (jute cv. JRO 524) and dominant weed species (viz. *Echinochloa colona, Eleusine indica, Digitaria sanguinalis, Cyperus rotundus* and *Physalis minima*) were germinated in petridishes separately. One g seeds of crop and each weed species were placed on filter paper in petridish (20 cm diameter) separately. Five ml of aqueous solution of 1 ppm of pendimethalin was poured separately in each petridish. While for control 5 ml of distilled water was added. The petridishes were placed in BOD incubator at 35$\pm$ 2^0C for germination of the seeds. Samples were taken out for enzyme analysis at 6, 24 and 48 hours after treatment. Seeds sample was extracted in tris HCl buffer (pH 4.8) and crude extract was used for assay of α-amylase activities according to Sadasivam and Manickam (1996).

The details of the procedure of α-amylase enzyme test as followed below –

Materials

- Sodium acetate buffer, 0.1 M pH 4.7

Solution A 0.2 M solution of acetic acid (1.155 ml in 100 ml)

Solution B 0.2 M solution of sodium acetate (2.72 g of $C_2H_3O_2$ Na $3H_2O$ in 100 ml)

X ml of A, y ml of B, diluted to a total of 100 ml

- Starch, 1% solution

  Prepare a fresh solution by dissolving 1 g starch in 100 ml acetate buffer slightly warm, if necessary.
- Dinitrosalicylic acid reagent
- 40% Rochelle salt solution (potassium sodium tartarate)
- Maltose solution: Dissolve 50 mg maltose in 50 ml distilled water in a standard flask and store it in a refrigerator. This solution is used to prepare standard curve.

- Extraction of α- amylase: Extract 1 g of sample material with 5-10 volumes of ice-cold 10 ml calcium chloride solution overnight at 4^0C or for 3 h at room temperature. Centrifuge the extract at 54,000 g (20000 r.p.m.) at 4^0C for 20 min. The supernatant is used as enzyme source.

Procedure

- Pipette out 1 ml of starch solution and 1 ml of properly diluted enzyme in a test tube.
- Incubate it at 27^0C for 15 min.
- Stop the reaction by the addition of 2 ml of dinitrosalicylic acid reagent.
- Heat the solution in a boiling water bath for 5 min.
- While the tubes are warm, add 1 ml potassium sodium tartrate solution.
- Then cool it in running tap water
- Make up the volume to 10 ml by addition of 5 ml water.
- Read the absorbance at 560 nm.
- Terminate the reaction at zero time in the control tubes.
- Prepare a standard graph with 0-100 μg maltose.

Calculation

A unit of α- amylase is expressed as mg of maltose produced during 15 min incubation with 1% starch. Then the α- amylase activity is expressed in μg maltose released per gram of fresh tissue per minute.

Chapter-4

RESULTS

4.0 Influence of Nitrogen and Weed Management on Tossa Jute and their treatment effect on Blackgram

The experiment was started with jute sown in the month of April, 2003 & 2004 and it was followed by blackgram as per scheduled treatments (described in detail in the chapter on Materials and Methods). The biometrical observations recorded are presented hereunder.

4.1 Jute

4.1.1 Studies on weed of jute

4.1.1.1 General studies on the weed flora

Regular survey was made in the experimental field immediately after sowing of jute with a view to determine the different weed species present, their abundance, sequence of appearance and special characteristic features. Although, three different categories, grass, sedge and broadleaf weeds, were observed, but among them grasses and sedges are the dominant weed flora in the experimental plots.

All together there were 18 species of weeds, of which 7 were grasses, 3 species were sedges and rest 8 species were broadleaved ones. Details of the weed species recorded from the experimental field with their characteristics are presented in the Table 4.1.

Among these weed species the following were the most predominant weed flora present in the experimental plots.

1. *Cynadon dactylon*
2. *Echinoclloa colonum*
3. *Brachiaria ramosa*
4. *Eleusine indica*
5. *Cyperus rotundus*
6. *Dactyloctaneum aegypticum* (L.)
7. *Digera arvensis*
8. *Physalis minima*
9. *Amaranthus viridis*
10. *Solanum nigram*

Table 4.1 Weed species recorded from the experimental field

Sl. No.	Botanical Name	Family	English Name	Local Name	Characteristics
A	Grasses				
1.	*Cynadon dactylon* (L.) Pers.	Poaceae	Bermuda grass	Dub grass	A hardy perennial grass, reproduced by creeping rootstocks and seeds.

Sl. No.	Botanical Name	Family	English Name	Local Name	Characteristics
					Flowering and fruiting time Sept. to Dec and May to July
2.	*Echinocloa colona* (L.) Link	Poaceae	Barnyard grass	Shyama	An annual grass weed propagated by seeds, mainly prevalent in kharif season. Flowering and fruiting time June to Nov
3.	*Eleusine indica* (L.) Gaernt.	Poaceae	Goose grass	Kodai	Annual grass, propagated by seeds. Wind mill like appearance of the inflorescence
4.	*Brachiaria ramosa*	Poaceae	Brachiaria	Bauspata	A creeping annual grass propagated by seeds. Flowering and fruiting time Aug. to Oct.
5.	*Digitaria sanguinalis*	Poaceae	Crab grass	Kewai	Annual grass propagated by seeds. Flowering and fruiting occurs throughout the year
6.	*Dactyloctaneum aegypticum* (L.)	Poaceae	Star grass	Makra	Annual grass propagated by seeds
B.	**Sedge**				
1.	*Cyperus rotundus* L.	Cyperaceae	Nut sedge	Mutha	Perennial herb, propagated by seeds and

Sl. No.	Botanical Name	Family	English Name	Local Name	Characteristics
					underground stem. Flowering and fruiting time July to Nov.
C.	**Broad leaf weed**				
1.	*Digera arvensis*	Amaranthaceae	Digera	Latma nuria	Annual weed, mostly found in kharif season, propagated by seeds.
2.	*Physalis minima*	Euphorbiaceae			Annual weed, propagated by seeds.
3.	*Amaranthus viridis* L	Amaranthaceae	Pig weed	Note shak	Annual weed, propagated by seeds, flowering and fruiting throughout the year.

4.1.2 Weed dynamics of jute

4.1.2.1 Weed population

4.1.2.1.1 Effect of nitrogen application on grass weed population

At 30 DAS lower grass weed population were recorded (Table 4.2) in the treatment (N_1) where basal nitrogen was skipped as compared to the treatment where basal nitrogen was applied (N_2). Similar trend was found at 60 and 90 DAS where N_1 produced significantly lower weed population than N_2.The trend was similar for both the year of experiment and in pooled data also. The lowest population (29.77 m^{-1}) was recorded from N_1 at 90 DAS during 2004 and highest number (42.62 m^{-1}) was observed from N_2 at 60 DAS during 2003.

4.1.2.1.2 Effect of weed management on grass weed population

Grass weed population recorded at different dates of observation (Table 4.2) from different weed management treatment during 2003 and 2004 as well as from pooled data showed that significantly higher population were recorded from unweeded control treatment. At 30 DAS, W_4 i.e. application of quizalofop ethyl recorded lower weed population than W_3, which received one hand weeding. Whereas, higher weed population was obtained from the treatment where pendimethalin was applied (W_5 & W_7), as compared to hand weeding (W_3). W_5 produced significantly higher number of weed than W_6. The trend was similar for 2003 and 2004 also. 30 days after the first observation (60 DAS), W_6 where POE herbicide was applied along with one hand weeding recorded significantly lower weed population than rest of the treatment. W_7 which received PE herbicide along with one hand weeding recorded statistically at par weed population with the hand weeding twice (W_3) treatment. There was significant difference between W_4, W_6 and W_5, W_7. During both the year of experiment similar trend was followed. At 90 DAS, W_6 recorded significantly lower weed population than all other treatment, except hand weeding twice (W_3), where no significant difference in weed population was observed. Trend was similar for 2003 and 2004. Lowest grass weed population was obtained from W_2 treatment at all dates of observation.

Table 4.2 Effect of treatments on grass weed population (per sqm) of jute at 30,60 & 90 DAS

Treatment	Grass Weed Population (number m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	36.53	33.93	35.23	42.33	34.73	38.53	34.19	29.77	31.98
N_2	38.90	38.04	38.47	42.62	42.54	42.57	35.62	34.45	35.03
CD(P=0.05)	-	-	-	2.81	5.88	3.74	1.40	3.66	2.51
Weed Management (W)									
W_1	82.22	90.85	86.53	110.00	98.78	104.39	95.33	85.43	90.38
W_2	0	0	0	0	0	0	0	0	0
W_3	40.05	38.46	39.25	38.83	32.41	35.37	20.33	18.31	19.32
W_4	27.72	23.58	25.65	34.33	35.21	34.77	32.00	29.38	30.69
W_5	43.03	39.40	42.21	51.17	49.86	50.51	42.83	40.55	41.69
W_6	28.33	21.00	24.66	24.00	21.65	22.82	24.50	20.60	22.55
W_7	42.67	38.63	40.65	39.00	32.54	35.77	31.33	30.54	30.94
CD(P=0.05)	10.23	11.42	9.82	9.87	11.20	8.53	6.00	8.14	4.97

4.1.2.1.3 Interaction effect of nitrogen application and weed management on grass weed population :

Interaction effect of nitrogen application and weed management on grass weed population was significant (Table 4.3). Pooled data showed that at all dates of observation significantly higher weed population were recorded from N_2W_1than all other treatment combinations except N_1W_1 at 60 and 90 DAS. During the first observation (30 DAS) N_1W_4

produced significantly lower weed population (24.03 m^{-1}) than rest of the treatment combination. Whereas, at 60 DAS N_1W_6 recorded lower population of weed than rest of treatment combination but no significant difference was observed among N_1W_6 , N_2W_6 and N_1W_3. The treatment combination N_1W_6 produced significantly lower weed population than N_2W_6 at 90 DAS and there was no significant difference between N_1W_6 and N_1W_3. Similar trend of observation was found during both the year of experiment. The lower weed populations were recorded from N_1W_2 and N_2W_2 treatment combinations at all dates of observation.

4.1.2.1.4 Effect of nitrogen application on sedge weed population :

Pooled data (Table 4.4) recorded lower sedge weed population from the treatment where basal nitrogen was not applied (N_1) as compared to the treatment received nitrogen as basal (N_2) at all dates of observation but at 90 DAS the difference in population was significant. During both the year of experiment similar trend was noticed. The lowest sedge weed population of 46.55 m^{-1} was obtained during 2002 at 90 DAS from the treatment N_2.

Table 4.4 Effect of treatments on sedge weed population (per sqm) of jute at 30, 60 & 90 DAS

Treatment	Sedge Weed Population (number m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	65.66	44.52	55.09	66.42	56.67	61.54	56.33	46.55	51.44
N_2	66.48	57.40	61.94	66.80	62.23	64.55	58.52	49.86	54.19
CD(P=0.05)	-	-	-	-	-	-	1.87	2.11	1.73
Weed Management (W)									
W_1	135.50	121.40	128.45	144.16	123.10	133.63	119.50	90.40	104.95
W_2	00	00	0	00	00	0	00	00	0
W_3	47.50	39.73	43.62	46.33	42.53	44.43	40.83	37.83	39.33
W_4	60.50	51.50	56.00	69.33	70.20	69.76	63.33	59.80	61.56
W_5	84.83	40.30	62.56	88.50	80.50	84.50	77.66	60.33	68.99
W_6	54.33	58.43	56.38	47.00	40.33	43.66	39.83	36.76	38.29
W_7	79.83	45.40	62.61	71.00	59.50	65.25	60.83	52.33	56.58
CD(P=0.05)	12.65	11.00	10.82	16.41	10.22	11.31	12.00	14.30	10.65

Table 4.3 Interaction effect of N application and weed management on grass weed population (number/sqm) at 30, 60 and 90 DAS

Weed Management (W)	Grass Weed Population (number m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	81.10	83.33	86.56	95.14	83.83	89.23	119.0	101.0	87.44	110.1	103.22	105.5	99.00	91.67	81.40	89.46	90.2	90.56
W_2	00	00	00	00	0	0	00	00	00	00	0	0	00	00	00	00	0	0
W_3	36.77	43.33	34.39	42.53	35.58	42.93	35.67	42.00	29.53	35.29	32.60	38.64	21.00	19.67	14.87	21.75	17.95	20.71
W_4	26.11	29.33	21.96	25.20	24.03	27.26	30.67	38.00	32.60	37.82	31.63	37.91	31.00	33.00	26.50	32.26	28.75	32.63
W_5	43.72	42.33	37.66	41.14	40.69	41.73	51.33	51.00	43.52	56.20	47.42	53.6	38.33	43.33	40.00	41.10	39.16	42.21
W_6	26.00	30.67	19.43	22.57	22.71	26.62	23.00	25.00	19.43	23.87	21.21	24.43	20.33	28.67	17.47	23.73	18.90	26.20
W_7	42.00	43.33	37.55	39.71	39.77	41.52	36.67	41.33	30.58	34.50	33.62	37.91	29.67	33.00	28.21	32.87	28.94	32.93
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	' 03	'04	P	'03	'04	P
CD (P=0.05)	11.71	10.37	9.04	4.21	3.48	3.30	12.52	10.09	10.10	6.27	5.16	5.07	12.14	10.50	11.05	6.25	5.86	5.32

Table 4.5 Interaction effect of N application and weed management on sedge weed population (number/sqm) at 30, 60 and 90 DAS

Weed Mana-gement (W)	Sedge Weed Population (number m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	129.33	141.66	105.0	137.8	117.16	139.73	138.7	149.7	118.9	127.3	128.8	138.5	113.0	126.0	86.73	94.07	99.86	110.03
W_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_3	46.00	49.00	32.63	46.83	39.31	47.91	43.33	49.33	39.73	45.33	41.53	47.33	37.33	44.33	34.66	41.00	35.99	42.67
W_4	57.66	63.33	45.90	57.10	51.78	60.21	66.66	72.00	67.60	72.80	67.13	72.40	59.66	67.00	54.80	64.80	57.23	65.90
W_5	86.00	83.66	33.83	46.77	59.91	65.21	91.00	86.00	79.70	81.30	85.35	83.65	79.33	76.00	63.60	57.06	71.46	66.53
W_6	56.00	52.66	52.33	64.53	54.16	58.59	53.00	41.00	34.16	46.50	43.58	43.75	44.00	35.66	35.43	38.09	39.75	36.87
W_7	84.66	75.00	42.00	48.80	63.33	61.90	72.33	69.66	56.60	62.40	64.46	66.03	61.00	60.66	50.66	54.00	55.83	57.33
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	03	'04	P	'03	'04	P
CD (P=0.05)	38.16	21.46	20.00	12.17	10.48	8.33	20.98	24.5	19.73	10.41	8.00	9.11	21.05	17.97	19.5	9.86	8.12	8.66

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.2.1.5 Effect of weed management on sedge weed population :

Table 4.4 showed that effect of weed management on population of sedge weed was significant. Maximum population was recorded from unweeded control plot (W_1) at all dates of observation and it was significantly higher than rest of the treatment. Hand weeding twice treatment (W_3) recorded significantly lower population than rest of the treatment at 30 DAS but at 60 and 90 DAS, W_3 produced statistically at par weed population with W_6. Significant difference was also found between W_6 and W_4, W_5 and W_7 at all dates except 30 DAS. Highest number of weed was recorded from W_1 treatment at 60 DAS during 2003. Weed free treatment always results minimum weed population. 2003 and 2004 showed similar trend like pooled data.

4.1.2.1.6 Interaction effect of nitrogen application and weed management on sedge weed population :

From the pooled data (Table 4.5) it is clear that interaction effect of nitrogen application and weed management on sedge weed population was significant. At all dates of observation, N_2W_1 recorded significantly higher population of weed as compared to the rest of the treatment combinations. N_1W_6, N_1W_3 and N_2W_3, N_2W_6 recorded statistically at par weed population at all dates of observation. The trend of observation was similar for both the year of experiment. At 30 and 90 DAS pooled data revealed that N_1W_3 produced significantly lower population of sedge weed as compared to N_2W_3. Lowest number (34.66 m^{-2}) of sedge weed was provided by N_1 at 90 DAS during 2004.

4.1.2.1.7 Effect of nitrogen application on broadleaf weed population :

At different dates (60 & 90 DAS) application of nitrogen as basal dose (N_2) significantly increases the number of broad leaf weed (Table 4.6) as compared to the treatment where basal nitrogen was skipped (N_1) as observed from the pooled data. At 30 DAS N_1 recorded lower weed population compared to N_2. Similar trend was observed for 2003 and 2004 also. Lowest number (16.28 m^{-2}) of broad leaf weed was recorded at 30 DAS during 2004 from N_1 treatment, whereas, the highest number (40.88 m^{-2}) counted during 2003 at 60 DAS from N_2 treatment.

4.1.2.1.8 Effect of weed management on broadleaf weed population :

Significantly higher weed population was recorded from unweeded control plot than rest of the treatments, at all the dates of observation (Table 4.6). This trend was followed during both the year as well as in pooled data. At 30 DAS significantly higher weed population was recorded from the treatment where quizalofop ethyl was applied as POE herbicide (W_4 or W_6) than the treatment where pendimethalin was applied as PE herbicide (W_5 or W_7), whereas, W_3 and W_4 or W_6 produced statistically at par weed population. At 60 and 90 DAS, W_5 produced significantly lower weed population than W_4, but W_6 and W_7 recorded statistically at par weed population. There was no significant difference in weed population obtained from hand weeding plot (W_3) and application of pendimethalin along with one hand weeding (W_7) at 60 and 90 DAS.

Table 4.6 Effect of treatments on broadleaf weed population (per sqm) of jute at 30, 60 & 90 DAS

Treatment	Broad Leaf Weed Population (number m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	33.15	16.28	24.71	37.78	21.96	29.87	36.82	21.71	29.28
N_2	38.44	19.89	29.16	40.88	28.02	32.45	39.56	24.54	32.05
CD(P=0.05)	-	-	-	-	5.87	2.55	2.70	2.79	2.75
Weed Management (W)									
W_1	60.66	40.50	50.58	83.16	53.70	68.43	69.33	46.53	57.93
W_2	0	0	0	0	0	0	0	0	0
W_3	27.50	11.33	19.41	31.83	20.20	26.01	25.33	18.70	22.01
W_4	47.16	25.70	36.43	49.66	32.83	41.24	58.50	39.73	49.12
W_5	31.16	12.00	21.58	35.00	16.90	27.45	45.83	27.30	36.56
W_6	49.10	25.76	37.43	39.69	22.80	29.74	38.50	19.73	29.12
W_7	35.00	11.33	23.16	36.00	11.80	23.90	30.00	9.93	19.96
CD(P=0.05)	17.00	9.50	12.62	14.20	9.30	9.76	18.31	10.70	9.15

4.1.2.1.9 Interaction effect of nitrogen application and weed management on broadleaf weed population :

Results obtained from the pooled data at different dates of observation indicated that the interaction effect of nitrogen application and weed management on broad leaf weed population was significant (Table 4.7). Significantly higher weed population were recorded from N_2W_1 treatment combination than rest of the treatment at all dates of observation. At 30 DAS, significantly lower weed population was obtained from N_1W_5 or N_1W_7 than N_1W_4 or N_2W_4 respectively but N_1W_3 and N_2W_3 recorded statistically at par population with N_1W_5 or N_1W_7 and N_2W_5 or N_2W_7 respectively. 30 and 60 days after the first observation N_1W_3 and N_2W_3 recorded significantly lower weed population than N_1W_4 and N_2W_4 but there was no significant difference between N_1W_7, N_2W_7 and N_1W_3 , N_2W_3 respectively. Significant variation in weed population was observed between N_1W_7 and N_2 W_7 at 60 DAS. Highest 84.52 broadleaf weed m^{-2} was obtained from N_2W_1 treatment combination at 60 DAS during 2003.

Table 4.7 Interaction effect of N application and weed management on broadleaf weed population (~~number/sqm~~) at 30, 60 and 90 DAS

Weed Management (W)	Broad Leaf Weed Population (number m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	51.20	70.12	32.49	48.51	41.84	59.31	79.78	86.54	51.16	56.24	65.47	71.39	67.15	71.51	43.17	49.89	55.16	60.70
W_2	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
W_3	25.68	29.32	10.25	12.41	17.96	20.86	31.24	32.42	18.51	21.89	24.87	27.15	23.79	26.87	17.28	20.12	20.53	23.49
W_4	45.08	49.24	25.15	26.25	35.11	37.74	48.10	51.22	32.66	33.00	40.38	42.11	57.88	59.12	37.64	41.82	47.76	50.47
W_5	28.91	33.41	10.90	13.10	19.90	23.25	33.55	36.45	18.67	20.53	26.11	28.49	44.72	46.94	25.91	28.69	35.31	37.81
W_6	48.08	50.12	24.54	26.98	36.31	38.55	39.15	40.23	22.02	23.58	30.58	31.90	37.08	39.92	18.98	20.48	28.03	30.20
W_7	33.13	36.87	10.66	12.00	21.89	24.43	32.67	39.33	10.71	12.89	21.69	26.11	27.42	32.58	9.04	10.82	18.23	21.70
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P
CD (P=0.05)	21.55	18.76	15.42	10.12	7.83	6.54	15.71	12.16	11.50	7.24	5.60	4.18	12.20	10.41	14.17	8.27	5.42	5.16

Table 4.9 Interaction effect of N application and weed management on grass weed biomass (g/sqm) at 30, 60 and 90 DAS

Weed Management (W)	Grass Weed Biomass (g m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	21.68	25.20	24.07	29.67	22.88	27.43	30.08	30.68	20.67	25.73	25.37	28.20	27.61	29.67	26.99	28.53	27.30	29.10
W_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_3	5.97	6.67	5.39	6.61	5.68	6.64	5.25	5.77	3.58	4.98	4.41	5.37	4.12	5.00	3.14	4.86	3.63	4.93
W_4	3.56	4.50	4.29	4.31	3.92	4.40	7.12	8.00	5.88	7.12	6.50	7.56	6.87	6.67	6.03	6.93	6.45	6.80
W_5	9.86	10.16	9.34	9.90	9.60	10.03	11.08	11.14	9.55	10.25	10.31	10.69	8.89	8.50	7.34	8.90	8.11	8.70
W_6	4.20	4.91	4.53	4.89	4.36	4.90	6.08	6.71	4.08	6.72	5.08	6.71	5.22	5.79	5.20	5.54	5.21	5.66
W_7	10.27	10.92	9.34	10.20	9.80	10.56	8.96	9.26	7.54	8.78	8.25	9.02	7.02	7.12	6.76	7.00	6.89	7.06
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	Pooled	'03	'04	Pooled	'03	'04	Pooled	'03	'04	Pooled	03	'04	Pooled	'03	'04	Pooled
CD (P=0.05)	2.11	1.96	1.75	1.06	1.00	1.02	2.54	2.12	1.99	0.61	1.07	0.81	2.66	2.07	2.14	0.80	1.01	0.89

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

Plate 1. Experimental plots of jute at 5 Days After Sowing

Plate 2. Unweeded control treatment vs. weed free treatment in jute

4.1.2.2 Weed biomass

4.1.2.2.1 Effect of nitrogen application on grass weed biomass :

Pooled data of grass weed biomass (Table 4.8) revealed that significantly higher weed biomass was produced by the treatment received basal nitrogen (N_2) than N_1, where basal nitrogen was not applied at all the dates of observation except 90 DAS. The trend was similar for 2003 and 2004 at 30 and 60 DAS except for 2003 at 60 DAS. At 90 DAS pooled data recorded higher biomass was obtained from N_1 but there was no significant difference with N_2, but the variation was significant for the year 2004. The lowest weed biomass of 7.32 g m^{-2} was recorded from N_1 treatment at 60 DAS during 2004 and highest of 10.22 g m^{-2} was produced by N_2 at 60 DAS during 2003.

Table 4.8 Effect of treatments on grass weed biomass (g/ sqm) of jute at 30,60 & 90 DAS

Treatment	Grass Weed Biomass (g m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	7.93	8.13	8.03	9.79	7.32	8.56	8.53	7.92	8.22
N_2	8.90	9.36	9.17	10.22	9.08	9.65	8.96	8.82	8.89
CD(P=0.05)	0.93	1.02	0.89	-	1.54	0.98	-	0.87	-
Weed Management (W)									
W_1	23.44	26.87	25.15	30.38	23.20	26.79	28.64	27.76	28.20
W_2	0	0	0	0	0	0	0	0	0
W_3	6.32	6.00	6.16	5.51	4.28	4.89	4.56	4.00	4.28
W_4	4.03	4.24	4.63	7.56	6.50	7.03	6.77	6.48	6.62
W_5	10.01	9.62	9.81	11.11	9.90	10.50	8.69	8.12	8.40
W_6	4.55	4.21	4.38	6.39	5.40	5.89	5.50	5.37	5.93
W_7	10.59	9.77	10.18	9.11	8.16	8.63	7.07	6.88	6.97
CD(P=0.05)	3.01	2.20	1.98	2.17	1.89	1.76	2.11	2.28	1.75

4.1.2.2.2 Effect of weed management on grass weed biomass :

Unweeded control plot (W_1) recorded significantly higher weed biomass (Table 4.8) than rest of the treatment during both the year of experiment as well as in pooled data. At 30 DAS, application of quizalofop ethyl (W_4 and W_6) produced lower weed biomass than hand weeding treatment (W_3). At all the dates of observation significant variation in weed biomass were observed between the treatments received only quizalofop ethyl (W_4) and pendimethalin (W_5). Similar trend was found during both the year. At 60 and 90 DAS treatment received POE application of quizalofop ethyl along with one hand weeding (W_6) recorded statistically at par weed biomass with the treatment received twice hand weeding (W_3). During 2003 at 60 DAS, W_1 recorded highest grass weed biomass (30.38 g m^{-2}).

4.1.2.2.3 Interaction effect of nitrogen application and weed management on grass weed biomass :

Interaction effect of nitrogen application and weed management on biomass of grass weed was significant as observed from the pooled data (Table 4.9). N_2W_1 treatment combination recorded significantly higher grass weed biomass than rest of the treatment combinations at all the dates of observation. At 30 DAS, N_1W_4 recorded significantly lower weed biomass than N_1W_3. 30 days after the first observation showed that treatment combination N_1W_3 and N_2W_3; N_1W_4 and N_2W_4; N_1W_6 and N_2W_6 recorded statistically at par weed biomass. At 90 DAS there was no significant difference in weed biomass obtained from N_1W_3 and N_1W_6; N_2W_3 and N_2W_6. Whereas, significantly lower weed biomass was produced by N_1W_3 than N_2W_3. The highest grass weed biomass of 30.68 g m^{-2} was recorded from N_2W_1 treatment combination at 60 DAS during 2003.

4.1.2.2.4 Effect of nitrogen application on sedge weed biomass :

It is clear from the pooled data (Table 4.10) that at all the dates of observation the treatment which did not received basal nitrogen (N_1) recorded lower weed biomass as compared to the treatment where basal nitrogen was applied. Similar trend was observed during both the year of experiment. Lowest biomass of 12.82 g m^{-2} was obtained at 30 DAS from N_1 during 2004, whereas, the highest (18.54 g m^{-2}) was recorded from N_2 at 60 DAS during 2003.

4.1.2.2.5 Effect of weed management on sedge weed biomass :

Effect of weed management on sedge weeds biomass was significant at different dates of observation as obtained from the pooled data (Table 4.10). Significantly higher weed biomass were recorded from the unweeded control plot at all the dates of observation. Similar trend was observed during both the year of experiment. At 30 DAS, hand weeding (W_3) recorded lower weed biomass than application of POE herbicide quizalofop ethyl (W_4 & W_6) but there was no significant difference between these treatments. At 60 and 90 DAS pooled data showed that hand weeding twice (W_3) produced significantly lower weed biomass than the treatments received quizalofop ethyl or pendimethalin alone but there was no significant difference between W_3 and W_6 (quizalofop ethyl along with one hand weeding). During 2003 at 60 DAS unweeded control plot recorded maximum weed biomass (40.13 g m^{-2}).

Table 4.10 Effect of treatments on sedge weed biomass (g/ sqm) of jute at 30,60 & 90 DAS

Treatment	Sedge Weed Biomass (g m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	14.60	12.82	13.71	18.46	14.89	16.72	16.25	13.90	15.07
N_2	15.15	13.83	14.49	18.54	16.43	17.44	16.67	14.98	15.82
Weed Management (W)									
W_1	29.38	26.85	28.12	40.13	32.10	36.12	37.69	32.21	34.95
W_2	0	0	0	0	0	0	0	0	0
W_3	9.49	9.11	9.30	11.51	9.20	10.35	9.75	8.23	8.99
W_4	12.17	11.62	11.89	16.13	15.96	16.04	15.01	12.98	13.99
W_5	20.66	19.55	20.10	27.37	22.76	25.06	20.69	18.00	19.35
W_6	12.11	11.50	11.80	12.18	10.98	11.58	11.27	10.93	11.10
W_7	20.29	14.70	17.49	22.20	18.66	20.43	20.80	19.20	20.00
CD(P=0.05)	5.00	3.10	3.95	4.50	5.70	4.10	3.65	4.58	3.82

Table 4.12 Effect of treatments on broadleaf weed biomass (g/ sqm) of jute at 30,60 & 90 DAS

Treatment	Broad Leaf Weed Biomass (g m^{-2})								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	15.85	10.13	12.99	23.22	14.66	18.94	17.88	13.10	15.49
N_2	18.58	11.76	15.16	25.16	15.78	20.47	19.33	14.86	17.09
Weed Management (W)									
W_1	34.28	20.64	27.46	44.40	37.96	41.18	36.29	29.41	32.85
W_2	0	0	0	0	0	0	0	0	0
W_3	10.40	7.56	8.98	16.90	11.78	14.34	9.76	8.48	9.12
W_4	21.69	11.83	16.76	32.29	23.81	28.05	36.24	25.50	30.87
W_5	15.12	10.82	12.97	24.95	12.59	18.77	19.44	16.08	17.76
W_6	22.84	13.74	18.29	30.58	10.46	20.52	15.61	10.27	12.94
W_7	16.22	12.08	14.15	20.26	9.94	15.10	12.92	8.14	10.53
CD(P=0.05)	6.34	4.67	3.77	5.68	4.66	4.17	3.74	3.75	3.47

4.1.2.2.6 Interaction effect of nitrogen application and weed management on sedge weed biomass :

Effect of interaction of nitrogen application and weed management on biomass of sedge weed was significant as observed from the pooled data (Table 4.11). N_2W_1 treatment combination recorded significantly higher sedge weed biomass than rest of the treatment combination as found from the pooled data at all the dates of observation. At 30 DAS, weed biomass obtained from N_1W_3 and N_2W_3 were statistically at par with N_1W_6, N_1W_4 and N_2W_6, N_2W_4 respectively. However, at 60 and 90 DAS N_1W_3 and N_2W_3 produced significantly lower weed biomass than N_1W_4 and N_2W_4 respectively, but there was no significant difference between N_1W_3 and N_1W_6. Significantly lower weed biomass was obtained from N_1W_3 (8.17 g m^{-2}) than N_2W_3 (9.80 g m^{-2}) at 90 DAS.

4.1.2.2.7 Effect of nitrogen application on broadleaf weed biomass :

Comparatively lower weed biomass were obtained from the treatment N_1 where basal nitrogen was skipped as compared to N_2 which received basal nitrogen, as clearly observed from the pooled data (Table 4.12). During 2003 and 2004 similar trend of observation was recorded. But there was no significant difference between the main plot treatment N_1 and N_2. The lowest weed biomass (10.13 m^{-2}) was obtained from N_1 at 30 DAS during 2004 and highest (25.16 m^{-2}) was produced by N_2 during 2003 at 60 DAS.

4.1.2.2.8 Effect of weed management on broadleaf weed biomass :

Pooled data (Table 4.12) obtained from the two years experiment data revealed that significantly higher broadleaf weed biomass were recorded by the unweeded control treatment W_1 at 30, 60 and 90 DAS. Application of pendimethalin as PE herbicide alone (W_5) recorded significantly lower weed biomass than the treatment where quizalofop ethyl was applied as POE herbicide (W_4) at all the dates of observation. At 60 and 90 DAS, treatment received application of pendimethalin along with one hand weeding (W_7) recorded statistically at par weed biomass with hand weeding twice W_3 treatment. The trend was similar for 2003 and 2004 also.

4.1.2.2.9 Interaction effect of nitrogen application and weed management on broadleaf weed biomass :

Significantly higher weed biomass were recorded by the treatment combination N_2W_1 than all other treatment combination as observed from the pooled data (Table 4.13). At 30 DAS, N_1W_3 produced significantly lower weed biomass than N_1W_4 but there was statistically at par weed biomass between N_1W_3 and N_1W_5. At 60 and 90 DAS, weed biomass obtained from N_1W_3 and N_1W_7 were statistically at par. The trend was similar for N_2W_3 and N_2W_7 also. Statistically different weed biomass was produced by N_1W_1 and N_2W_1 at all the dates of observation. At 90 DAS N_1W_7 treatments combination recorded statistically lower weed biomass (9.40 m^{-2}) than N_2W_7 (11.66 m^{-2}).

Table 4.11 Interaction effect of N application and weed management on sedge weed biomass (g/sqm) at 30, 60 and 90 DAS

Weed Management (W)	Sedge Weed Biomass (g m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	28.60	30.17	25.84	27.86	27.22	29.01	39.08	41.19	31.75	32.45	35.41	36.82	36.27	39.12	31.22	33.20	33.74	36.16
W_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_3	9.30	9.67	8.25	9.97	8.77	9.82	11.04	11.98	8.90	9.50	9.97	10.74	9.25	10.24	7.10	9.36	8.17	9.80
W_4	11.67	12.68	11.24	12.00	11.45	12.34	16.37	15.90	15.00	16.92	15.68	16.41	14.66	15.36	12.72	13.24	13.69	14.30
W_5	20.71	20.61	19.10	20.00	19.90	20.31	27.40	27.34	20.98	24.54	24.47	25.66	21.14	20.24	17.15	18.85	19.14	19.54
W_6	11.95	12.28	11.06	11.94	11.50	12.11	12.96	11.40	9.90	12.06	11.43	11.73	11.76	10.79	10.71	11.15	11.23	10.97
W_7	19.96	20.62	14.30	15.10	17.13	17.86	22.41	22.00	17.75	19.57	20.08	20.78	20.67	20.93	18.40	20.00	19.53	20.46
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	03	'04	P	'03	'04	P
CD (P=0.05)	7.19	6.11	5.65	1.56	1.70	1.12	5.30	4.58	4.06	2.07	1.20	1.11	5.10	3.78	4.14	2.15	1.70	1.53

Table 4.13 Interaction effect of N application and weed management on broadleaf weed biomass (g/sqm) at 30, 60 and 90 DAS

Weed Management (W)	Broad Leaf Weed Biomass (g m^{-2})																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	30.40	38.16	17.41	23.87	23.90	31.01	42.55	46.25	37.33	38.59	39.94	42.42	34.73	37.85	27.58	31.24	31.15	34.54
W_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W_3	9.22	11.58	7.16	7.96	8.19	9.77	16.28	17.52	11.21	12.35	13.74	14.93	9.30	10.22	7.84	9.12	8.57	9.67
W_4	20.86	22.52	11.66	12.00	16.26	17.2	31.41	33.17	22.98	24.64	27.19	28.90	35.49	36.99	24.70	26.30	30.09	31.64
W_5	13.14	17.10	10.44	11.20	11.79	14.15	24.03	25.87	11.20	13.98	17.61	19.92	18.93	19.95	14.30	17.86	16.61	18.90
W_6	21.95	23.73	13.24	14.24	17.59	18.98	30.19	30.97	10.10	10.82	20.14	20.89	15.22	16.00	10.00	10.54	12.61	13.27
W_7	15.44	17.00	11.06	13.10	13.25	15.05	18.14	22.38	9.80	10.08	13.97	16.23	11.52	14.32	7.28	9.00	9.40	11.66
	N X W			W X N			N X W			W X N			N X W			W X N		
Interaction	'03	'04	P	'03	'04	P	'03	'04	Pooled	'03	'04	P	03	'04	P	'03	'04	P
CD (P=0.05)	10.90	10.21	8.02	6.27	5.62	6.44	12.00	10.94	10.87	3.20	2.89	2.40	10.88	6.04	7.20	3.11	2.76	2.63

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.3 Weed Control Efficiency

4.1.3.1 Effect of nitrogen application on Weed Control Efficiency (WCE)

Table 4.14 showed higher weed control efficiency (pooled data) in the treatment where basal nitrogen was not applied (N_1) as compared to the treatment received basal nitrogen (N_2), at all the dates of observation. Data of both years also revealed the similar trend of variation. Highest WCE of 76.43 % was recorded from the treatment N_1 at 60 DAS during 2004, whereas, lowest was provided by N_2 at 30 DAS (61.10 %) during 2003.

4.1.3.2 Effect of weed management on Weed Control Efficiency (WCE)

Weed free treatment (W_3) recorded the maximum weed control efficiency of 100 % at all the dates of observation. It was closely followed by the hand weeding treatment W_3 (91.69 and 86.68 % respectively) at 60 and 90 DAS. W_6 i.e. application of quizalofop ethyl as POE herbicide along with one hand weeding produced WCE next to hand weeding treatment at 60 and 90 DAS (Table 4.14). At 30 DAS application of POE herbicide alone (W_4), recorded WCE next to the treatment received only one hand weeding (W_3). Minimum weed control efficiency was recorded from the treatment where only pendimethalin was applied as PE herbicide (W_5). Similar type of variation in WCE was also observed during both the year of experiment (Table 4.14).

Table 4.14 Effect of treatments on Weed Control Efficiency at 30, 60 and 90 DAS

Treatment	WCE (%)								
	30 DAS			60 DAS			90 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	63.51	65.80	64.66	72.47	76.43	74.45	71.45	73.59	72.52
N_2	61.10	64.15	62.62	70.49	74.82	72.65	70.57	71.81	71.19
Weed Management (W)									
W_1	-	-	-	-	-	-	-	-	-
W_2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
W_3	69.90	69.67	69.78	90.48	92.91	91.69	86.54	86.82	86.68
W_4	56.49	62.76	59.62	51.28	50.38	50.83	52.42	52.78	52.60
W_5	47.42	46.22	46.82	44.80	48.70	46.75	43.46	49.63	46.54
W_6	54.13	60.39	57.26	77.22	91.22	84.22	73.44	75.27	84.35
W_7	45.92	50.84	48.38	65.12	70.58	67.85	70.25	71.71	70.98

Table 4.15 Interaction effect of N application and weed management on Weed control Efficiency (WCE) at 30, 60 and 90 DAS

Weed Management (W)	Weed control Efficiency (%)																	
	30 DAS						60 DAS						90 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W_2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
W_3	70.57	69.23	71.45	67.89	71.01	68.56	91.86	89.10	94.53	91.29	93.19	90.19	87.44	85.64	87.84	85.80	87.64	85.72
W_4	58.61	54.37	63.82	61.70	61.21	58.03	52.60	49.96	51.37	49.39	51.98	49.67	52.74	52.10	53.46	52.10	53.10	52.10
W_5	48.90	45.94	47.16	45.28	48.03	45.61	45.03	44.57	49.82	47.58	47.42	46.07	43.94	42.98	50.98	48.28	47.46	45.63
W_6	54.74	53.52	60.84	59.94	57.79	56.73	79.20	75.24	91.98	90.46	85.59	82.85	74.02	72.86	76.36	74.18	75.19	73.52
W_7	48.27	43.57	51.58	50.10	49.92	46.83	66.15	64.09	70.92	70.24	68.53	67.16	70.61	69.89	72.91	70.51	71.76	70.20

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.3.3 Interaction effect of nitrogen application and weed management on Weed Control Efficiency (WCE) :

From the table 4.15 it was very clear that both N_1W_2 and N_2W_2 recorded 100 % efficiency in controlling the weeds at each date of observation. These two were closely followed by N_1W_3 and N_2W_3 (93.19 and 90.19 % respectively) at 60 DAS. At all the dates of observation N_1W_3 recorded higher WCE than N_2W_3. Interaction of W_4 and W_6 with N_1 and N_2 recorded more or less similar WCE (56.73 to 61.23 %) at 30 DAS. At 60 and 90 DAS, N_1W_6 and N_2W_6 produced WCE next to N_1W_3 and N_2W_3 respectively. At all the dates of observation lower efficacy for controlling weeds were observed from N_1W_5 and N_2W_5 treatment combination. During 2003 and 2004 similar trend of variation was noticed.

4.1.4 Growth attributes of jute

4.1.4.1 Plant height

4.1.4.1.1 Effect of nitrogen application on plant height

At 25, 50, 75 & 100 DAS, without basal nitrogen application treatment (N_1) recorded higher plant height than the treatment received basal nitrogen (N_2). The trend was similar during both the year of experiment, as well as in pooled data. At 100 DAS, highest plant height (286.98 cm) was obtained from N_1 treatment during 2004.

4.1.4.1.2 Effect of weed management on plant height :

Pooled data (Table 4.16 a & b) showed that at all dates of observation, the unweeded control treatment (W_1) recorded the minimum height (18.21, 95.42, 146.32, 175.14 cm respectively), whereas the maximum was provided by W_2, the weed free treatment (31.43, 132.70, 250.28, 326.76 cm respectively). Plant heights recorded from W_2 treatment were significantly higher than all other treatments at all dates of observation. W_2 was followed by W_3, the hand weeded treatment at 25 DAS but there was significant difference. At all other dates of observation W_2 was closely followed by W_6, the treatment received one POE herbicide along with one hand weeding at 35 DAS and there was no significant difference between these two treatments. At 75 and 100 DAS, W_7 (PE herbicide application along with one hand weeding) also recorded plant height closely followed by W_6. The trend was similar in both the years.

Table 4.16 (a) Effect of treatments on plant height (cm) of jute at 25 & 50 DAS

Treatment	Plant height					
	25 DAS			50 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	19.94	20.45	20.20	112.23	113.28	112.76
N_2	19.65	20.37	20.01	110.46	112.21	111.34
Weed Management (W)						
W_1	18.60	17.82	18.21	94.63	96.21	95.42
W_2	30.85	32.00	31.43	132.16	133.24	132.70
W_3	23.21	25.12	24.17	118.21	118.97	118.59
W_4	18.81	19.07	18.94	104.56	105.72	105.14
W_5	13.68	14.20	13.94	100.76	102.87	101.82
W_6	19.13	19.99	19.56	121.73	122.47	122.10
W_7	14.27	15.11	14.69	107.39	109.21	108.30
CD(P=0.05)	3.19	3.32	2.47	7.76	6.87	5.82

Table 4.16 (b) Effect of treatments on plant height (cm) of jute at 75 & 100 DAS

Treatment	Plant height					
	75 DAS			100 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	212.16	215.40	213.78	286.88	287.70	287.29
N_2	211.02	213.99	212.50	285.61	286.92	286.265
Weed Management (W)						
W_1	147.18	145.46	146.32	173.73	176.55	175.14
W_2	245.46	255.10	250.28	327.65	325.88	326.76
W_3	227.31	232.41	229.86	312.05	316.24	314.14
W_4	208.63	210.95	209.79	279.25	277.45	278.35
W_5	202.55	203.60	203.07	278.66	277.21	277.94
W_6	231.60	234.45	233.03	314.58	321.46	318.02
W_7	218.40	220.86	219.63	310.80	316.40	313.60
CD(P=0.05)	16.15	17.92	12.93	12.58	14.00	10.79

4.1.4.1.3 Interaction effect of nitrogen application and weed management on plant height:

According to table 4.17 a and b the interaction effect of nitrogen application and weed management on plant height of jute was significant. N_2W_1 showed the minimum plant height (94.92, 145.69, 174.25 at 50, 75 & 100 DAS, respectively) at all dates of observation except 25 DAS. Maximum plant height of jute was recorded from N_1W_2 treatment combination at all dates of observation except 25 DAS. At 25 DAS, N_2W_2 and N_2W_5 recorded the highest and lowest plant height respectively. At all dates of observation, except 25 DAS, N_1W_6 and N_1W_3 recorded statistically at par plant height. The similar trend was followed by the treatment combinations N_2W_6 and N_2W_3. Pooled data of observation at 100 DAS revealed that N_1W_6 recorded statistically higher plant height than N_2W_6.

Table 4.17 (a) Interaction effect of N application and weed management on plant height (cm) of jute at 25 & 50 DAS

Weed Management (W)	Plant height											
	25 DAS						50 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	18.70	18.50	17.87	17.00	18.28	17.75	95.20	94.06	96.28	96.24	95.74	94.92
W_2	30.66	31.03	31.49	32.51	31.08	31.77	135.96	128.36	133.37	133.11	134.67	131.51
W_3	24.46	21.96	25.14	25.10	24.82	23.53	117.36	119.06	120.07	118.87	118.72	118.89
W_4	18.46	19.16	19.16	18.98	18.81	19.07	103.76	105.36	106.23	105.21	104.99	105.17
W_5	13.60	13.71	14.31	14.09	13.95	13.9	100.43	101.10	103.87	101.87	102.15	101.62
W_6	19.66	18.60	20.11	19.87	19.89	19.25	124.36	119.10	122.94	122.00	123.65	121.38
W_7	13.99	14.56	15.12	15.10	14.55	14.83	108.57	106.20	110.20	108.22	109.40	107.81
	N X W			W X N			N X W			W X N		
Interaction	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
CD (P=0.05)	5.21	4.80	4.41	1.21	1.01	0.60	12.74	11.43	10.24	4.33	3.14	3.02

Table 4.17 (b) Interaction effect of N application and weed management on plant height (cm) of jute at 75 and 100 DAS

Weed Management (W)	Plant height											
	75 DAS						100 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	147.30	147.06	146.59	144.33	146.94	145.69	174.56	172.90	177.50	175.60	176.03	174.25
W_2	243.63	247.30	255.65	254.65	249.64	250.97	327.86	327.43	326.45	325.31	327.15	326.37
W_3	229.53	225.10	230.52	234.30	230.02	229.72	312.63	311.46	317.50	314.98	315.07	313.22
W_4	212.03	205.23	211.25	210.65	211.64	207.94	279.23	279.26	276.25	278.65	277.74	278.95
W_5	202.26	202.83	205.00	202.20	203.63	202.51	279.50	277.83	277.82	276.60	278.66	277.22
W_6	233.00	230.20	236.36	232.54	234.68	231.37	317.50	311.66	320.86	322.06	319.18	316.86
W_7	217.36	219.43	222.45	219.27	219.91	219.35	309.86	311.73	317.52	315.28	313.69	313.51
	N X W			W X N			N X W			W X N		
Interaction	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
CD (P=0.05)	14.00	19.17	15.58	6.10	4.00	5.17	15.20	12.24	12.11	5.10	4.22	2.30

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.4.2 Basal diameter of jute

4.1.4.2.1 Effect of nitrogen application on basal diameter :

Pooled data (Table- 4.18 a & b) showed that at all dates of observation N_1 recorded higher basal diameter than N_2 treatment. The highest basal diameter 1.478 cm was obtained at 100 DAS during 2004 from the treatment which did not received basal nitrogen (N_1). But, there was no significant difference between N_1 and N_2 at all dates of observation.

Table 4.18 (a) Effect of treatments on basal diameter (cm) of jute at 25 & 50 DAS

Treatment	Basal diameter					
	25 DAS			50 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	0.335	0.345	0.345	0.595	0.577	0.586
N_2	0.337	0.336	0.336	0.570	0.593	0.581
Weed Management (W)						
W_1	0.303	0.308	0.305	0.505	0.511	0.508
W_2	0.390	0.388	0.389	0.693	0.688	0.690
W_3	0.356	0.361	0.358	0.616	0.624	0.620
W_4	0.341	0.355	0.348	0.553	0.529	0.541
W_5	0.296	0.300	0.298	0.545	0.563	0.554
W_6	0.350	0.381	0.365	0.591	0.600	0.596
W_7	0.316	0.310	0.313	0.575	0.581	0.578
CD(P=0.05)	0.048	0.050	0.037	0.045	0.041	0.033

Table 4.18 (b) Effect of treatments on basal diameter (cm) of jute at 75 & 100 DAS

Treatment	Basal diameter					
	75 DAS			100 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	1.031	1.088	1.059	1.400	1.478	1.439
N_2	1.045	1.067	1.056	1.408	1.467	1.437
Weed Management (W)						
W_1	0.963	1.001	0.982	1.005	0.995	1.000
W_2	1.231	1.312	1.272	1.605	1.750	1.677
W_3	1.066	1.100	1.083	1.498	1.620	1.559
W_4	1.003	1.005	1.004	1.378	1.421	1.399
W_5	0.948	1.000	0.974	1.370	1.289	1.329
W_6	1.083	1.125	1.104	1.501	1.582	1.541
W_7	0.973	1.002	0.988	1.471	1.610	1.540
CD(P=0.05)	0.080	0.118	0.079	0.096	0.081	0.054

4.1.4.2.2 Effect of weed management on basal diameter :

At 25, 50, 75 and 100 DAS, maximum basal diameter (0.389, 0.690, 1.272 and 1.677 cm respectively) were recorded from weed free treatment (W_2), which was statistically higher than all other treatment (Table 18 a and b). W_1 i.e. unweeded control plot showed the minimum value at all dates of observation. Hand weeding twice at 15 and 35 DAS (W_3) recorded basal diameter followed by weed free treatment (W_2) at all dates of observation. Pooled data recorded at 100 DAS showed statistically at par value of W_6 and W_3 treatments (1.541 and 1.559 cm respectively). Similar trend was noticed during both the year of experiment. There was significant difference in values (pooled data) obtained from W_4 and W_6 treatment at all dates of observation except at 25 DAS.

4.1.4.2.3 Interaction effect of nitrogen application and weed management on basal diameter :

Pooled data (Table 4.19 a and b) showed that interaction effect of nitrogen application and weed management on basal diameter of jute was significant. Minimum basal diameters (0.507, 0.962 and 0.995 cm respectively) were recorded from N_2W_1 treatment combinations at 50, 75 and 100 DAS. At 100 DAS N_1W_2 treatments combination showed highest value (1.740 cm), which was significantly higher than N_2W_2 and all other treatment combinations (pooled data). Value obtained from N_1W_2 was followed by N_1W_6. Statistically at par basal diameter were obtained from N_1W_3 and N_1W_7 at 100 DAS. N_1W_6 recorded statistically higher basal diameter than N_2W_7 (1.560 and 1.523 cm respectively) at 100 DAS. At 25 DAS N_1W_5 produced more basal diameter (0.302 cm) than N_2W_5 (0.295 cm), which was statistically higher.

4.1.4.3 Leaf Area Index (LAI)

4.1.4.3.1 Effect of nitrogen application on LAI :

At 25 DAS pooled data (Table 4.20 a and b) of LAI revealed that without basal nitrogen application treatment (N_1) recorded statistically higher value than N_2 (with basal nitrogen application). The trend was also similar for the year 2003. At all other dates of observation (Table 19 a & b) N_1 produced higher LAI than N_2. At 100 DAS maximum LAI (6.828) was recorded from N_1 treatment during 2004 and minimum (1.060) obtained from N_2 treatment at 25 DAS during 2004.

Table 4.19 (a) Interaction effect of N application and weed management on basal diameter (cm) of jute at 25 and 50 DAS

Weed Management (W)	Basal diameter											
	25 DAS						50 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	0.300	0.306	0.306	0.310	0.303	0.308	0.506	0.503	0.510	0.512	0.508	0.507
W_2	0.386	0.393	0.391	0.385	0.389	0.389	0.713	0.673	0.658	0.718	0.685	0.695
W_3	0.373	0.340	0.362	0.360	0.367	0.352	0.623	0.610	0.620	0.628	0.621	0.619
W_4	0.330	0.353	0.360	0.350	0.345	0.352	0.566	0.540	0.512	0.546	0.539	0.543
W_5	0.293	0.300	0.311	0.289	0.302	0.295	0.573	0.516	0.574	0.552	0.573	0.534
W_6	0.353	0.346	0.375	0.387	0.364	0.366	0.593	0.590	0.591	0.609	0.592	0.599
W_7	0.313	0.320	0.316	0.304	0.315	0.312	0.590	0.560	0.574	0.588	0.582	0.574
Interaction CD (P=0.05)	N X W			W X N			N X W			W X N		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
	0.084	0.086	0.080	0.027	0.022	0.021	0.090	0.081	0.075	0.022	0.017	0.010

Table 4.19 (b) Interaction effect of N application and weed management on basal diameter (cm) of jute at 75 and 100 DAS

Weed Management (W)	Basal diameter											
	75 DAS						100 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	0.953	0.973	1.051	0.951	1.002	0.962	1.010	1.000	0.980	1.010	1.000	0.995
W_2	1.230	1.233	1.300	1.324	1.265	1.278	1.606	1.603	1.622	1.878	1.740	1.614
W_3	1.096	1.036	0.995	1.205	1.045	1.121	1.486	1.510	1.710	1.530	1.520	1.598
W_4	0.983	1.026	1.100	0.910	1.042	0.968	1.366	1.390	1.520	1.322	1.356	1.443
W_5	0.936	0.960	1.050	0.950	0.983	0.965	1.390	1.350	1.310	1.268	1.309	1.350
W_6	1.050	1.116	1.120	1.130	1.085	1.123	1.496	1.506	1.550	1.614	1.560	1.523
W_7	0.973	0.973	1.000	1.004	0.986	0.988	1.500	1.443	1.580	1.640	1.542	1.540
Interaction CD (P=0.05)	N X W			W X N			N X W			W X N		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
	0.114	0.117	0.108	0.051	0.040	0.035	0.096	0.081	0.080	0.023	0.042	0.030

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.4.3.2 Effect of weed management on LAI :

From the pooled data (Table 4.20 a & b) it is clear that at all dates of observation W_2 i.e. weed free treatment produced maximum LAI (1.386, 3.505, 7.610, 8.350 respectively) than all other treatment and it was statistically higher then rest of the treatment. On the other hand unweeded control plot (W_1) recorded minimum value (1.268, 4.118 and 5.193, respectively) at all dates of observation except 25 DAS. The trend was similar in both the year of experiment. At 100 DAS, LAI obtained from W_6 (6.940) was statistically higher than W_4 and W_5 . LAI obtained at 25 DAS revealed that application of one POE herbicide at 15 DAS (W_4) produced statistically higher value than application of one PE herbicide at 1 DAS (W_5). At all the dates of observation LAI obtained from W_2 were followed by W_3 (hand weeding).

Table 4.20 (a) Effect of treatments on LAI of jute at 25 & 50 DAS

Treatment	LAI of jute					
	25 DAS			50 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	1.607	1.138	1.372	2.201	2.268	2.234
N_2	1.078	1.060	1.069	2.128	2.201	2.164
CD(P=0.05)	0.424	0.102	0.217	-	-	-
Weed Management (W)						
W_1	0.950	1.000	0.975	1.237	1.300	1.268
W_2	1.322	1.450	1.386	3.386	3.624	3.505
W_3	1.191	1.210	1.200	2.823	2.920	2.871
W_4	1.056	1.100	1.078	2.006	2.050	2.028
W_5	0.982	0.955	0.968	1.700	1.800	1.750
W_6	1.028	1.100	1.064	2.078	2.100	2.089
W_7	0.979	0.910	0.944	1.921	1.852	1.886
CD(P=0.05)	0.101	0.092	0.086	0.680	0.700	0.540

Table 4.20 (b) Effect of treatments on LAI of jute at 75 & 100 DAS

Treatment	LAI of jute					
	75 DAS			100 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	5.776	5.701	5.738	6.714	6.828	6.771
N_2	5.538	5.444	5.491	6.541	6.698	6.619
Weed Management (W)						
W_1	4.354	3.882	4.118	5.162	5.224	5.193
W_2	7.709	7.511	7.610	8.201	8.500	8.350
W_3	6.703	6.810	6.756	7.804	7.874	7.839
W_4	5.098	5.124	5.111	5.930	6.120	6.025
W_5	5.127	4.985	5.087	5.888	5.775	5.831
W_6	5.419	5.400	5.409	6.881	7.000	6.940
W_7	5.189	5.300	5.214	6.527	6.850	6.689
CD(P=0.05)	0.910	0.820	0.590	0.840	0.770	0.610

4.1.4.3.3 Interaction effect of nitrogen application and weed management on LAI :

Interaction effect of nitrogen application and weed management on LAI was significant as observed from the pooled data (Table 4.21 a & b). At all dates of observation N_1W_2 recorded the maximum basal diameter (1.454, 3.567, 7.803 and 8.356 respectively) followed by N_2W_2. LAI obtained from N_1W_3 and N_2W_3 were statistically at par with N_1W_2 and N_2W_2 respectively at 100 DAS whereas, N_1W_6 recorded statistically higher LAI than N_2W_6 treatment combination. N_1W_6 and N_2W_6 produced LAI statistically at par with N_1W_3 and N_2W_3 treatment combinations at 100 DAS. At 25 DAS, lowest LAI was produced by N_1W_7 treatment combination which received one PE herbicide application and it was significantly lower than N_1W_2 and N_1W_3. But at all other days of observation, minimum LAI was provided by N_1W_1, except at 100 DAS where N_2W_1 recorded the minimum value.

4.1.4.4 Total dry weight

4.1.4.4.1 Effect of nitrogen application on total dry weight :

Total dry weight of jute recorded at different dates of observation (Table 4.22 a & b) revealed that maximum values (7.010, 10.865, 12.106 and 13.553 t ha^{-1} respectively) were provided by the treatment N_1 (without basal nitrogen) and minimum values (6.935, 10.483, 11.714 and 13.078 t ha^{-1} respectively) obtained from the treatment received basal nitrogen (N_2). At 25 and 50 DAS N_1 and N_2 produced statistically at par values, whereas, at 75 and 100 DAS the values vary significantly. The trend was similar for both the year of experiment as well as for pooled data also. The highest total dry weight 13.794 t ha^{-1} was recorded from N_1 treatment at 100 DAS during 2004.

4.1.4.4.2 Effect of weed management on total dry weight :

Pooled data obtained from two years of experiment at different dates of observation showed (Table 4.22 a & b) that maximum dry weight were provided by the treatment W_2 at all dates of observation followed by W_3. Minimum values were obtained from unweeded control (W_1) plots at all 50, 75 & 100 DAS. At 25 DAS the lowest dry weight was recorded from the treatment received one PE herbicide application (W_5). The trend was similar for both the year of experiment at all dates of observation. During 2004, W_2 recorded the highest total dry weight of 16.00 t ha^{-1}. At all dates of observation W_2 produced significantly higher dry weight than rest of the treatment except at 25 DAS (during 2003). At 50, 75 and

Table 4.21 (a) Interaction effect of N application and weed management on LAI of jute at 25 and 50 DAS

Weed Management (W)	LAI of jute											
	25 DAS						50 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	0.946	0.954	1.050	0.950	0.998	0.952	1.122	1.353	1.366	1.234	1.244	1.293
W_2	1.319	1.325	1.590	1.310	1.455	1.317	3.410	3.363	3.725	3.523	3.567	3.443
W_3	1.177	1.206	1.300	1.120	1.238	1.163	2.907	2.738	3.000	2.840	2.953	2.789
W_4	1.055	1.056	0.980	1.220	1.017	1.138	2.066	1.947	2.200	1.900	2.133	1.923
W_5	0.991	0.974	1.000	0.910	0.995	0.942	1.623	1.777	1.740	1.860	1.681	1.818
W_6	1.034	1.023	1.150	1.050	1.092	1.036	2.086	2.070	2.050	2.150	2.068	2.100
W_7	0.950	1.008	0.900	0.920	0.925	0.964	2.196	1.646	1.800	1.904	1.998	1.775
Interaction	N X W			W X N			N X W			W X N		
CD (P=0.05)	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
	0.110	0.172	0.126	0.028	0.021	0.023	0.76	0.61	0.63	0.27	0.30	0.25

Table 4.21 (b) Interaction effect of N application and weed management on LAI of jute at 75 and 100 DAS

Weed Management (W)	LAI of jute											
	75 DAS						100 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	4.205	4.503	3.954	3.810	4.079	4.156	5.246	5.079	5.106	5.342	5.210	5.176
W_2	7.775	7.642	7.832	7.190	7.803	7.416	8.290	8.112	8.400	8.600	8.356	8.345
W_3	6.930	6.476	6.852	6.768	6.891	6.622	7.633	7.975	7.827	7.921	7.948	7.730
W_4	5.262	4.934	5.320	4.928	5.291	4.931	5.837	6.023	6.050	6.190	6.106	5.943
W_5	5.301	4.952	5.000	4.970	5.165	5.010	5.800	5.976	5.895	5.655	5.815	5.847
W_6	5.629	5.210	5.534	5.266	5.581	5.238	6.883	6.879	6.790	7.210	7.044	6.836
W_7	5.330	5.049	5.421	5.179	5.361	5.065	6.102	6.952	6.820	6.880	6.916	6.461
Interaction	N X W			W X N			N X W			W X N		
CD (P=0.05)	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
	1.12	1.08	0.90	0.32	0.44	0.35	1.56	1.70	1.42	030	0.21	0.20

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethyl 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

100 DAS, W_6 treatment which received one POE herbicide at 15 DAS along with one hand weeding at 35 DAS recorded dry weight next to hand weeding twice (W_3) and there was no significant difference between the treatments. During both the year of experiment as well as in pooled data similar trend was observed. At 25 DAS significantly higher plant dry weight (7.378 t ha^{-1}) was recorded from W_4 treatment than W_5 (4.42 t ha^{-1}). At 100 DAS, W_7 recorded significantly lower value (12.949 t ha^{-1}) than W_6 treatment (13.865 t ha^{-1}).

Table 4.22 (a) Effect of treatments on total dry weight (t/ha) of jute at 25 & 50 DAS

Treatment	Total dry weight of jute					
	25 DAS			50 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	6.845	7.173	7.010	10.190	11.54	10.865
N_2	6.826	7.044	6.935	9.877	11.00	10.438
Weed Management (W)						
W_1	5.875	6.120	5.997	8.055	8.874	8.464
W_2	9.055	9.950	9.502	12.861	14.000	13.431
W_3	8.636	8.674	8.655	11.025	12.985	12.00
W_4	7.225	7.531	7.378	9.831	10.927	10.380
W_5	4.583	4.642	4.613	8.636	9.100	8.868
W_6	7.033	7.352	7.192	10.776	12.423	11.599
W_7	5.443	5.490	5.467	9.053	10.620	9.837
CD(P=0.05)	0.85	0.83	0.72	0.90	1.02	0.94

Table 4.22 (b) Effect of treatments on total dry weight (t/ha) of jute at 75 & 100 DAS

Treatment	Total dry weight of jute					
	75 DAS			100 DAS		
	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)						
N_1	11.845	12.368	12.106	13.313	13.794	13.553
N_2	11.712	11.716	11.714	12.915	13.241	13.078
CD(P=0.05)	0.791	1.022	0.371	1.114	0.550	0.455
Weed Management (W)						
W_1	9.723	10.241	9.982	10.185	10.630	10.407
W_2	14.276	14.553	14.414	15.663	16.000	15.831
W_3	12.970	12.487	12.728	14.223	14.762	14.493
W_4	11.266	11.673	11.469	13.053	13.451	13.252
W_5	10.953	11.000	10.976	12.278	12.552	12.415
W_6	12.270	12.764	12.517	13.730	14.000	13.865
W_7	10.995	11.580	11.287	12.668	13.230	12.949
CD(P=0.05)	0.92	0.80	0.79	0.65	0.44	0.52

Plate 3. Experimental plots of jute at 25 Days After Sowing

Plate 4. Jute field at harvesting stage

4.1.4.4.3 Interaction effect of nitrogen application and weed management on total dry weight :

Significant interaction effect of nitrogen application and weed management on total dry weight was observed from the pooled data (Table 4.23 a & b). Maximum dry weights (6.084, 8.558, 14.632 and 16.239 t ha^{-1} respectively) were provided by the treatment combination N_1W_2 at all dates of observation followed by N_2W_2. At 25 DAS, N_1W_3 and N_2W_3 recorded values statistically at par with N_1W_2 and N_2W_2 . N_1W_1 produced significantly higher dry weight (6.084 t ha^{-1}) than N_2W_1 (5.915 t ha^{-1}) at 25 DAS. Minimum dry weights were recorded from N_2W_1 treatment combinations at all dates of observation except at 25 DAS, where lowest value produced by N_1W_7 (5.639 t ha^{-1}). At 100 DAS, significantly higher dry weight was recorded from N_1W_1, N_1W_2 and N_1W_6 than N_2W_1, N_2W_2 and N_2W_6, respectively and there was no significant difference between N_1W_3 and N_1W_6. The highest plant dry weight (16.552 t ha^{-1}) was obtained from N_1W_2 treatment combinations during 2003 at 100 DAS.

4.1.4.5 Crop Growth Rate (CGR)

4.1.4.5.1 Effect of nitrogen application on CGR :

Pooled data (Table 4.24) showed that at different dates of observation higher CGR of jute recorded from the treatment N_1 (skipping basal nitrogen) as compared to N_2, where basal nitrogen was applied. The similar trend was followed in 2003 and 2004. The highest CGR (10.413 g m^{-2} day^{-1}) was obtained at 75 – 100 DAS from N_1 during 2004 and lowest (8.502 g m^{-2} day^{-1}) at 25 -50 DAS from N_2 during 2003.

4.1.4.5.2 Effect of weed management on CGR :

Effect of weed management on CGR was significant at different dates of observation as found from the pooled data (Table 4.24). At all dates of observation maximum CGR (13.886, 14.889 and 12.696 g m^{-2} day^{-1} respectively) were recorded from weed free treatment (W_2) followed by hand weeding twice (W_3). W_2 was significantly higher than rest of the treatments. Whereas, unweeded control plot (W_1) produced the minimum CGR at all dates, which was significantly lower than all other treatments. There was significant difference between W_6 and W_7 at all dates of observation. The highest CGR of 12.755 g m^{-2} day^{-1} was produced by W_2 treatment at 75-100 DAS during 2003.

Table 4.23 (a) Interaction effect of N application and weed management on total dry weight (t/ha) of jute at 25 and 50 DAS

Weed Management (W)	Total dry weight of jute											
	25 DAS						50 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	5.916	5.833	6.252	5.998	6.084	5.915	8.226	7.883	8.890	8.798	8.558	8.340
W_2	9.143	8.966	10.048	9.852	9.595	9.409	12.733	12.990	14.326	13.674	13.529	13.332
W_3	8.723	8.550	8.800	8.548	8.761	8.549	11.383	10.666	12.974	12.996	12.178	11.831
W_4	7.200	7.250	7.761	7.301	7.480	7.275	10.303	9.360	11.128	10.726	10.715	10.043
W_5	4.516	4.650	4.557	4.727	4.536	4.688	8.703	8.570	9.549	8.651	9.126	8.610
W_6	7.033	7.033	7.456	7.248	7.244	7.140	10.930	10.623	12.982	11.864	11.956	11.243
W_7	5.383	5.503	5.341	5.639	5.362	5.571	9.056	9.050	10.871	10.369	9.963	9.709
	N X W			W X N			N X W			W X N		
Interaction	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
CD (P=0.05)	1.22	1.10	1.14	0.47	0.34	0.39	1.06	1.20	1.12	0.52	0.49	0.48

Table 4.23 (b) Interaction effect of N application and weed management on total dry weight (t/ha) of jute at 75 and 100 DAS

Weed Management (W)	Total dry weight of jute											
	75 DAS						100 DAS					
	2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	9.613	9.833	10.752	9.730	10.182	9.781	10.230	10.140	10.965	10.295	10.597	10.217
W_2	14.303	14.250	14.961	14.145	14.632	14.197	15.926	15.400	16.552	15.448	16.239	15.424
W_3	13.380	12.560	12.870	12.104	13.125	12.332	14.450	13.996	14.853	14.671	14.651	14.333
W_4	11.766	10.766	11.945	11.401	11.855	11.083	13.090	13.016	13.652	13.250	13.371	13.133
W_5	10.866	11.040	11.200	10.800	11.033	10.920	12.333	12.223	12.830	12.274	12.581	12.248
W_6	12.173	12.366	12.952	12.576	12.562	12.471	14.133	13.326	14.242	13.758	14.187	13.542
W_7	10.816	11.173	11.900	11.260	11.358	11.216	13.033	12.303	13.465	12.995	13.249	12.649
	N X W			W X N			N X W			W X N		
Interaction	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
CD (P=0.05)	1.28	1.16	1.20	0.78	0.51	0.42	1.43	1.20	1.12	0.44	0.39	0.31

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethy 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

Table 4.24 Effect of treatments on CGR (g/sqm/day) of jute at 25-50, 50-75 & 75-100 DAS

Treatment	CGR of jute								
	25 - 50 DAS			50 -75 DAS			75 - 100 DAS		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Nitrogen Management (N)									
N_1	8.52	8.91	8.72	11.30	11.71	11.50	10.20	10.41	10.30
N_2	8.50	8.68	8.59	11.09	11.42	11.25	10.05	10.13	10.09
Weed Management (W)									
W_1	3.51	3.44	3.476	6.28	6.54	6.41	5.96	5.75	5.85
W_2	13.64	14.12	13.88	14.79	15.00	14.89	12.75	12.63	12.69
W_3	12.18	12.76	12.47	13.10	13.54	13.32	12.09	12.39	12.24
W_4	7.47	8.00	7.73	11.43	11.98	11.70	10.24	10.74	10.49
W_5	7.17	7.43	7.30	10.65	11.03	10.84	9.68	9.84	9.76
W_6	8.63	8.74	8.69	11.96	12.10	12.033	10.42	10.88	10.65
W_7	6.98	7.10	7.04	10.14	10.76	10.45	9.75	9.66	9.71
CD(P=0.05)	1.15	0.73	0.94	1.24	1.36	1.28	0.65	1.01	0.44

4.1.4.5.3 Interaction effect of nitrogen application and weed management on CGR :

Table 4.25 clearly showed that interaction effect of nitrogen application and weed management on CGR were significant. Pooled data indicate that N_1W_2 treatment combination recorded maximum CGR (13.96, 15.10 and 12.86 g m^{-2} day^{-1}, respectively) followed by N_2W_2 at all dates of observation, whereas, minimum were provided by N_2W_1 (3.50, 6.45 and 5.96 g m^{-2} day^{-1}, respectively). At 25-50 DAS, N_1W_3 and N_1W_7 recorded significantly higher CGR than N_2W_3 and N_2W_7 treatment combinations respectively. N_1W_3 produced significantly higher CGR than N_2W_3 at 75-100 DAS and there was no significant difference between N_1W_3 and N_1W_6. The highest value of CGR was obtained from N_1W_2 (15.14 g m^{-2} day^{-1}) at 50 - 75 DAS during 2004 and lowest value provided by N_2W_1 (3.35 g m^{-2} day^{-1}) at 25-50 DAS during 2004.

4.1.4.6 Yield of jute

4.1.4.6.1 Effect of nitrogen application on fibre yield :

In pooled data higher fibre yield of jute was obtained from the treatment where basal nitrogen was not applied as compared to the treatment received basal nitrogen (Table 4.26). This trend was similar for both the year of experiment but there was no significant difference between N_1 and N_2. However, in pooled data N_1 recorded significantly higher yield than N_2. The highest yield of 2.69 t ha^{-1} was produced by N_1 during 2004 and lowest (2.31 t ha^{-1}) was provided by N_2 in pooled data.

Table 4.25 Interaction effect of N application and weed management on CGR (g/sqm/day) of jute at 25-50, 50-75 and 75-100 DAS

Weed Management (W)	CGR of jute																	
	25- 50 DAS						50 - 75 DAS						75 - 100 DAS					
	2003		2004		Pooled		2003		2004		Pooled		2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2	N_1	N_2
W_1	3.47	3.55	3.53	3.35	3.50	3.45	6.31	6.26	6.60	6.48	6.45	6.37	6.09	5.84	5.84	5.66	5.96	5.75
W_2	13.69	13.59	14.23	14.03	13.96	13.81	15.06	14.53	15.14	14.86	15.10	14.69	12.95	12.58	12.78	12.49	12.86	12.53
W_3	12.38	11.99	12.96	12.57	12.67	12.28	13.02	13.20	13.76	13.33	13.39	13.26	12.38	11.81	12.65	12.13	12.51	11.97
W_4	7.63	7.32	8.11	7.89	7.87	7.60	11.76	11.11	12.00	11.96	11.88	11.53	10.54	9.94	10.87	10.62	10.70	10.28
W_5	6.92	7.42	7.53	7.33	7.22	7.37	10.65	10.66	11.12	10.94	10.88	10.8	9.50	9.87	9.89	9.80	9.69	9.83
W_6	8.56	8.71	8.80	8.69	8.68	8.70	11.85	12.08	12.41	11.79	12.13	11.93	10.01	10.83	10.99	10.76	10.50	10.79
W_7	7.05	6.92	7.24	6.96	7.14	6.94	10.46	9.82	10.94	10.58	10.70	10.20	9.96	9.56	9.87	9.46	9.91	9.51

Interaction CD (P=0.05)	N X W			W X N			N X W			W X N			N X W			W X N		
	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P	'03	'04	P
	1.29	1.18	1.20	0.38	0.30	0.37	1.20	1.32	1.17	0.52	0.41	0.39	1.72	1.23	1.10	0.56	0.37	0.42

N_1 = 50% N at 10 DAS + 25% 20 DAS + 25 % 40 DAS ; N_2 = 50% N basal +25% N at 20 DAS +25% 40 DAS; W_1 = Unweeded; W_2 = Weed free; W_3 = Hand weeding twice at 15 and 35 DAS; W_4 = Quizalofop ethy 5% @ 50 g / ha at 15 DAS; W_5 = Pendimethalin @ 750 g /ha at 1 DAS; W_6 = W_4 + hand weeding at 35 DAS; W_7 = W_5 + hand weeding at 35 DAS

4.1.4.6.2 Effect of weed management on fibre yield:

During 2003 and 2004 as well as in pooled data, significantly lower fiber yields (1.15, 1.43 and 1.23 t ha^{-1} respectively) were recorded from the unweeded control plot (W_1) as compared to the rest of the treatments (Table 4.26). Significantly higher fibre yields (3.51, 3.71 and 3.61 t ha^{-1} respectively) were obtained from the weed free (W_2) treatment than all other treatments in both the year of experiment and in pooled data. Hand weeding twice (W_3) plot produced fibre yield next to W_2 and it was significantly higher than the treatment received one POE herbicide (Quizalofop ethyl) or one PE herbicide (Pendimethalin) i.e.W_4 or W_5. Application of POE along with one hand weeding (W_6) recorded statistically at par fibre yield with hand weeding twice (W_3). The similar trend was followed during both the year of experiment. Highest fibre yield of 3.71 t ha^{-1} was obtained from W_2 treatment during 2004 and lowest (1.15 t ha^{-1}) was produced by W_1 during 2003.

Table 4.26 Effect of treatments on fibre yield (t/ha) of jute

Treatment	Fibre yield of jute (t/ha)		
	2003	2004	Pooled
Nitrogen Management (N)			
N_1	2.43	2.69	2.56
N_2	2.42	2.61	2.31
CD(P=0.05)	-	-	0.23
Weed Management (W)			
W_1	1.15	1.43	1.23
W_2	3.51	3.71	3.61
W_3	2.94	3.01	2.97
W_4	2.19	2.66	2.43
W_5	2.06	2.20	2.13
W_6	2.73	2.88	2.80
W_7	2.44	2.69	2.57
CD(P=0.05)	0.49	0.52	0.34

4.1.4.6.3 Interaction effect of nitrogen application and weed management on fiber yield :

Pooled data showed significant interaction effect of nitrogen application and weed management on fiber yield of jute (Table 4.27). Highest fibre yield (3.63 t ha^{-1}) was recorded from N_1W_2 treatment combinations followed by N_2W_2 and lowest yield of 1.12 t ha^{-1} was produced by N_2W_1. Significantly higher fibre yield was obtained from N_1W_6 than N_2W_6 but there was no significant difference between N_1W_3, N_1W_6 and N_2W_3 , N_2W_6. Significant variation in fibre yield was noticed between N_1W_4, N_2W_4 and N_1W_6, N_2W_6, respectively. The trend was similar for both the year of experiment.

Table 4.27 Interaction effect of N application and weed management on fibre yield (t/ha) of jute

Weed Management (W)	Fibre yield of jute (t / ha)					
	2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2
W_1	1.06	1.24	1.46	1.40	1.26	1.12
W_2	3.48	3.53	3.77	3.65	3.63	3.59
W_3	2.95	2.93	3.02	3.00	2.98	2.96
W_4	2.21	2.16	2.62	2.70	2.42	2.43
W_5	2.05	2.07	2.21	2.19	2.13	2.13
W_6	2.82	2.65	3.10	2.66	2.96	2.65
W_7	2.48	2.40	2.68	2.70	2.58	2.55
Interaction	N X W			W X N		
	2003	2004	Pooled	2003	2004	Pooled
	0.63	0.66	0.52	0.27	0.31	0.24

4.1.4.6.4 Effect of nitrogen application on stick yield :

Significantly lower stick yield was recorded in the treatment received basal nitrogen (N_2) as compared to the treatment where basal nitrogen was skipped (N_1), as revealed from 2003 as well as in pooled data (Table 4.28). During 2004, there was no significant difference in stick yield was observed between N_1 and N_2 but comparatively higher yield was recorded by the treatment N_1. The highest stick yield of 6.89 t ha^{-1} was produced by N_1 during 2004 and lowest yield of 6.44 t ha^{-1} was recorded from N_2 during 2003.

Table 4.28 Effect of treatments on stick yield (t/ha) of jute

Treatment	Stick yield of jute (t/ha)		
	2003	2004	Pooled
	Nitrogen Management (N)		
N_1	6.70	6.89	6.79
N_2	6.44	6.85	6.64
CD(P=0.05)	0.25	-	0.11
	Weed Management (W)		
W_1	3.37	3.62	3.49
W_2	8.49	8.68	8.58
W_3	7.74	7.91	7.83
W_4	6.62	7.05	6.95
W_5	5.82	6.06	5.94
W_6	7.19	7.52	7.36
W_7	6.40	6.86	6.63
CD(P=0.05)	0.71	0.60	0.59

4.1.4.6.5 Effect of weed management on stick yield :

Different weed management treatment produced significantly different stick yield of jute during both the year of experiment. Pooled data showed that significantly higher yield of 8.58 t ha^{-1} was obtained from weed free treatment (W_2) followed by hand weeding twice at 15 and 35 DAS i.e.W_3. Application of quizalofop ethyl as POE herbicide along with one hand weeding at 35 DAS (W_6) recorded significantly higher yield than application of only pendimethalin (W_5) but there was no significant difference in stick yield between W_3 and W_6. Similar trend was followed during both the year of experiment. Highest stick yield of 8.68 t ha^{-1} was recorded during 2004 from W_2 and lowest (3.37 t ha^{-1}) was produced by W_1 during 2003 (table 4.28).

4.1.4.6.6 Interaction effect of nitrogen application and weed management on stick yield :

Interaction effect of nitrogen application and weed management on stick yield of jute was significant as observed from the table 4.29. Pooled data of interaction effect recorded significantly higher yield from the treatment combinations N_1W_2 than rest of the treatment combination with N_1, followed by N_2W_2 but there was no significant difference between N_1W_2 and N_2W_2.The trend was similar for 2003 and 2004 also. Pooled data revealed that N_1W_6 recorded significantly higher yield than N_2W_6 and there was no significant difference in stick yield between N_1W_3 and N_1W_6 ; N_2W_3 and N_2W_6. The minimum stick yield was produced by N_2W_1 during 2003 and N_1W_1 during 2004. Highest yield of 8.59 t ha^{-1} was obtained from N_1W_2 in pooled data.

Table 4.29 Interaction effect of N application and weed management on stick yield (t/ha) of jute

Weed Management (W)	Stick yield of jute (t / ha)					
	2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2
W_1	3.38	3.36	3.59	3.65	3.48	3.51
W_2	8.51	8.47	8.66	8.70	8.59	8.58
W_3	7.48	7.64	7.95	7.87	7.72	7.75
W_4	6.58	6.65	7.10	7.00	6.84	7.05
W_5	6.22	5.43	6.10	6.02	6.16	5.73
W_6	7.32	7.07	7.61	7.43	7.46	7.25
W_7	6.52	6.29	6.84	6.88	6.68	6.58
Interaction	N X W			W X N		
	2003	2004	Pooled	2003	2004	Pooled
	0.89	0.72	0.70	0.31	0.29	0.22

Plate 5. Blackgram in control plot of previous crop

Plate 6. Blackgram in weed free plot of previous crop

4.1.4.7 Effect of different weed management methods on net return per rupee investment in jute

Table 4.30 clearly showed that the common cost for cultivation of jute for all the post plant weed management were same and the individual treatment cost varied accordingly. The highest treatment cost was for cleaning weeds throughout the crop growth period (W_2) and it was followed by hand weeded twice treatment (W_3). The trend was similar for net return, but net return per rupee investment was not followed the trend. Highest value of B:C ratio was obtained from W_6 treatment and it was followed by W_4 where only quizalofop ethyl was applied as post emergence herbicide at 15 DAS. The lowest value of 0.83 was recorded by the unweeded control treatment followed by weed free treatment (1.43).

4.2 Blackgram

4.2.1 Seed yield

4.2.1.1 Effect of nitrogen application on the next season blackgram yield :

Pooled data of two years (Table 4.31) showed higher yield (0.982 t ha^{-1}) from the plot (N_1), which received split application of nitrogen in the previous crop jute, than the treatment N_2 (0.979 t ha^{-1}). But, there was no significant difference in yield. During 2004 same trend was followed but during 2003 N_2 recorded higher yield (0.987 t ha^{-1}) than N_1 (0.986 t ha^{-1}).

4.2.1.2 Effect of weed management on the next season blackgram yield :

Table 4.31 clearly showed that highest yield of blackgram were recorded from the previous year weed free plot (W_2) during 2003 as well as in pooled data also. However, there was no significant variation in yield obtained from different plots. During the first year of experiment, plot which received pendimethalin along with one hand weeding at the previous crop jute (W_7), recorded grain yield next to W_2. Whereas, during 2004, W_4 which received quizalofop ethyl as POE herbicide in the jute growing season, recorded the highest grain yield (1.004 t ha^{-1}). The lowest yield of blackgram was recorded from the plot which was unweeded control during the previous crop jute. The similar trend in lowest grain yield was found during both the year of experiment.

Table 4.30 Effect of different weed management methods on net return per rupee investment in jute

Treatment	Fibre yield (t ha^{-1})	Stick yield (t ha^{-1})	Returns from fibre (Rs)	Returns from sticks (Rs)	Total Return (Rs)	Common cost (Rs)	Treatment cost (Rs)	Total cost (Rs)	Net Return (Rs)	Net return per rupee investment
	A	B	C = (A X P_F)	D = (B X P_S)	E= C+D	F	G	H=F+G	I=E-H	J=I/H
W_1 : Un-weeded control	1.23	3.49	12669.00	3490.00	16159.00	8829.75	0.00	8829.75	7329.25	0.83
W_2 : Weed free	3.61	8.58	37183.00	8580.00	45763.00	8829.75	9936.00	18765.75	26997.25	1.43
W_3 : HW twice 15+35 DAS	2.97	7.83	30591.00	7830.00	38421.00	8829.75	4968.00	13797.75	24623.75	1.78
W_4 : Quzalofop-ethyl	2.43	6.95	25029.00	6950.00	31979.00	8829.75	1848.40	10678.15	21300.85	1.99
W_5 : Pendimethalin	2.13	5.94	21939.00	5940.00	27879.00	8829.75	1360.90	10190.65	17688.35	1.73
W_6 : T4 + HW 35 DAS	2.80	7.36	28840.00	7360.00	36200.00	8829.75	3090.40	11919.40	24280.60	2.03
W_7 : T5 + HW 35 DAS	2.57	6.63	26471.00	6630.00	33101.00	8829.75	3223.50	12053.25	21047.75	1.74

Table 4.31 Treatment effect of previous crop on seed yield (kg/ha) of Blackgram

Treatment	Seed yield of Blackgram (t/ha)		
	2003	2004	Pooled
Nitrogen Management (N)			
N_1	0.986	0.978	0.982
N_2	0.987	0.970	0.979
Weed Management (W)			
W_1	0.960	0.930	0.945
W_2	1.021	0.997	1.009
W_3	0.994	1.004	0.999
W_4	0.958	0.970	0.964
W_5	0.990	0.940	0.965
W_6	0.985	0.989	0.987
W_7	1.002	0.987	0.994

4.2.1.3 Interaction effect of treatments on the next season blackgram yield :

Interaction effect of treatments on the next season blackgram yield was not significant as reveled by the Table 4.32. Pooled data showed that the highest yield (1.011 t ha^{-1}) of blackgram was recorded from the plot N_2W_7 followed by N_1W_2 and N_2W_2. Lowest yield of 0.939 t ha^{-1} was produced from N_2W_1 plot. During 2003 and 2004 highest yield was obtained from N_1W_2 and N_2W_7 respectively. Lowest yield of 0.929 t ha^{-1} was recorded from N_2W_4 during 2003 and N_2W_5 during 2004 respectively.

Table 4.32 Interaction effect of treatments of previous crop on seed yield (kg/ha) of Blackgram

Weed Management (W)	Seed yield of Blackgram (t / ha)					
	2003		2004		Pooled	
	N_1	N_2	N_1	N_2	N_1	N_2
W_1	0.950	0.970	0.952	0.908	0.951	0.939
W_2	1.030	1.012	0.990	1.004	1.010	1.008
W_3	0.998	0.990	1.012	0.996	1.005	0.993
W_4	0.987	0.929	0.983	0.958	0.985	0.943
W_5	0.975	1.005	0.951	0.929	0.963	0.967
W_6	0.972	0.998	0.994	0.984	0.983	0.991
W_7	0.996	1.008	0.960	1.014	0.978	1.011

4.3 Influence of pendimethalin on α–amylase activity of jute seed and different weed seeds during germination

Influence of pendimethalin on α-amylase activity during germination of seeds was studied in laboratory condition at different intervals of treatment and the results have been presented in Table 4.33. The data pertaining the α-amylase activity in seeds revealed that the maximum activity of 214.00 (μg maltose released per gram fresh tissue per minute) was found in tubers of *Cyperus rotundus* after 6 hours of soaking which was followed by seeds of *Echinochloa colona* and jute seeds. The maximum reduction in α-amylase activity of 8.94% was recorded in seeds of *Digitaria sanguinalis* on 6 hours after treatment, whereas the reduction was 20.34% in *Echinochloa colona* followed by *Digitaria sanguinalis* (15.83%), *Physalis minima* (11.29%) and jute seeds (10.87%) on 24 hours after treatment.

The α-amylase activity was found highest in tuber of *Cyperus rotundus* (414.33and 362.00 μg maltose released per gram fresh tissue per minute under control and pendimethalin treatment, respectively) during 48 hours after treatment. On the contrary, the lowest value was recorded from *Physalis minima* (163.00 and 115.00 μg maltose released per gram fresh tissue per minute). The maximum reduction of α-amylase activity was found in seeds of *Echinochloa colona* (34.43%) at 48 hours after treatment followed by *Eleusine indica* (30.0%), *Digitaria sanguinalis* (28.97%) and jute seeds (18.55%), whereas the minimum reduction percentage of 12.63 was recorded in the tubers of *Cyperus rotundus* during the same observation period.

Table 4.33. Effect of pendimethalin on α-amylase activity during germination of jute & different weed seeds

Plant species		α-amylase activity (μg maltose released per gram fresh tissue per minute)			Reduction (%) of α-amylase activity (μg maltose released per gram fresh tissue per minute) in seeds		
		Hours after treatment			Hours after treatment		
		6	24	48	6	24	48
Jute seed (var. JRO 524)	Control	180.67	254.67	370.00	-	-	-
	Pendimethalin	170.33	227.00	301.33	5.72	10.87	18.55
Echinochloa colona	Control	186.00	232.67	362.00	-	-	-
	Pendimethalin	172.00	185.33	237.33	7.52	20.34	34.43
Eleusine indica	Control	178.67	211.33	337.00	-	-	-
	Pendimethalin	171.67	192.00	235.67	3.91	9.14	30.00
Digitaria sanguinalis	Control	141.67	160.00	270.33	-	-	-
	Pendimethalin	129.00	134.67	192.00	8.94	15.83	28.97
Cyperus rotundus	Control	214.00	266.33	414.33	-	-	-
	Pendimethalin	207.67	252.00	362.00	2.95	5.38	12.63
Physalis minima	Control	105.00	118.00	163.00	-	-	-
	Pendimethalin	101.67	104.67	115.00	3.17	11.29	29.44

Plate 7. Seeds in petridishes for enzyme analysis

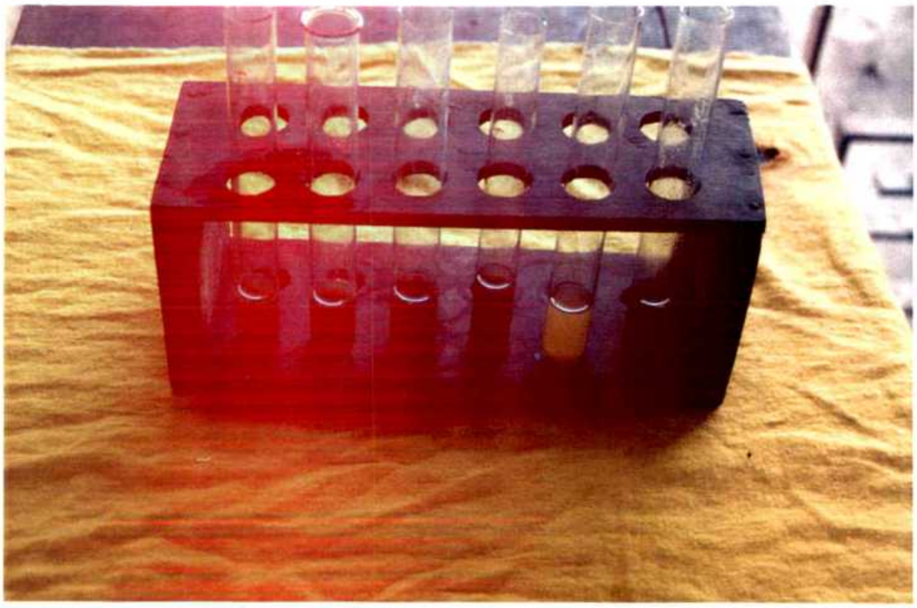


Plate 8. Seeds extract and reagents in test tubes for enzyme analysis

Chapter-5

DISCUSSION

The results, presented in the Table 4.1 – 4.33 of "Influence of Nitrogen and Weed Management on Tossa Jute and their treatment effect on Blackgram", are briefly discussed here in the following pages.

5.1 Jute

5.1.1 Weed density and biomass

The density as well as biomass of all categories of weeds (Table 4.2 to 4.13) were lower under the treatment where basal nitrogen was skipped as compared to the treatment which received basal nitrogen. This may be due to lower competing ability of weeds which grow quicker & faster to the cultivated crop jute in absence of basal nitrogen. In case of grass weed, the treatment without basal nitrogen (N_1) recorded 16.53 % lower weed population at 60 DAS and 12.43 % lower weed biomass at 30 DAS than the treatment with basal nitrogen (N_2). At 30 DAS, 11.05 % higher sedge weed population and at 60 DAS, 4.63 % higher sedge weed biomass was observed in the treatment where basal nitrogen was applied as compared to treatment without basal nitrogen. The broadleaf weed on the other hand also showed 7.95 % lower population and 7.47 % lower weed biomass by the treatment N_1 at 60 DAS than N_2. Among all categories of weeds, population variation was lower in case of dicot weeds, as they pose minimum problem in jute as compared to monocot weeds. Ghorai *et.al.,*(2004) and Saraswat (1980) also expressed similar opinion while working in this alluvial region.

Among the post-plant weed management treatments, as normally found, unweeded control (W_1) recorded the maximum and weed free plots (W_2) recorded the minimum population and dry weight of all categories of weeds. Whereas, hand weeding (W_3) at 15 DAS effectively controlled all the weeds and the same at another 20 days later could be able to control the second flash of weeds. Bhattacharya *et. al.,* (2004) and Das *et. al.*(1997), observed similar type of results. Incase of grass and sedge weeds at 60 DAS, lower weed population of 35.48 % and 1.74 % respectively were recorded from the treatment which received POE application of quizalofop ethyl at 15 DAS along with one hand weeding at 35 DAS (W_6) than twice hand weeding at 15 and 35 DAS (W_2). This might be due to the fact that the herbicide quizalofop ethyl has an excellent ability to control monocot weeds and hand

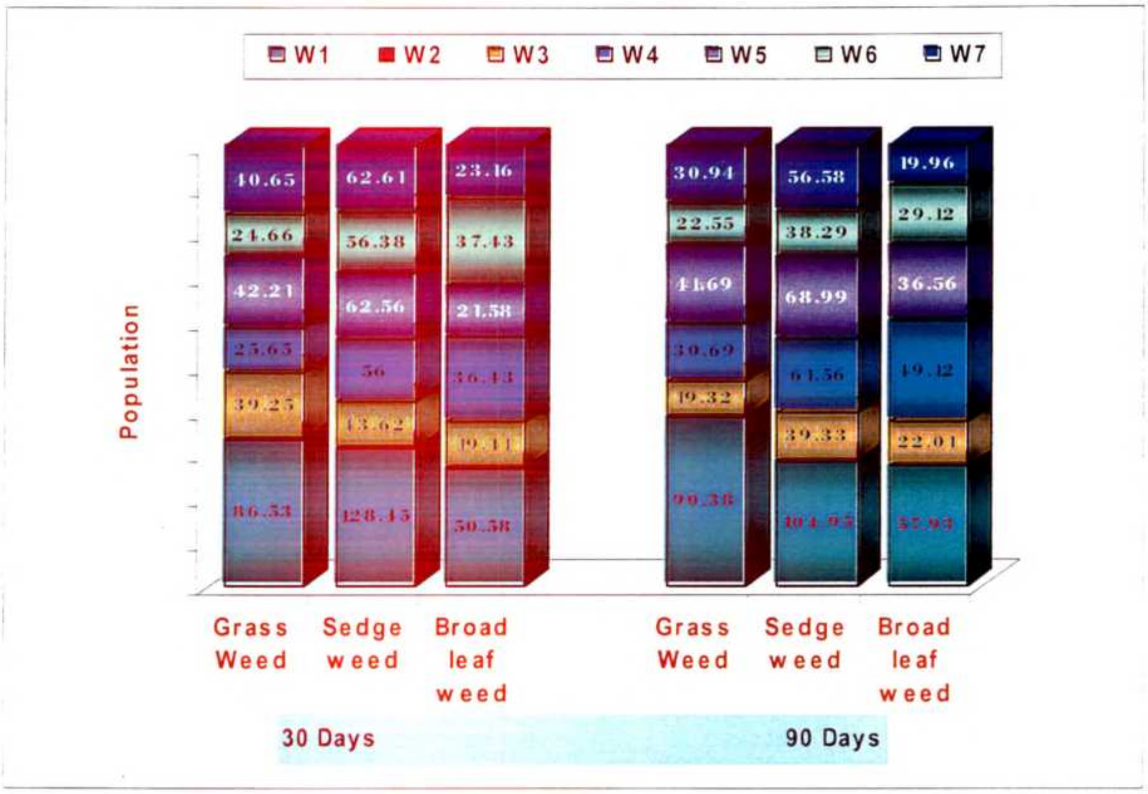


Fig. 3. Effect of Weed Management on different kinds of weed population at 30 and 90 DAS

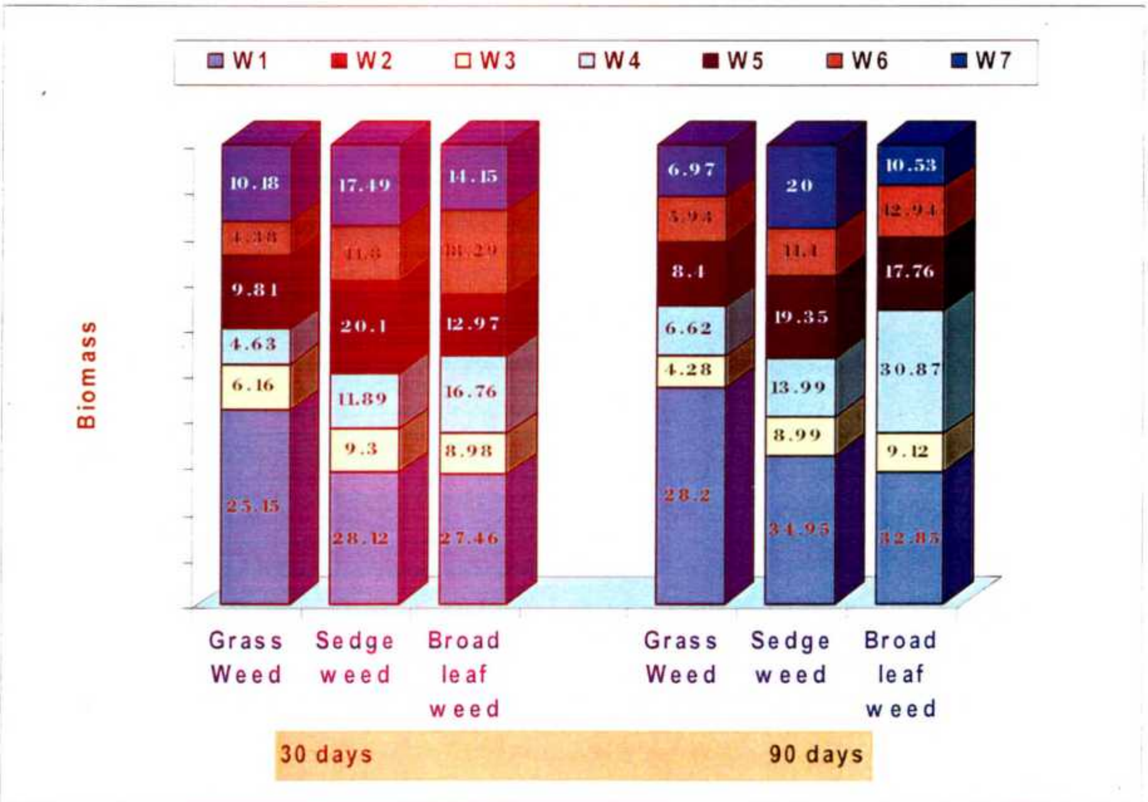


Fig. 4. Effect of Weed Management on different kinds of weed biomass on 30 and 90 DAS

weeding at 35 DAS, further managed the second flash of monocot weeds. However, biomasses obtained from these two treatments were statistically at par for grass and sedge weeds at 60 DAS. Similar type of findings was reported by Bhattacharya *et. al.,* (2004). In case of broadleaf weeds at 60 and 90 DAS higher population and weed biomass were obtained from the treatment W_6 as compared to W_2 as the quizalofop ethyl has very little effect on controlling broadleaf weeds whereas because of its good controlling ability pendimethalin applied as PE at 1 DAS along with one hand weeding at 35 DAS, recorded better efficacy than W_6. Similar type of observation with pendimethalin was reported by Das *et.al.* (1994) and Bhattacharya *et. al.,* (2004). This is further proved when the treatments received only quizalofop ethyl (W_4 or W_6) recorded significantly lower grass weed population and biomass at 30 DAS than the treatments received either pendimethalin at 1 DAS (W_5 or W_7) or only one HW at 15 DAS (W_2).

The interaction effect between the nutrient and weed management revealed that the treatment, where weeds were allowed to grow after basal nitrogen application (N_2W_2) resulted the maximum population as well as dry weight of all categories of weeds as compared to the rest of the treatment combinations. This was because of the fact that initial nitrogen helped the weeds to grow at faster rate in the weedy check plot where no weed control measure was adopted. On the contrary, lower population & biomass of weeds were provided by the treatment combination where only top dressing of nitrogen was done followed by application two hand weedings at 15 and 35 DAS (N_1W_3). This might be due to non-availability of initial nitrogen for the weeds, leading to less competing ability with the crop, and subsequently controlling all categories of weeds by two hand weedings. Incase of grass and sedge weed at 60 and 90 DAS, statistically at par population and biomass were recorded between the treatment combinations N_1W_6 and N_2W_6, where quizalofop ethyl was applied as POE herbicide at 15 DAS followed by one hand weeding at 35 DAS in combination with either basal nitrogen or without basal nitrogen, with hand weeding twice plots (N_1W_3 and N_2W_3). The reason behind this might be quizalofop ethyl along with one hand weeding controlled grass and sedge weeds as effectively as twice hand weeding. However, N_1W_6 recorded lower grass weed population (27.86 % lower at 90 DAS) than N_2W_6. Incase of broadleaf weeds pendimethalin followed by one hand weeding at 35 DAS in combination with both of the nitrogen application (N_1W_7 and N_2W_7) produced significantly lower weed

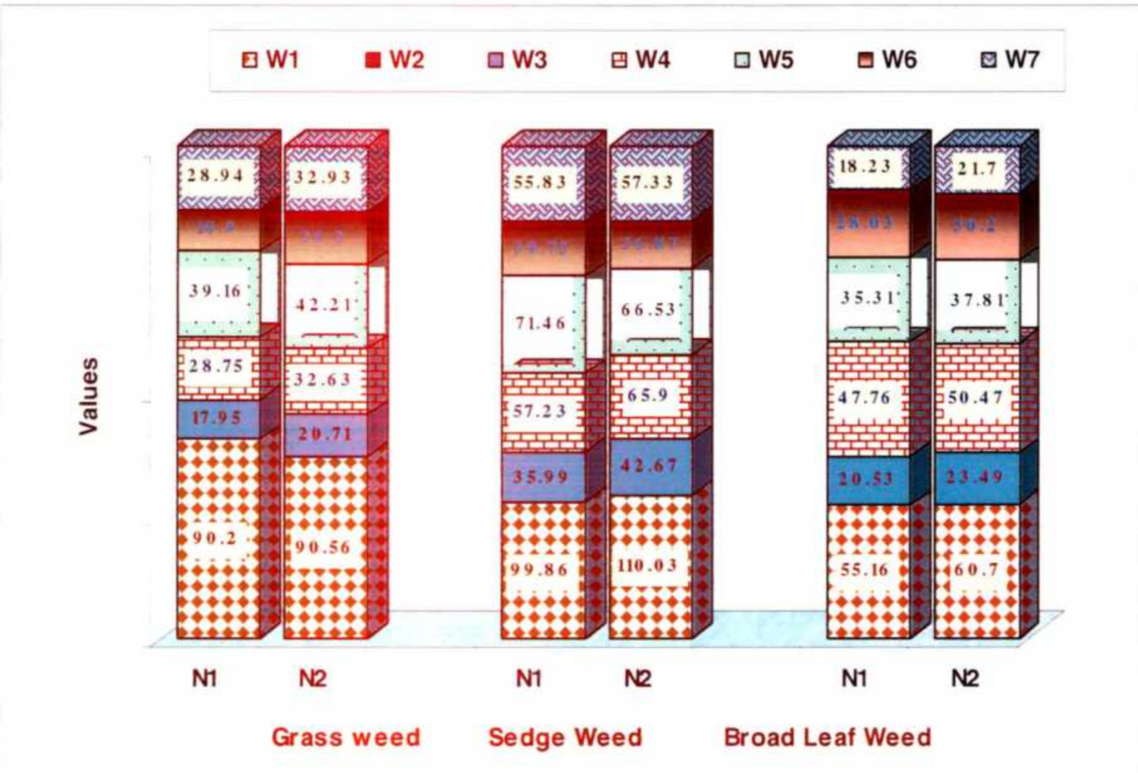


Fig. 5. Interaction effect of weed management and time of nitrogen application on different kinds of weed population in jute at 90 DAS

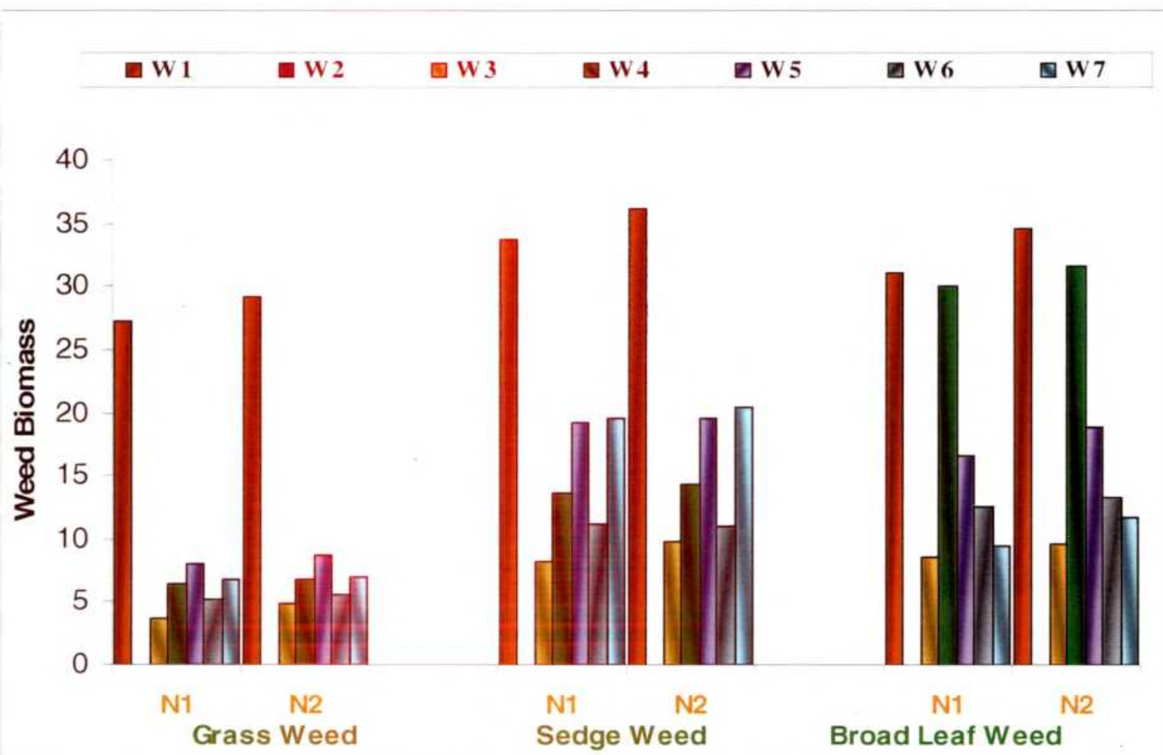


Fig. 6. Interaction effect of weed and time of nitrogen management on different kinds of weed biomass of jute at 90 DAS

population than hand weeding twice in combination with nitrogen application (N_1W_2 and N_2W_2). At 30 DAS, application of only quizalofop ethyl at 15 DAS along with nitrogen application at 10 DAS (N_1W_4) controlled grassy weeds in a better way than only one hand weeding at 15 DAS with basal nitrogen application (N_2W_3).

5.1.2 Growth and yield attributes

The plant height, basal diameter and LAI of jute were more in the plots where basal nitrogen was skipped (N_1) than those plots where basal nitrogen was applied (N_2), at all the dates of observation (Table 4.16 - 4.20). This might be due to lower weed population and biomass in the N_1 treatment, leaded to less competition of weeds for growth resources and supply of nitrogen after germination of jute, both of which results better plant growth of jute. At 50 DAS, 1.25 % higher plant height was recorded in the treatment where basal nitrogen was not applied as compared to the treatment N_2. Similarly about 22.08 % higher LAI and 2.60 % higher basal diameter was recorded at 30 DAS. All these leaded to higher total dry weight as well as higher CGR of jute in the treatment N_1 than treatment received basal nitrogen (N_2). About 3.93 % higher total dry weight of jute was recorded at 50 DAS from the treatment N_1.

Among weed management treatments, application of quizalofop ethyl at 15 DAS followed by one hand weeding at 35 DAS (W_6), which effectively reduced competition of the crop with the weeds of all categories, specially grasses and sedges, showed higher growth and yield attributes like plant height, basal diameter, LAI, etc. than application of only quizalofop ethyl (W_4) or pendimethalin (W_5) or even pendimethalin along with one hand weeding (W_7), by making growth resources more available to the crop. As a result higher total dry weight of jute as well as higher CGR was found from the treatment W_6. Sarkar (2006) also opined similar type of results. Due to the same reason, twice hand weeded treatment (W_3) was superior to W_4 and W_5. The lower growth attributes in pendimethalin treated plot might be due to higher crop-weed competition than treatment received quizalofop ethyl. The unweeded control treatment (W_1) rendered the growth resources less available to the crop due to higher crop-weed competition, which was reflected on the lower yield attributing characters. Whereas, the treatment W_2, where crop was grown without facing any competition from weeds at any time in its life span, performed the best due to getting the growth resources to the greatest extent. About 46.40 % higher plant

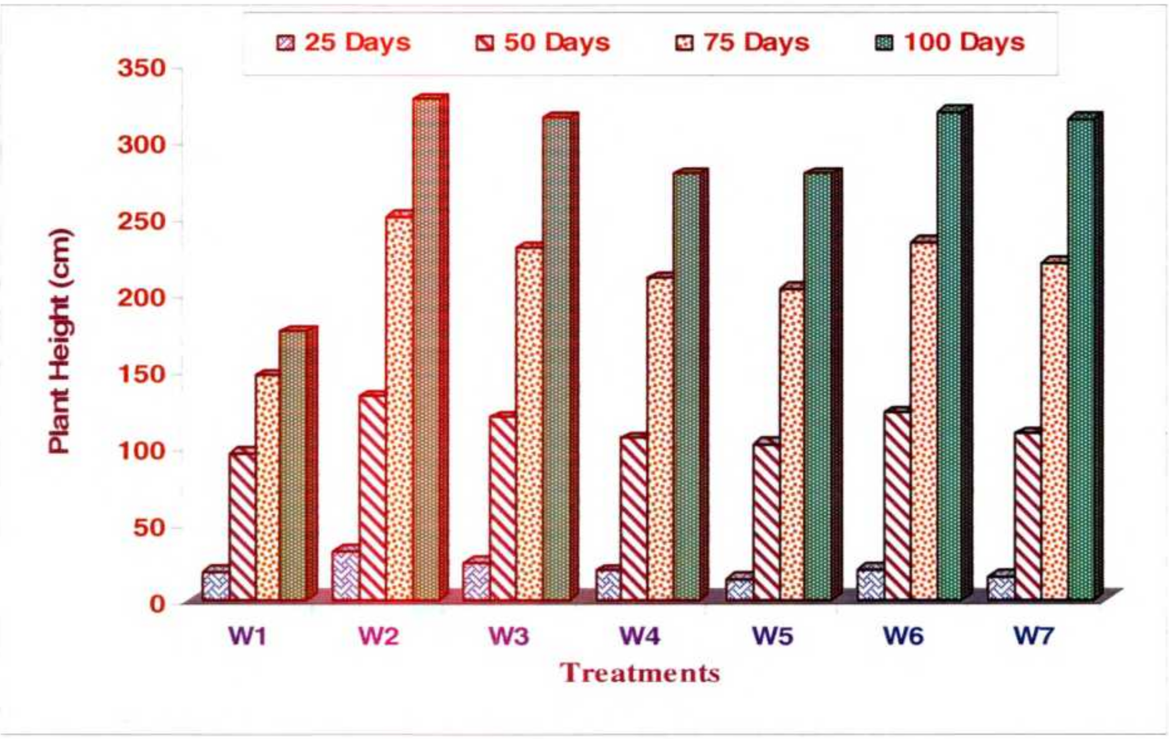


Fig. 7. Effect of Weed Management on plant height at different stages of growth

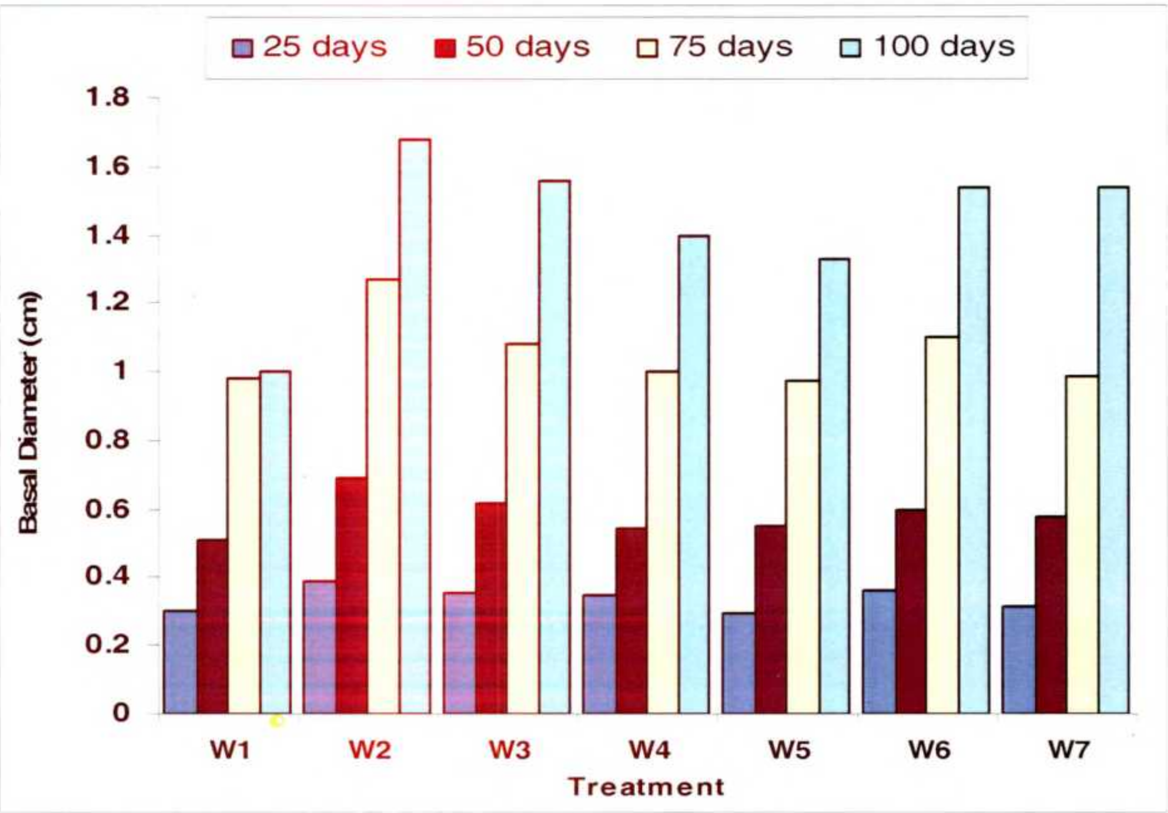


Fig. 8. Effect of Weed Management on basal diameter at different stages of growth

height was recorded by the weed free treatment at 100 DAS as compared to unweeded control. However, there was no significant difference in plant height at 50, 75 and 100 DAS between twice hand weeded treatment and application of quizalofop ethyl along with one hand weeding treatment (W_6). This might be attributed to better effectiveness of the post emergence herbicide in controlling weeds when coupled with one hand weeding. Unweeded control plot recorded 34.26 % lower total dry weight of jute than weed free situation (W_2), whereas hand weeded treatment produced only 8 % lower dry weight of jute than the treatment W_2. The difference in dry weight of jute between the treatment W_3 and W_6 was only 4.33 % at 100 DAS. Bhattacharya *et. al.,* (2004) from West Bengal, also expressed similar opinion.

Regarding interaction of nitrogen application and weed management, skipping of basal nitrogen followed by weed free in the post plant period (N_1W_2) recorded the maximum plant height, basal diameter and LAI at 100 DAS followed by N_2W_2. It was due to no crop-weed competition, higher availability of plant nutrients and supply of nitrogen after germination of crop, all of these made the plant with higher growth attributes. Due to severe crop-weed competition and lower availability of plant nutrients, N_2W_1 showed the minimum growth and yield attributes. Application of nitrogen at 10 DAS followed by application of quizalofop ethyl at 15 DAS coupled with one hand weeding at 35 DAS (N_1W_6) recorded higher plant height at 50, 75 and 100 DAS than treatment hand weeded at 15 and 35 DAS coupled with application of basal nitrogen (N_2W_3). This might be due to the fact that quizalofop ethyl controlled grassy and sedge weeds in a better way along with one hand weeding when basal nitrogen was not applied than application of basal nitrogen along with only hand weeding. At 100 DAS, 46.73 % higher plant height of jute was obtained from N_1W_2 than N_2W_1. The maximum and minimum total dry weight of jute was produced by N_1W_2 and N_2W_1 respectively at 100 DAS. This was also due to maximum and minimum crop-weed competition along with more and less availability of nutrients to the jute plants respectively, which results more plant height, basal diameter and more LAI in N_1W_2 and less plant height, basal diameter and LAI in N_2W_1. About 37.08 % higher dry weight of jute was obtained from N_1W_2 than N_2W_1. Because of better controlling ability of weeds, quizalofop ethyl along with one hand weeding, N_1W_3 recorded only 3.16 % higher total dry weight than N_1W_6. Regarding CGR, the highest value at 75-100 DAS was recorded from the treatment combination N_1W_2

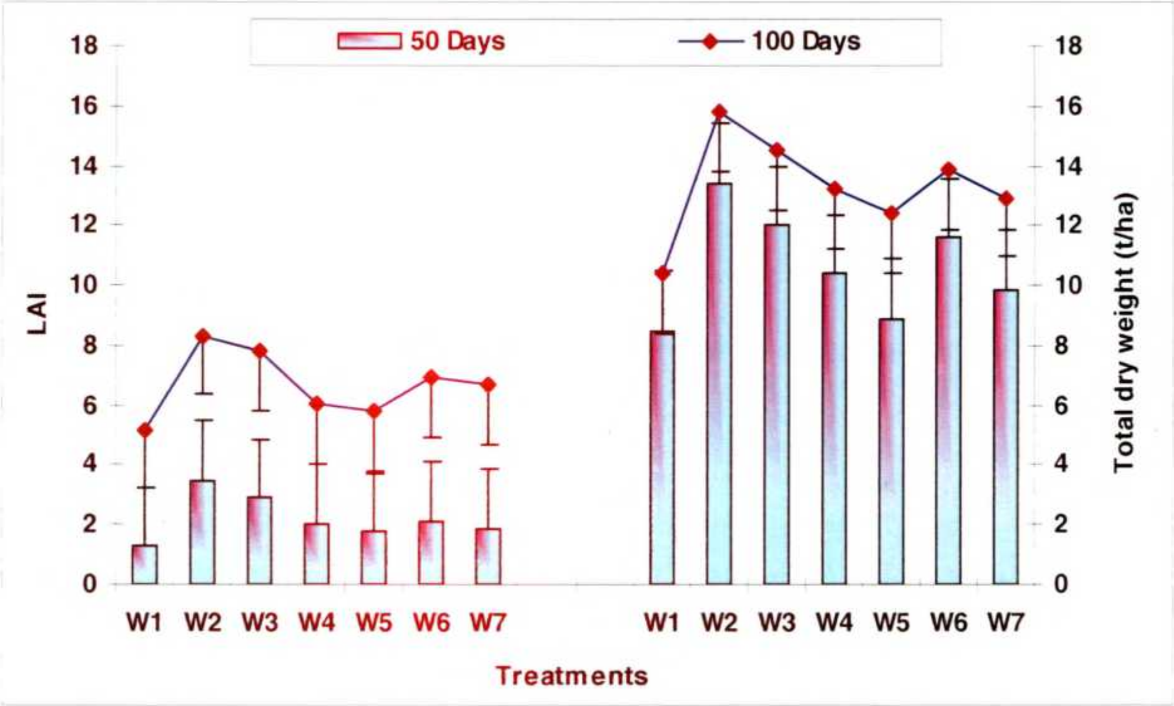


Fig. 9. Effect of Weed Management on LAI and Total dry weight at 50 and 100 DAS

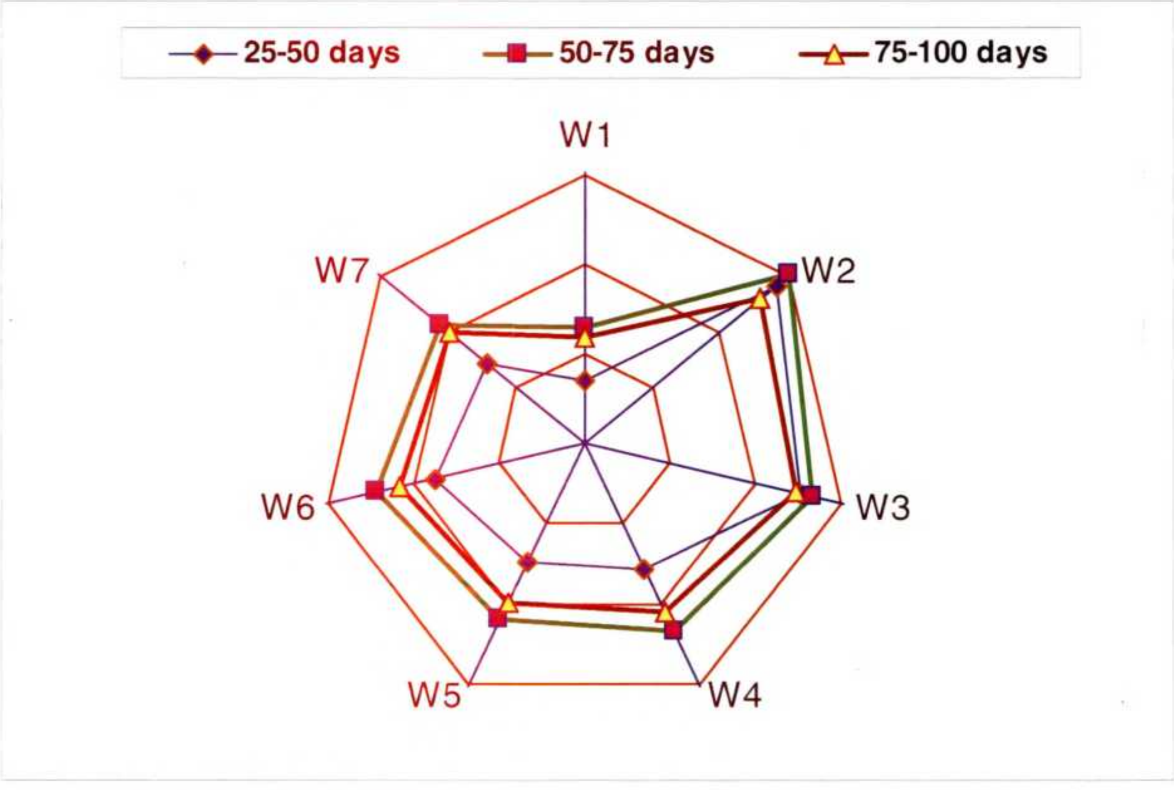


Fig. 10. Effect of Weed Management on Crop Growth Rate at different stages of growth

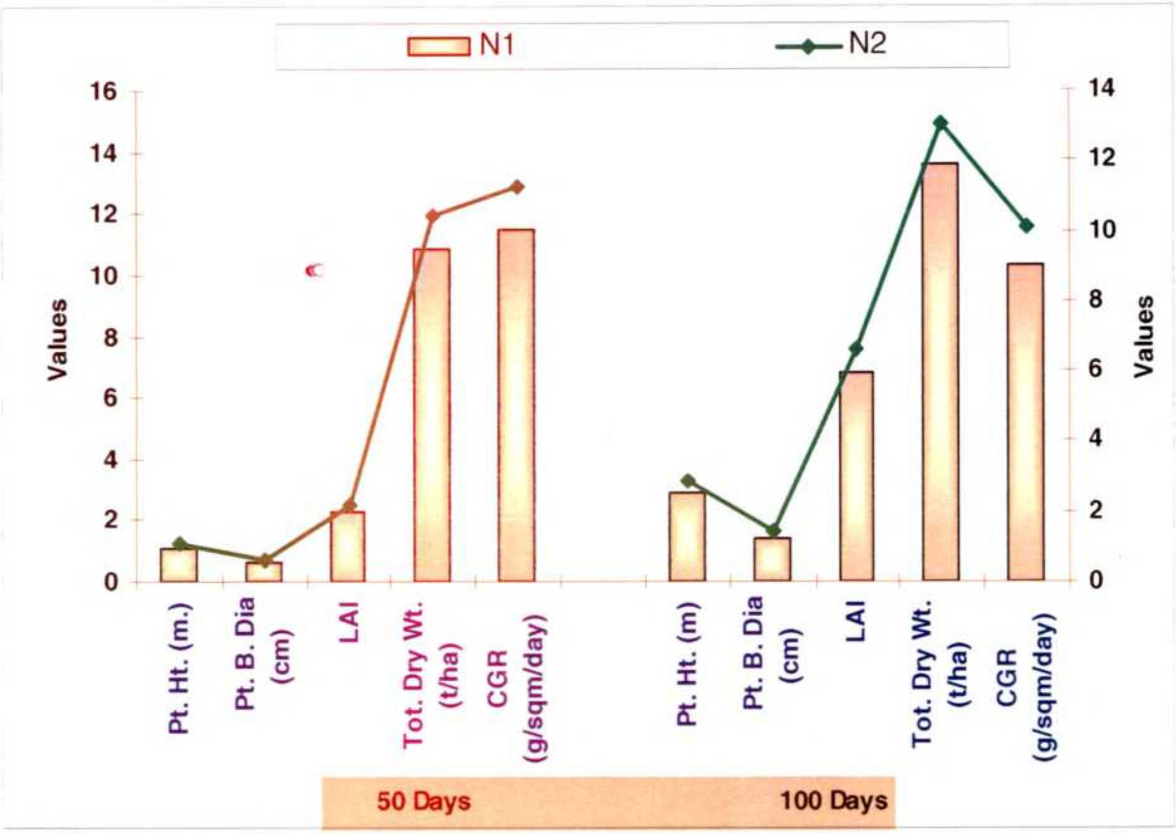


Fig. 11. Effect of time of nitrogen application on different parameters of Jute at 50 and 100 DAS

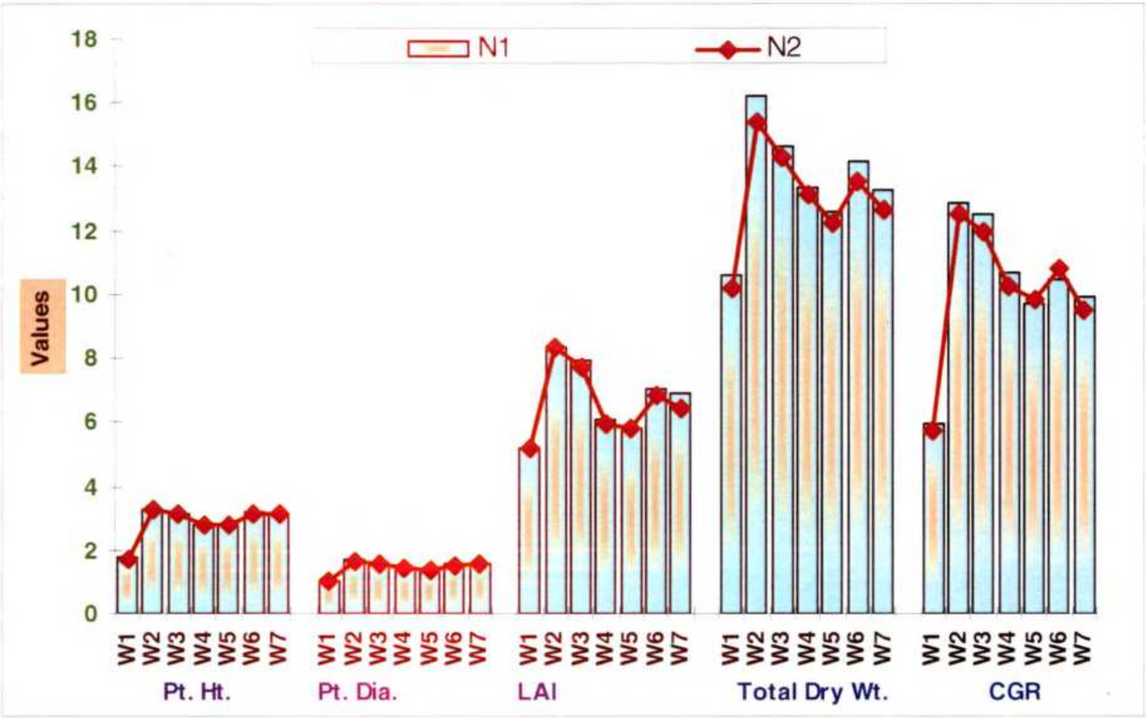


Fig. 12. Interaction effect of weed management and time of nitrogen application on different growth parameters of jute at 100 DAS

due to better condition for jute growth resulted from no crop-weed competition throughout the life span along with supply of nitrogen after germination of jute at 10 DAS.

5.1.3 Fibre and stick yield

Pooled data showed 9.76 % higher fibre yield from the treatment where nitrogen was applied at 10 DAS without basal nitrogen (N_1) than the treatment received nitrogen as basal dose (N_2) due to higher growth and yield attributing characters like plant height, basal diameter, LAI, etc. resulted from lower crop-weed competition and higher availability of nitrogen after emergence of the crop. On the contrary, 2.20 % lower stick yield of jute was recorded from the treatment N_2 where nitrogen was applied as basal dose. This might be due to higher crop-weed competition results lower growth and yield attributing characters of the crop, which ultimately reduced the fibre and stick yield. Moreover, nitrogen that was applied as basal, robbed by the weeds at the initial stage due to higher competing ability of the weeds at the initial growth phase and the crop deprived of the nutrient after emergence.

Among the various weed management treatments, uncontrolled growth of the weeds robbed up the growth resources like plant nutrients, soil moisture etc., which would be available to the jute and thereby resulted poor growth and yield attributing characters which were reflected on the fibre and stick yield of jute. Weeds, when allowed to grow unchecked, caused 65.92 % loss in fibre yield and 59.32 % loss in stick yield of jute. On the contrary, 17.72 % loss of fibre yield and 8.74 % stick yield were recorded when weeds were controlled through two hand weeding first at 15 DAS followed by 35 DAS (W_3) as compared to the weed free situation throughout the crop growth period. However, application of quizalofop ethyl at 15 DAS coupled with one hand weeding at 35 DAS (W_6) produced only 5.72 % lower fibre yield and 6 % lower stick yield than the tedious method of two hand weeding (W_3) but 23.92 % and 19.29 % higher fibre and stick yield, respectively than application of only pendimethalin at 1 DAS (W_5). The important reason behind this was effective weed controlling ability of quizalofop ethyl along with one hand weeding at 35 DAS and at the same time the lower ability of pendimethalin alone to control the weeds. However, application of quizalofop ethyl alone at 15 DAS (W_4) controlled the weeds in a better way than pendimethalin alone at 1 DAS (W_5), which was reflected on the growth and yield parameters and ultimately on fibre and stick yield of jute. This corroborates with the

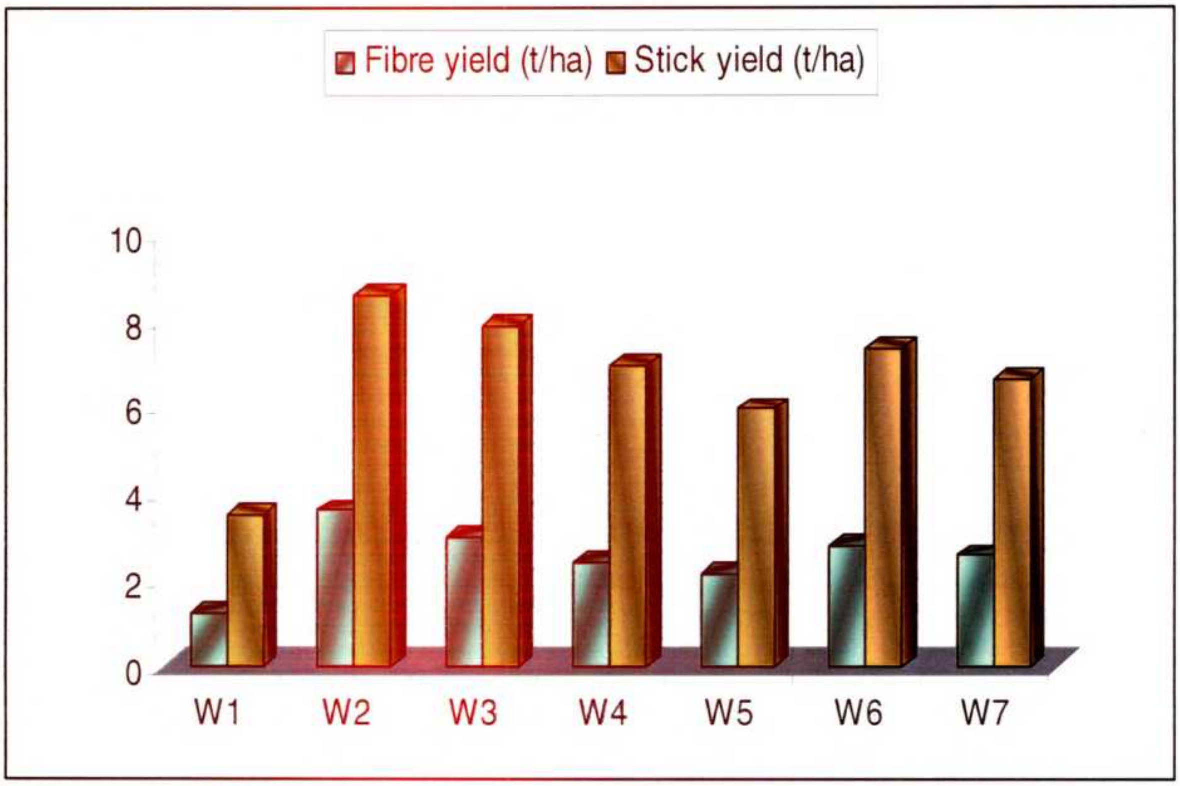


Fig. 13. Effect of Weed Management on fibre and stick yield (t/ha) of jute

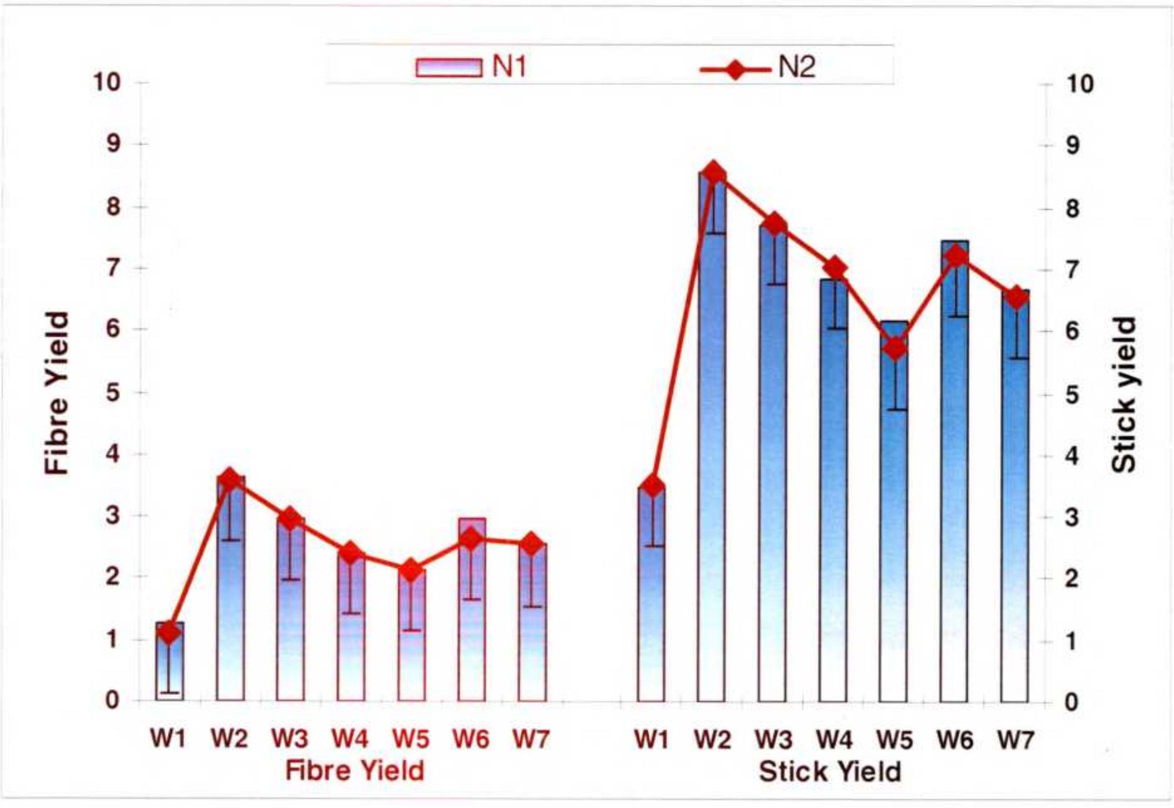


Fig. 14. Interaction effect of weed management and time of nitrogen application on fibre and stick yield (t/ha) of jute

findings of Bhattacharya *et. al.,*(2004). Due to weed free situation throughout the life span of jute, the treatment W_2 recorded the highest fibre and stick yield (3.61 and 8.58 t ha^{-1} respectively), whereas, due to severe crop-weed competition through out the life span the treatment W_1 produced lowest fibre and stick yield (1.23 and 3.49 t ha^{-1} respectively). It again proved that weeds were a major factor for reduction of both fibre and stick yield in jute. Mishra and Misra (1996), Mishra (1997) were also of the same opinion.

Among the treatment interactions, unweeded control treatment in combination with application of basal nitrogen (N_2W_1) recorded minimum fibre and stick yield due to lower growth and yield attributing character as a result of severe crop-weed competition. Whereas due to complete avoidance of competition from weed and supply of nitrogenous fertilizer after emergence of crop at 10 DAS (N_1W_2) resulted the highest fiber and stick yield of jute which were 69.14 % and 59.14 % higher respectively than N_2W_1. Better weed controlling ability of quizalofop ethyl along with nitrogenous fertilizer after emergence of crop (N_1W_6) results 62.16 % and 52.94 % higher fibre and stick yield respectively than N_2W_1. This might be due to the favourable condition for better growth and yield attributing characters of jute, which was reflected on the fibre and stick yield of jute. Pendimethalin was less effective in controlling weed than quizalofop ethyl as has been observed from the fibre and stick yield of jute. About 33.33 % and 20.37 % lower fibre and stick yield were recorded from the N_1W_4 than N_1W_2 treatment combination.

5.1.4 Weed control efficiency

Higher weed control efficiency was recorded at different dates of observation from the treatment where basal nitrogen was not applied as compared to the treatment received basal nitrogen. It was about 3 % higher at 30 DAS. The reason behind this might be lower availability of nitrogen during germination of weed hampers the growth and population of weeds, thereby indirectly controlled the weeds.

Different weed management practice recorded different WCE but the highest value at all the dates was recorded from weed free situation due to complete cleaning of weeds. It was followed by the practice of manual weeding at 15 and 35 DAS (W_3). However the efficiency of controlling weeds of the treatment quizalofop ethyl along with one hand weeding was slightly lower than W_3 at the final stage of observation. It was because of the fact that the treatment was as effective as hand weeding twice in controlling weed. Sarkar

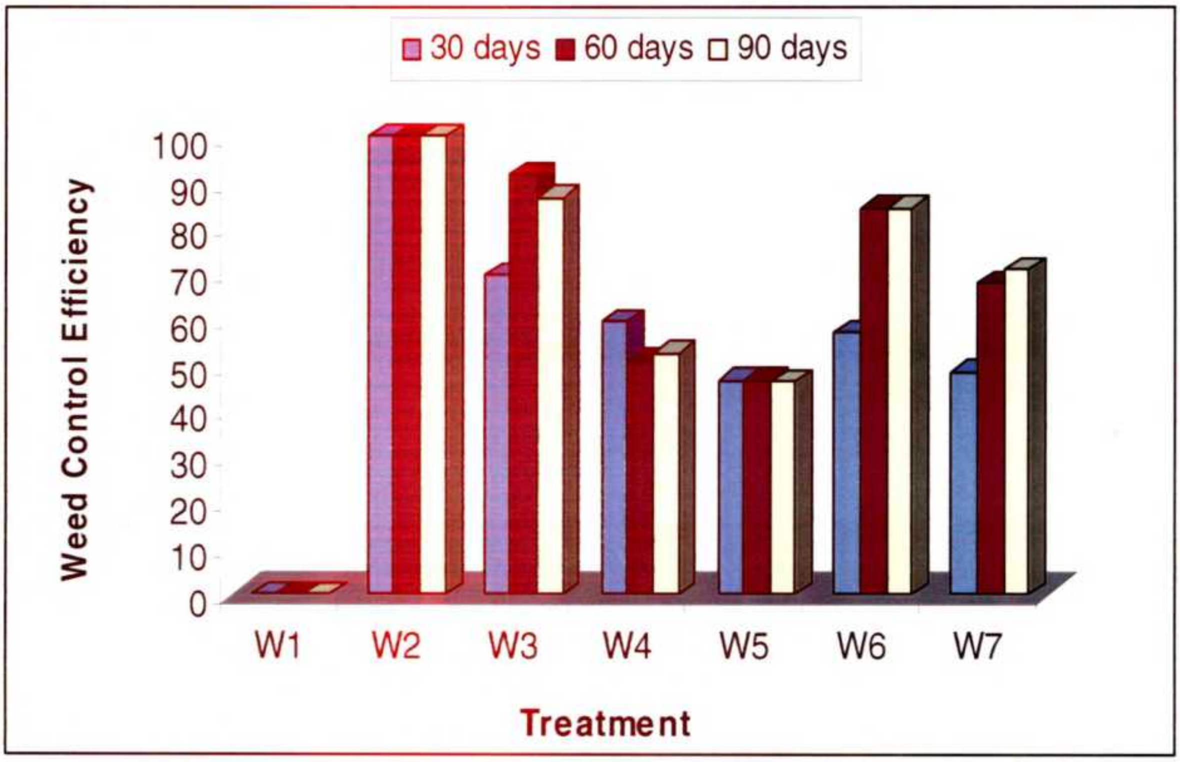


Fig. 15. Effect of Weed Management on weed control efficiency at 30, 60 and 90 DAS

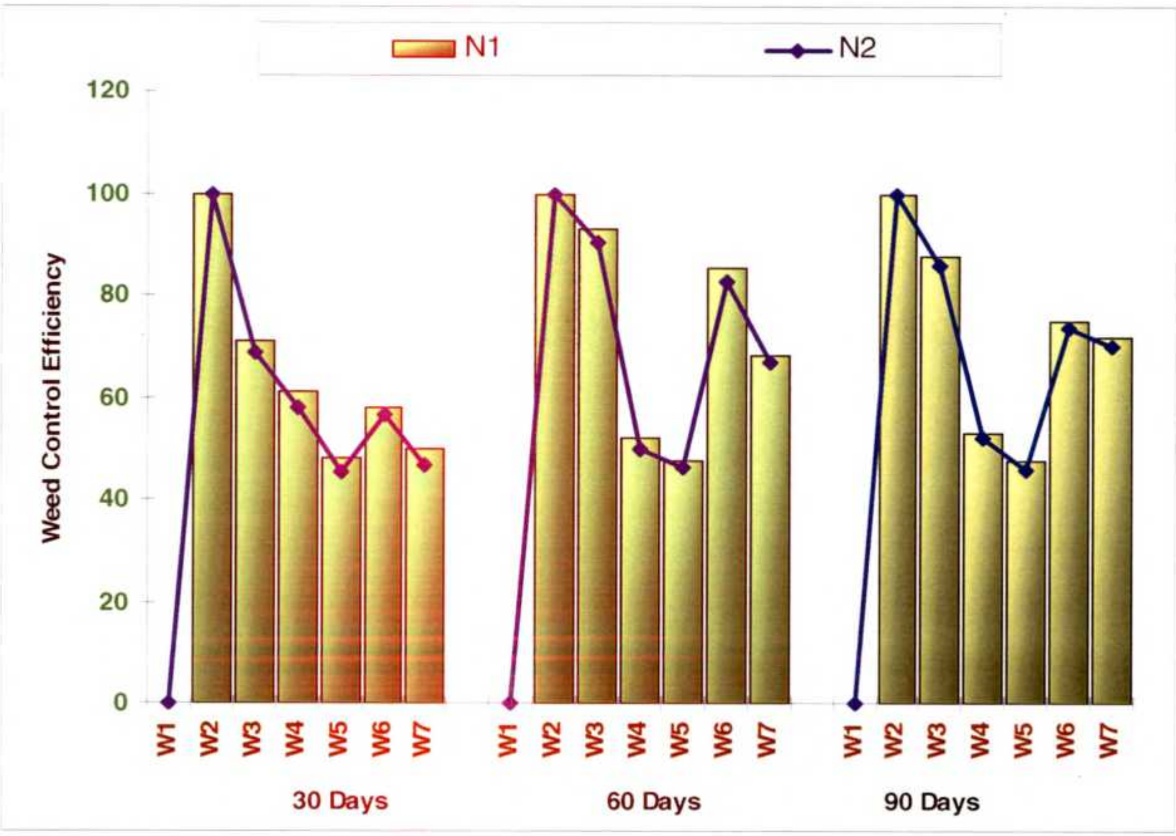


Fig. 16. Interaction Effect of Weed Management and time of Nitrogen application on Weed Control Efficiency at various growth stages

(2006) also expressed similarly. Due to severe crop-weed competition throughout the growth period there was no weed control efficiency of unweeded control treatment.

Due to the interaction effect of weed management and nitrogen application N_1W_2 and N_2W_2 recorded 100 % WCE as a result of complete removal of weed throughout the life span of jute. At 90 DAS, N_2W_3 recorded only 12.28 % higher WCE than N_1W_6. It indicated that the herbicide quizalofop ethyl effectively controlled weeds if provided one hand weeding at 35 DAS and nitrogen applied at 10 DAS, as twice hand weeding treatment combinations. At 30 DAS, only application of quizalofop ethyl combined with basal or without basal nitrogen effectively minimized weed population and dry weight as reflected by higher WCE than application of only pendimethalin along with basal or skipping basal nitrogen.

5.1.5 Production economics

The highest net return per rupee investment (2.03) was obtained from the treatment where quizalofop ethyl was applied followed by one hand weeding at 35 DAS (W_6) due to comparatively higher net return and lower total cost of production. On the contrary, due to lowest production in the unweeded control treatment, which was reflected on the net return and ultimately recorded lowest B:C ratio (0.83). Weed free treatment although produced highest net return due to highest fibre and stick yield than rest of the treatment but due to highest cost involved in weeding recorded lower B:C ratio. Sarkar (2006), working at West Bengal, also expressed similar opinion. Application of pendimethalin along with one hand weeding at 35 DAS (W_7) was superior than application of pendimethalin alone, which was reflected by the higher net return per rupee investment (1.74) of the treatment W_7. Due to higher treatment cost involved in twice manual weeding than herbicide application at 15 DAS coupled with one hand weeding at 35 DAS, recorded lower B:C ratio. Although W_6 recorded lower total return than W_2 and W_3 but due to lower treatment cost it showed higher net return per rupee investment than those treatments.

5.2 Blackgram

5.2.1 Seed yield

As during the cultivation of blackgram both the treatment N_1 and N_2 received same amount of fertilizer, there was no effect of the previous crop treatment on the yield of crop blackgram and for this reason the two treatments recorded more or less same seed yield.

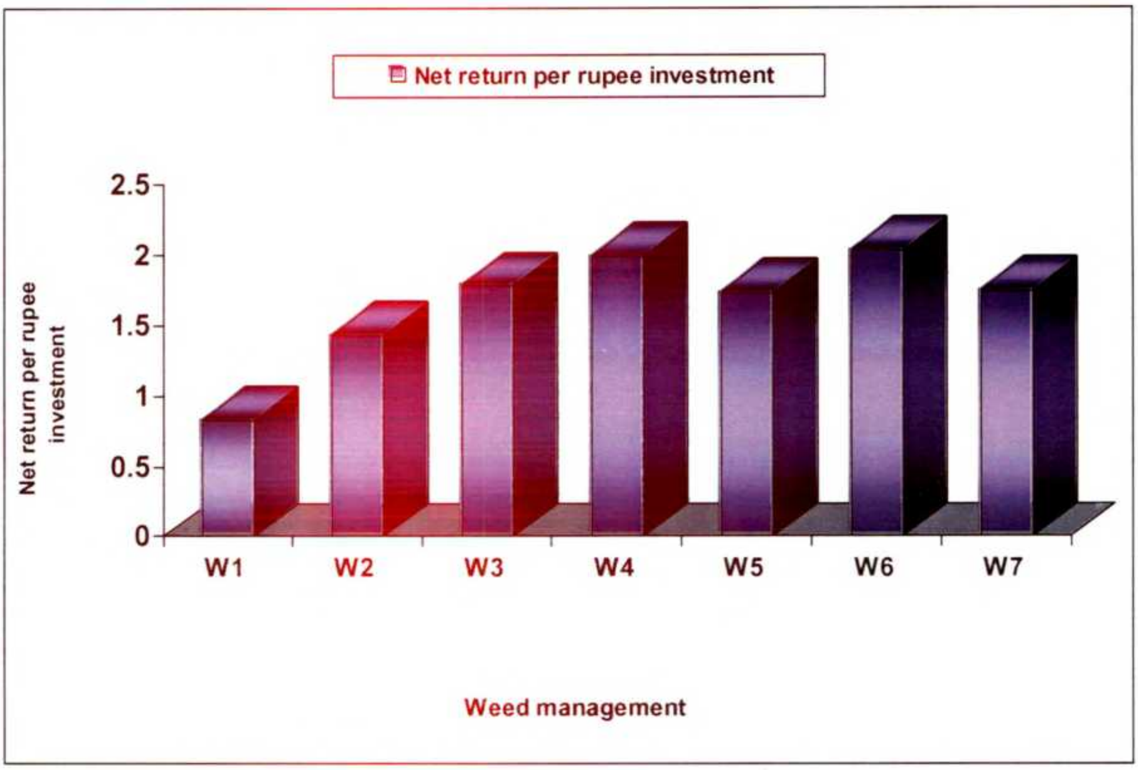


Fig. 17. Effect of weed management on net return per rupee investment of jute cultivation

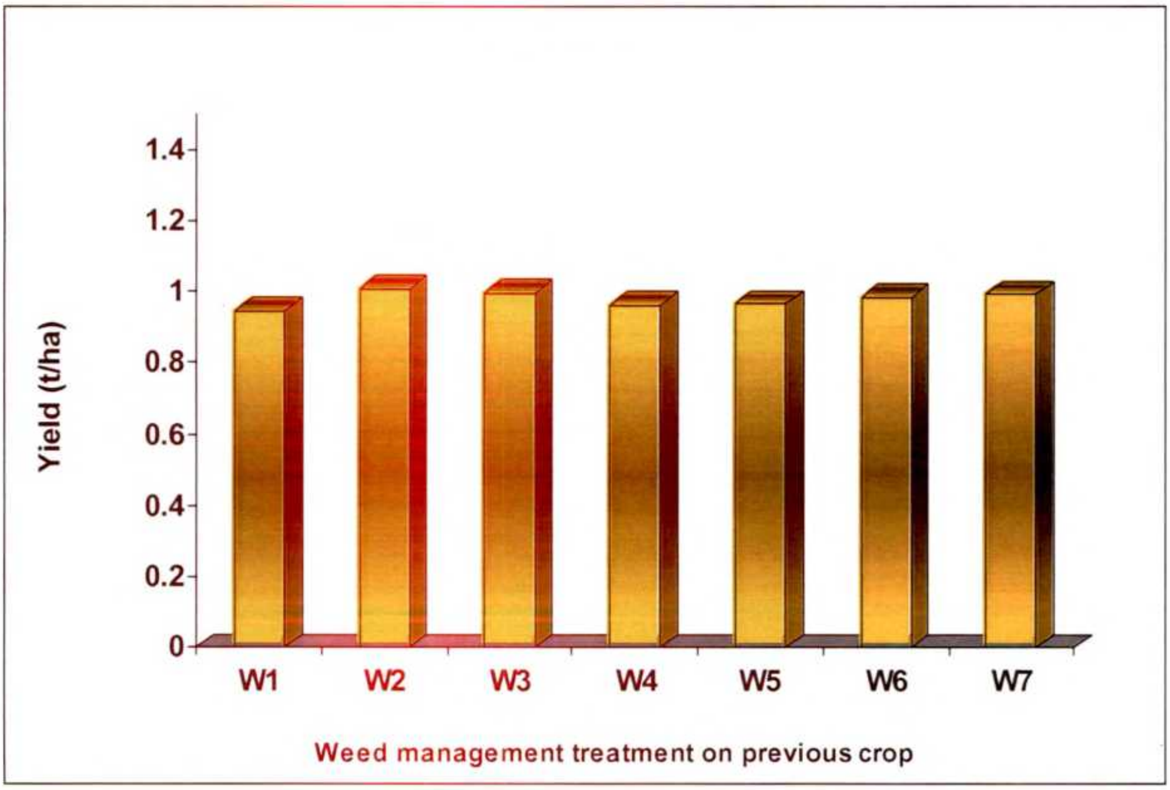


Fig. 18. Effect of weed management of previous crop on yield of blackgram

For the similar reason in the post plant weed management treatment in jute showed more or less similar effect on yield of blackgram. However, due to the effect of weed free situation throughout the life span of jute, recorded highest yield of blackgram. This might be due to less crop-weed competition in blackgram resulted from complete destruction of weed during the previous crop. It was followed by the yield obtained from hand weeded twice in jute treatment due to similar reason of lower crop-weed competition. Yield obtained from the plot received quizalofop ethyl or pendimethalin in jute showed no harmful effect on the yield of next crop blackgram, as revealed by the yield obtained from those plots. This coincides with the findings of Ghorai *et. al.,* (2004).

Regarding interaction effect, similar trend of observation was found for seed yield of blackgram. About 7.02 % higher seed yield was recorded from N_1W_2 than the treatment combination of N_2W_1. But for the rest of the treatment combinations more or less similar yield was recorded, as there was no significant effect of the previous crop treatment combination. Highest yield recorder treatment combination N_1W_7 clearly indicated that there was no deleterious effect of pendimethalin applied on the previous crop, on the next season blackgram.

5.3 Influence of pendimethalin on α-amylase activity of jute seed and different weed seeds during germination

Pendimethalin, an important herbicide of dinitroaniline group, is used to control weeds in many upland crops including pulses and oilseeds (Yadav *et al.,* 1984). These are applied to the soil primarily to inhibit germination and growth of undesirable plant. During germination the stored food materials are hydrolysed by various enzymes to provide energy and raw materials for synthesis of other biomolecules for the production of healthy and normal seedlings. Any change in the pattern of hydrolysis of reserved food materials will adversely affect the growth and development of seedlings resulting in abnormality.

The activity of α-amylase in seeds during germination increased with passage of time both in crop (jute) as well as in weed species (Table 4.33). In general, the α-amylase activity in seeds decreased with the application of herbicide (pendimethalin) as compared to no herbicide (control). Faster degradation of reserved food material (starch) was necessary to enhanced α-amylase activity.

Among the different weeds, tubers of *Cyperus rotundus* have showed higher α-amylase activity and minimum inhibition of that particular enzyme which helped the degradation (hydrolysis) of starch to maltose. This result is in conformity with the findings of Mandal (2005). The seeds of grass weeds have showed higher initial α-amylase activity (141.67 – 186.00 μg maltose released per gram fresh tissue per minute) and maximum inhibition of the same on treating with pendimethalin (28.97 – 34.43%) after 48 hours. Jute seeds also recorded reduction of 18.55 % in α-amylase activity at 48 hours after treatment, which hampered the hydrolysis of starch to maltose. In addition to these, pendimethalin also hampered the assemblification of microtubules (polymerization of tubulin, the major protein content), which is very much essential for formation of cell wall, as a result arrestation of cell division, formation of polynucleate cells and eventually inhibition of root and plant growth (Hess, 1987; Vaughen and Lehnen,1991).

Chapter-6

SUMMARY AND CONCLUSION

Jute (*Corchorus* sp) is one of the important commercial fibre crop next to seed fibre cotton. Among several bottlenecks, one of the great problem to achieve high yield is the heavy infestation of obnoxious weeds in jute crop field during the early growth stages. A loss of 50-80 % in fibre yield due to weed was reported by Mishra, 1997. The problem of nutrition is largely associated with growth, yield and quality of fibre and as well as with crop-weed competition. To find out the proper eco-safety and economically sound management practice, a field experiment on "Influence of Nitrogen and Weed Management on Tossa Jute and their treatment effect on Blackgram "was conducted in the typical Gangetic alluvium (Inceptisol) and sandy loam soil of 'C' Block Farm, Kalyani (23.5°N latitude, 89°E longitude and 9.75 m AMSL) of Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, during *pre-kharif* and *kharif* seasons of 2003 and 2004. The primary studies were the effect of different weed management practices, effect of skipping basal nitrogen on the weed crop competition, yield of jute and also their interaction effect on growth and yield of jute. The experiment was laid out in split plot design where two nitrogen management were placed in the main plots while seven treatments comprising of both chemical and mechanical methods were considered either solely or in combination in the sub plots, replicated thrice.

During both the year, jute was infested by all categories of weeds viz. grass, sedge and broad leaved weeds but among them grasses and sedges are the dominant weed flora in the experimental field. The predominant grassy weeds were *Cynadon dactylon* (L.), *Echinocloa colonum* (L.), *Brachiaria ramose, Eleusine indica* Gaertn., *Digitaria sanguinalis, Dactyloctaneum aegypticum* and sedges were *Cyperus rotundus* L. Among the broadleaf weeds *Digera arvensis, Physalis minima* were the predominant species.

In main plot treatment, the densities as well as the biomass of all categories of weeds were lower under the treatment where basal nitrogen was skipped (N_1) as compared to the treatment which received 50 % nitrogen as basal (N_2). This might be due to lower competing ability of weeds with the crop in absence of basal nitrogen. Among the post-plant weed management treatments, as normally found, unweeded control (W_1) recorded the maximum and weed free plots (W_2) recorded the minimum population and dry weight of all categories of weeds. Whereas, hand weeding (W_3) at 15 DAS effectively controlled all the weeds and the same at another 20 days later also able to control second flash of the available weeds. The grass and sedge weeds at 60 DAS, recorded lower population recorded from the treatment which received quizalofop ethyl @ 50 g ha $^{-1}$ as post emergence herbicide at 15 DAS along with one hand weeding at 35 DAS (W_6) than hand weeding twice at 15 and 35 DAS (W_2). This might be due to better efficacy of the herbicide quizalofop ethyl to control grassy weeds, along with one hand weeding. Incase of broadleaf weeds, at 60 and 90 DAS higher population and weed biomass were obtained from the treatment W_6 as compared to W_2. The reason behind this was the lower effectiveness of quizalofop ethyl in controlling broadleaf weeds. Interaction effect of treatments on grass and sedge weeds at 60 and 90 DAS did not show any statistical difference in regards to population and biomass from the treatment combinations, where quizalofop ethyl was applied at 15 DAS followed by one hand weeding at 35 DAS in combination with either basal nitrogen (N_1W_6) or without basal nitrogen (N_2W_6), with hand weeding twice plots (N_1W_3 and N_2W_3).

The plant height, basal diameter and LAI of jute were more in the plots where basal nitrogen was skipped (N_1) than plots with basal nitrogen application (N_2), at all the dates of observation. This might be due to lower weed density and biomass in the N_1 treatment that leaded to less competition of weeds for growth resources and supply of nitrogen after germination of jute and thus both of which results better plant growth of jute. Among weed management treatments, application of quizalofop ethyl at 15 DAS followed by one hand weeding at 35 DAS (W_6), which effectively reduced competition of the crop with the weeds of all categories, specially grasses and sedges, showed higher growth and yield attributes like plant height, basal diameter, LAI, etc. than application of only quizalofop ethyl (W_4) or pendimethalin (W_5) or even pendimethalin along with one hand weeding (W_7), by making growth resources more available to the crop. As a result, higher total dry weight of jute as well as higher CGR was found from the treatment W_6. Application of nitrogen at 10 DAS followed by application of quizalofop ethyl at 15 DAS coupled with one hand weeding at 35 DAS (N_1W_6) recorded higher plant height at 50, 75 and 100 DAS than the treatment twice hand weeding coupled with application of basal nitrogen (N_2W_3). This might be due to the fact that quizalofop ethyl controlled grassy and sedge weeds in a better way along with one hand weeding when basal nitrogen was not applied than where it was applied along with only hand weeding.

Pooled data showed 9.76 % higher fibre yield from the treatment where nitrogen was applied at 10 DAS without basal nitrogen (N_1) than the treatment received nitrogen as basal dose (N_2). This was mainly due to higher growth and yield attributing characters like plant height, basal diameter, LAI, etc. resulted from lower crop-weed competition and higher availability of nitrogen after emergence of the crop. Application of quizalofop ethyl at 15 DAS coupled with one hand weeding at 35 DAS (W_6) produced only 5.72 % lower fibre yield and 6 % lower stick yield than presently followed the tedious two hand weeding (W_3) but 23.92 % and 19.29 % higher fibre and stick yield, respectively than application of only pendimethalin at 1 DAS (W_5). The important reason behind this was effective weed controlling ability of quizalofop ethyl along with one hand weeding at 35 DAS and at the same time lower ability of pendimethalin alone to control the weeds. However, application of quizalofop ethyl alone at 15 DAS (W_4) controlled the weeds in a better way than pendimethalin alone at 1 DAS (W_5), which was reflected on the growth and yield parameters and ultimately on fibre and stick yield of jute. Better weed controlling ability of quizalofop ethyl along with nitrogenous fertilizer after emergence of crop (N_1W_6) results 62.16 % and 52.94 % higher fibre and stick yield respectively than N_2W_1. This might be due to the favourable condition for better growth and yield attributing characters of jute, which was reflected on the fibre and stick yield of jute. Pendimethalin was less effective in controlling weed than quizalofop ethyl as has been noticed from the fibre and stick yield of jute.

Lower availability of nitrogen during germination of weed hampers the growth and population of weeds; thereby indirectly controlled the weeds as revealed from the WCE of the treatment where basal nitrogen was not applied as compared to the treatment received basal nitrogen. The efficiency of controlling weeds of the treatment quizalofop ethyl along with one hand weeding was slightly lower than manual weeding at 15 and 35 DAS at the final stage of observation, because of the fact that this treatment was as effective as hand weeding twice in controlling weed. At 30 DAS, only application of quizalofop ethyl combined with basal or without basal nitrogen effectively minimized weed population and dry weight as reflected by higher WCE than application of only pendimethalin along with basal or skipping basal nitrogen.

All the treatments did not show any harmful or adverse effect on the yield of the following crop blackgram, which clearly indicated the safety of the herbicides used for the next season crop.

Influence of pendimethalin on α-amylase activity during germination of crop (jute) and dominant weed seeds was studied in laboratory condition at different intervals. The α-amylase activity is expressed in μg maltose released per gram of fresh tissue per minute. The α-amylase activity in seeds decreased with the application of herbicide (pendimethalin) as compared to no herbicide (control). Among the different weeds, tubers of *Cyperus rotundus* have showed higher α-amylase activity and minimum inhibition of that particular enzyme which helped the degradation (hydrolysis) of starch to maltose. The maximum reduction of α-amylase activity was found in seeds of *Echinochloa colona* (34.43%) at 48 hours after treatment followed by *Eleusine indica* (30.0%) and *Digitaria sanguinalis* (28.97%). Jute seeds also recorded reduction of 18.55% in α-amylase activity at 48 hours after treatment, which hampered the hydrolysis of starch to maltose.

The highest net return per rupee investment (2.03) was obtained from the treatment where quizalofop ethyl was applied followed by one hand weeding at 35 DAS (W_6) due to comparatively higher net return and lower total cost of production. Due to higher treatment cost involved in twice manual weeding than herbicide application at 15 DAS coupled with one hand weeding at 35 DAS, recorded lower B: C ratio.

Therefore, from this experiment conducted in this Inceptisol it may be concluded that application of 50 % of nitrogenous fertilizer at 10 DAS of jute by skipping the basal nitrogen followed by application of quizalofop ethyl @ 50 g ha^{-1} at 15 DAS coupled with one hand weeding at 35 DAS could be able to manage effectively the most problematic grass and sedge weeds of jute and increasing the fibre and stick yield with higher net return per rupee investment. In spite of the fact that weed free treatment gave highest fibre and stick yield followed by hand weeding twice treatment (at 15 and 35 DAS), yet considering the economic factor the best weed management method in tossa (olitorius) jute was application of quizalofop ethyl along with one hand weeding (W_6). Therefore, for jute, skipping of basal nitrogen and application of 50 % of nitrogenous fertilizer at 10 DAS and remaining part in two equal splits at 20 and 40 DAS followed by application of quizalofop ethyl @ 50 g ha^{-1} at 15 DAS coupled with one hand weeding at 35 DAS, proved best amongst all the treatment combinations used in this experiment and can be safely recommended for jute based cropping systems in this Gangetic alluvial plains of West Bengal.

Chapter-7

FUTURE SCOPE OF RESEARCH

Future Scope of Research

The field experiment was conducted at the alluvial region (Inceptisol) of West Bengal to study the effect of different weed management practices and effect of skipping basal nitrogen on the weed crop competition and yield of jute and also their interaction effect on growth and yield of jute. But still there are some scopes to conduct some more work on it. The scopes for future research noticed during the investigation are as followed –

- Residual effect of these herbicides both in soil and plant may be investigated in addition to their effect on ground water and other components of the environment.
- Under different agro-climatic situations of West Bengal, similar type of experimented may be conducted.
- Effect of skipping basal nitrogen on insect pest, disease pathogen and soil nematodes can be studied further.
- Proper eco-safety management on the basis of critical crop-weed competition period may be studied.
- The selectivity of herbicide pendimethalin was tested only with hydrolytic enzymes specially α – amylase. This may be done with other hydrolytic enzymes like β-amylase, Lipase, Protease, etc. and also in many other enzymes which are under the control of Gibberellins.
- The selectivity of quizalofop ethyl may also be studied
- Compatibility of these herbicides with fertilizer and other pesticides may be examined.
- Effect of these treatments on quality of jute fibre may be studied in detail.

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