Studies on Nutrient and Weed Management in Winter Babycorn (*Zea mays* L.) under the Gangetic Alluvium of West Bengal

A
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in
AGRONOMY

By
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2010

DEDICATED

TO MY

BELOVED PARENTS

AND

HUSBAND

"Santanu"

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

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Certificate

This is to certify that the work recorded in the thesis entitled ***"Studies on Nutrient and Weed Management in Winter Babycorn (Zea mays L.) under the Gangetic Alluvium of W.B."*** *submitted by* ***Sangita Jana*** *in partial fulfillment of the requirements for the award of the Degree of Doctor of Philosophy in Agriculture (Agronomy) of the Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal is the faithful and bonafide research work carried out under my personal guidance and supervision. The results of the investigation reported in this 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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List of Abbreviations

%	:	Percent	l	:	Litre
@	:	At the rate of	m^{-2}	:	per square meter
/	:	Per	Rs.	:	Rupees
C.D.	:	Critical difference	K	:	Potassium
cm	:	Centimeter	M	:	Metre
cv.	:	Cultivar	mm	:	Milimetre
DAS	:	Days after sowing	m^2	:	Metre square
°E	:	Degree east longitude	Max.	:	Maximum
e.g.	:	examli gracia (for example)	MOP	:	Muriate of potash
et al.	:	et alia (and others)	N	:	Nitrogen
etc.	:	et cetera	NS	:	Not significant
Expt.	:	Experiment	No.	:	Number
Fig.	:	Figure	P	:	Phosphorus
g	:	Gram	µ mol	:	micromole
ha	:	Hectare	ppm	:	Parts per million
i.e.	:	id est (that is to say)	S.Em	:	Standard error of mean
°C	:	Degree Celsius	sp.	:	Species
kg	:	Kilogram	SSP	:	Single super phosphate
t	:	Tonne	µg	:	microgram
DAA	:	Days after application	Min	:	Minimum
Sec	:	Second	&	:	and
hr	:	Hour	WP	:	Wettable powder
CGR	:	Crop growth rate	G	:	Granule
FYM	:	Farm yard manure	CPE	:	Cumulative pan evaporation
HW	:	Hand weeding	pH	:	Log^{10} hydrogen ion concentration
Viz.	:	Videlicet (such as)			

Abstract

The cultivation of babycorn has enormously been successful as an export venture in Thailand, China and Taiwan. Its sweet flavour and crisp nature contributes in increasing popularity in India as a high value crop. However, the lack of knowledge of use and production technology seems to be the major constraints for popularization among cultivators. Of the various practices, nutrient and weed management play a vital role in its context. Nitrogen is considered to be the most limiting factor for realizing higher yield. Organic sources of nutrients can be advocated to field crops to maintain sustainability of crop productivity and soil fertility. Further, heavy fertilization and wide spacing of the crop as well as slow growth at early stage during winter season encourage severe weed infestation, resulting in drastic reduction of babycorn yield. Keeping this in view, two field experiments were taken on irrigated babycorn (cv. Early Composite) during *rabi* season of 2005-06 and 2006-07 at Instructional Farm (sandy-clay loam) of BCKV, Jaguli, Nadia, under the Gangetic Alluvium of West Bengal, i) to study the effect of organic manures (vermicompost, FYM) and nitrogen fertilizer on growth, yield attributes, yield, quality and nutrient uptake of babycorn and to evaluate their residual effect on soil fertility; ii) to evaluate the efficacy of different weed control methods on growth and yield of babycorn and iii) to analyze the economics of the nutrient and weed management practices.

The experiment I (Nutrient management) was consisting of five main-plot treatments viz., No organic manure (M_0), vermicompost @ 2 t ha^{-1} (M_1), vermicompost @ 4t ha^{-1} (M_2), FYM @ 5 t ha^{-1} (M_3) & FYM @ 10 t ha^{-1} (M_4); and four sub-plot treatments viz., without N fertilizer (N_0), 60 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2) & 180 kg N ha^{-1} (N_3), in a split-plot design with three replications. Experiment II (Weed management) comprised of seven treatments like - Atrazine @ 2 kg a.i. ha^{-1} (W_1), Metribuzin @ 2 kg a.i. ha^{-1} (W_2), Straw mulching @10 t ha^{-1} (W_3), 2 HW at 20 and 40 DAS (W_4),

Atrazine @ 1 kg ha^{-1} + HW at 30 DAS (W_5) and Metribuzin @ 1 kg ha^{-1} + HW at 30 DAS (W_6) and Weedy check (W_7) in a randomized block design with three replications.

The results of the experiment I revealed that vermicompost @ 4t ha^{-1} (M_2) treatment produced maximum number of cobs $plant^{-1}$ (2.25), babycorn yield (1521 kg ha^{-1}) and green fodder yields (46.45 t ha^{-1}) and quality parameters (reducing sugar, total sugar, protein and TSS), followed FYM @ 10 t ha^{-1} (M_4). Again, the yield attributes, yield and quality of babycorn was significantly higher with 120 kg N ha^{-1} (N_2). However, the interaction effect showed significantly highest results in terms of above characters with vermicompost @ 4t +120 kg N ha^{-1} (M_2N_2), which was at par with vermicompost 4t +180 kg N ha^{-1} (M_2N_3). The higher benefit: cost ratio was obtained with FYM @ 5 t + 120 kg N ha^{-1} (M_3N_2) treatment. Similarly, the maximum effect of treatments on residual soil fertility (total soil N, available P and K content after harvest of babycorn) was observed in vermicompost @ 4 t + 180 N kg ha^{-1}.

The results of the experiment II showed that among weed control treatments, the highest weed control efficiency, yield attributes and yield of babycorn (1464 kg ha^{-1}) was in 2 HW at 20 and 40 DAS (W_4), followed by Straw mulching @ 10 t ha^{-1} (W_3). However, the integration of herbicides coupled with hand-weeding i.e. Atrazine @ 1 kg ha^{-1} + HW at 30 DAS (W_5) or Metribuzin @ 1 kg ha^{-1} + HW at 30 DAS (W_6) exhibited superiority over the respective herbicide alone (Atrazine @ 2 kg a.i.ha^{-1} or Metribuzin @ 2 kg a.i. ha^{-1}). The benefit: cost ratio was also highest with W_4 treatment. Straw mulch treatment showed the maximum favourable effect on the soil microbial growth, however, the toxic effect of herbicides on the bacterial population being recovered at 25 DAS onwards.

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CHAPTER 1

Introduction

Introduction

Agricultural production systems have reached a so called plateau and therefore, time has come to boost the profits through diversification and sustainable agriculture. There is ample scope for inclusion of a number of new crops in conventional cropping system. Babycorn is one such new crop, which can improve the economic status of poor farmer and will help in boosting up the agricultural development in the near future in India. A crop of Babycorn gets ready within 45 - 60 days. Being a very short duration crop farmer can grow it 3 to 4 times in a year depending upon the agro-climatic conditions and can also be a substitute in times of crop failure. Therefore, babycorn is not only a cash crop but also a very good catch crop.

In the real sense babycorn is the plant of maize (*Zea mays*) in its early reproductive stage. Babycorn is the baby phase of maize cob, which is picked up at a very tender stage with more than 80% moisture content or just after silk emergence. Babycorn is a very important crop since it has so many uses.

1) The tender cobs are consumed raw as a natural food. It is very tasty, sweet and easy to consume because of its tenderness and sweetness with nutritive value addition.
2) It can be used as a vegetable in daily culinary preparation and for preparing delicacies for special occassion.
3) It is also processed and consumed with juices of fruit, vegetables, meat, egg and several dishes are served in star hotels.
4) After harvesting, besides the stalk leaves amounting to 15 - 20 t/ha, husk and silk amounting to 2.4 t/ha are used is animal feed of high digestibility.

But at present babycorn is mainly grown for vegetable purpose. This venture has proved enormous success in countries like Thailand, Taiwan, Sri Lanka and Myanmar. The countries like Guatemala, Zambia, Zimbabwe and South Africa have started its cultivation. Today Thailand and China are world leaders in babycorn production. It is a widely accepted crop and habituated as a cereal vegetable in USA, Europe and in some Asian countries.

In our country the cultivation of babycorn is of recent development. It's cultivation is now picking up in a serious way in Meghalaya, Western U.P., Haryana, Maharastra, Karnataka, Andhra Pradesh and West Bengal.

Attention is now being paid to explore its potential in India for earning foreign exchange and economic returns to the farmers since there are so many prospects of babycorn cultivation in our country.

1) Cultivation of babycorn generate employment for the rural poor since, 3 – 4 crops can be raised in a year.

2) Canning and pickling industries of babycorn offers huge export potential and provides employment to the youth.

3) Demand for babycorn as a health food is increasing in class hotels and middle class consumers.

4) The soft, nutritious, palatable green fodder has a high market demand. Therefore there is ample scope of growing babycorn in the areas where maize is grown for fodder purpose.

Besides these, the nutritional value of babycorn is also very high (Table 1.1). Its protein content is 1.9 g / 100 g of babycorn and it is comparable with other vegetables like cauliflower, cabbage and tomato. It's carbohydrate content is higher than cauliflower, cabbage and tomato. It is rich in calcium and its content is 28 mg / 100 g. It's P content is very high and it is 86 mg/100 g and higher than other vegetables. It's vitamin c content is higher than cauliflower and it is 11 mg/100 g.

Table 1.1: Nutritive value of babycorn / 100 g as compared with other vegetables

Nutrition	Babycorn	Cauliflower	Cabbage	Tomato
Moisture (%)	89.10	90.30	92.10	94.10
Fat (g)	0.20	0.04	0.20	0.20
Protein (g)	1.90	2.40	1.70	1.00
Carbohydrate (mg)	8.20	6.10	5.30	4.10
Ash (g)	0.06	0.80	0.70	1.60
Calcium (mg)	28.00	34.00	64.00	18.00
phosphorus (mg)	86.00	50.00	26.00	18.00
Iron	0.10	1.00	0.70	0.80
Thiamin (mg)	0.05	0.06	0.05	0.06
Riboflavin (mg)	0.08	0.08	0.05	0.04
Ascorbic acid (vit c/mg)	11.00	10.00	62.00	29.00
Niacin (mg)	0.03	0.70	0.69	0.60

Source : Yodpet, 1979.

Babycorn, being an exhaustive feeder, requires substantial amount of nutrients for higher productivity. The major constraints for achieving potential yield is the problems associated with crop nutrition and soil fertility. Present day agricultural system relies heavily on the continuous application of pure and high analysis fertilizers, resulting depletion of several plant nutrients as well as deterioration in certain physical properties of soil and a consequent decline in their yields has raised the question with regard to the sustainability of this system. While maintaining the soil fertility as well as sustainability of crop production, the use of the FYM, vermicompost and green manure has assured great significance in conjunction with chemical fertilizers (Singh and Biswas, 2000).

Nitrogen, a key element, is considered to be the most limiting factor for realizing higher yields. An adequate supply of nitrogen to babycorn is associated with efficient source to sink relationship leading to higher productivity (Pandey *et al.*, 2000). However, use efficiency of applied N fertilizer by most crops ranges from 20 to 60% (Aulakh *et al.*, 1992).

Hence, to sustain maximum productivity, increase fertilizer use efficiency and restore soil fertility, balance and integrated nutrient management approaches involving organic manures like FYM, vermicompost and inorganic N need to be standardized for babycorn.

Babycorn is heavily fertilized and widely spaced, both these attract a severe weed infestation that result into a drastic reduction in crop yield. Moreover, slow crop growth at early stage during winter season and frequent irrigation aggravate the situation. This yield reduction ranges from 20 to 50% depending on climate (Bhan, 1998).

Hence, to have higher productivity levels, proper weed management strategies are equally important and need to be standardized for babycorn grown in a specific agro-climatic situation.

Considering the above facts, the present investigation is undertaken with the following objectives –

a) To study the effect of organic manuring (vermicompost, FYM) and nitrogen fertilization on growth, yield attributes, yield, quality, and nutrient uptake of babycorn.

b) To formulate a sustainable production technology by combining organic and inorganic sources of nitrogen for maximization of babycorn yield.

c) To evaluate the residual effect of organic and inorganic fertilization on soil fertility.

d) To evaluate the efficacy of different weed control methods in babycorn and their impact on soil micro-flora.

e) To analyze the economics of the nutrient and weed management practices.

CHAPTER 2

Review of Literature

Review of Literature

2.1 Experiment – I: Nutrient management in babycorn

2.1.1 Effect of nutrient management on growth and development of baby corn

Sadiq *et al.* (2005) reported that the highest NP levels (180 : 90 kg N : P/ha) significantly delayed silking (60.25 days), increased plant height (176.8 cm), cobs per plant (1.50), 1000 grain weight (281.0 g) and grain yield (4272 kg/ha) of maize.

Sofi *et al.* (2005) reported that the grain and stover yield were increased significantly with each increament of nitrogen upto 160 kg/ha. The growth attributes (plant height, number of leaves per plant and plant dry weight also exhibited the same trend.

Panwar and Munda (2006) observed that the application of N at an increased level reduced the number of days to babycorn initiation, but increased the harvest period.

Singh *et al.* (2003) reported that plant height, number of green leaves at 120 DAS, dry matter production at 120 DAS, number of cobs per plant, recorded the highest values when N applied at 210 kg/ha, but these values were at par with those obtained with N at 180 kg/ha in maize.

De-Polli (1992) sated that drymatter production and total N content of the above ground parts of the plants were increased by increasing N rates.

Dia-Silva and De-Carvalho (1994) reported that plant height at 30 DAS, Leaf Number at 30 and 60 DAS and Leaf CP content increased with increasing N rate. Plant height at 60 DAS and dry matter production increased when K was applied with N. Stem CP percentage increased with increasing N rate.

A field experiment was conducted during the rainy season at Bhubaneswar to study the effect of N levels (40, 80 and 120 kg N/ha) and the timing of nitrogen application (1/2 basal + 1/2 at 25 DAS, 1/3 basal + 2/5 at 25 DAS + 1/4 at pre tasselling, 40 DAS) and 1/3 basal + 1/3 at 25 DAS + 1/3 at pre taselling along with non-nitrogen. Growth, yield attributes, babycorn yield increased significantly up to 120 kg N/ha. The difference between 80 and 40 kg N/ha were also significant. Nitrogen application in 3 levels splits as 1/3 basal + 1/3 at 25 DAS + 1/3 at pre tasselling (40 DAS) resulted in significantly higher growth, yield attributes, marketable babycorn yield (Bindhani and Mahapatra 2007).

A field experiment was conducted during rainy season at Central Research Station, OUAT, Bhubaneshwar to study the effect of planting geometry and nitrogen on sweet corn (*Zea mays* L.) c.v. 'Madhuri'. There are five N levels (0, 20, 40, 60 and 80 kg/ha). Application of 80 kg N/ha produced significantly highest number of prime cobs (62, 328 /ha), green cob yield (9.80 tonnes/ha), length (17.5 cm) and girth (16.7 cm) of cobs, green-forage yield (17.35 t/ha) and total N uptake (91.2 kg/ha). It was followed by 60 and 40 kg N/ha (Kar *et al.*, 2006).

Lourduraj (2006) reported that application of 100% recommended NPK along with 5t vermicompost is the optimum combination based on plant height and dry matter production.

Kumar and Puri (2001) reported that application of 90 kg N and 15 t FYM/ha resulted in maximum plant height.

Keskin *et al.* (2005) reported that plant height and plant weight of maize increased but stem ratio decreased with increasing N levels.

Vadivel *et al.* (2001) reported that maximum plant height, LAI, dry matter of maize and higher grain yield of maize obtained with 60 kg N/ha.

2.1.2 Effect of nitrogen on yield and yield attributing characters of babycorn

Tank *et al.* (2006) reported that nitrogen levels differed significantly on growth, yield and yield attributes. Among the different levels of nitrogen, application of nitrogen @ 180 kg N/ha produced significantly the highest no. of grains / cob, 1000 grain weight over control and 60 kg N/ha.

Kumar *et al.* (2005) reported that the total grain production of maize was higher when crop in the system was given 150% of the recommended NPK.

Panwar and Munda (2006) reported that the application of nitrogen at an increased level increased the babycorn and green fodder yield up to 80 kg N/ha, while nitrogen uptake was greatest with 120 kg N/ha.

Jayaprakash *et al.* (2004) reported that application of 200% recommended dose of fertilizer (150 : 75 : 37.5 kg NPK / ha) recorded significantly higher grain yield over application of 125 and 100% recommended dose of fertilizer application

Sahoo and Panda (1997) reported that application of 120 kg N/ha gave the highest yield of babycorn in winter season.

Meena *et al.* (2007) reported that yield attributes viz., no. of cobs / plant, no. of grains / plant, grain weight / plant, cob length and cob diameter increased significantly with application of nitrogen 120 kg N/ha. It also resulted in highest grain and straw yields and net realization as compared to other treatments.

Tiwari *et al.* (2004) reported that application of 90 kg N/ha significantly increased the mean yield by 28.49% over the control.

Kumar *et al.* (1992) reported that application of 225 kg N/ha results 13.72% and 2.47% more grain yield than 125 kg N / ha and 175 kg N / ha respectively.

Keskin *et al.* (2005) reported that green herbage yield, dry matter yield, ear no. per plant increased with increasing N level.

Porwal (2000) reported that application of N at 150 kg/ha recorded the highest grain stover yield.

Parmar and Sharma (2001) reported that the grain and stover yield of maize increased significantly up to 120 kg N/ha applied.

Sundar Singh (2001) reported that significant yield increase of both young cob and stover was recorded up to 150 kg N/ha and it was comparable with 180 kg N/ha.

Thakur *et al.* (1998) reported that babycorn yield increased significantly with increasing N rate up to a plateau at 150 kg/ha, cob and green fodder yields increased significantly up to 200 kg N/ha.

Banerjee *et al.* (2004) reported that increasing levels of N up to 150 kg/ha significantly increased the grain yield.

Singh and Totawat (2002) reported that application of 90 kg N / ha increased maize grain and stover yield, yield attributes and nutrient uptake.

Paliwal *et al.* (1999) reported that the yields, values of yield components and N, P and K uptake increased with increasing N rates.

Tyagi *et al.* (1998) reported that yield of spring maize increased with increasing N rates.

Maurya *et al.* (2005) reported that application of 150 kg N/ha significantly increased all the yield attributes i.e. number of cobs per plant, length of cobs, number of grains per cob and 1000 grain weight of maize. The highest grain and stover yields (46.44 and 84.86 q/ha) were obtained with the application of 150 kg N/ha. The highest net profit (Rs. 18,827) and benefit : cost ratio (2.58) were also obtained from this treatment. The highest mean value of harvest index (35.65%) was recorded with 150 kg N/ha but it was at par with 100 kg N/ha. All the treatments of N significantly enhanced the N uptake by grain and stover over no N.

Shivay *et al.* (2002) stated that grain yield, protein content and protein yield of maize significantly increased in intercropping with grain legumes over sole maize. The maximum grain yield (3.27 and 3.22 tonnes/ha) of maize was recorded in maize + black gram intercropping system and was significantly higher than that recorded in maize + black gram intercropping system and was significantly higher than that recorded under sole maize but was at par with maize + soyabean. Cob number, cob length, cob diameter, grains/cob, 1000 - grain weight, grain and stover yields, protein content and protein, yield of maize increased significantly with increasing doses of N applied to maize. The highest protein yield of maize was recorded with 120 kg N/ha and was significantly higher than other levels of nitrogen.

2.1.3 Effect of vermicompost on yield and yield attributing characters of babycorn

Jayaprakash *et al.* (2003) reported that significantly highest grain yield of maize was obtained with the application of vermicompost at 2 t/ha and was on par with the grain yield obtained with the application of FYM at 10 t/ha. .

Kumar *et al.* (2007) reported that application of vermicompost @ 2.5 t/ha recorded significantly higher yield and yield attributes of maize.

Pawar and Patil (2007) reported that maximum grain yield of maize was obtained due to combined application of vermicompost at 5 t/ha and 100% recommended dose of fertilizer.

Khadtare *et al.* (2006) reported that the yield and yield attributing characters like cob girth, cob length, cob weight, green fodder yield of sweet corn were significantly increased by the application of 25% recommended dose of nitrogen (150 kg N/ha) through vermicompost.

Meena *et al.* (2007) reported that significantly higher grain and stover yield of rabi maize were obtained with application of 1.5 t vermicompost / ha than 1.0, 0.5 t/ha and control.

2.1.4 Effect of FYM on yield and yield attributing characters of babycorn

Application of 100% recommended N through FYM recorded maximum test weight of maize (Kumpawat, 2004).

Application of FYM @ 10 t/ha increased the no. of cobs per plant, no. of grains per cob, 100 grain weight, grain and seed yield of maize (Mahala and Shaktawat, 2004).

Brar (2001) reported that grain yield, straw yield and nutrient uptake increased significantly from application of FYM 10 t/ha to 40 t/ha. Similar increases were observed with the application of N. Optimum yields can be obtained with 100 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha, in addition to 10 t FYM / ha.

2.1.5 Effect of nutrient management on yield and yield attributing characters of babycorn

Kumar *et al.* (2005) reported that yield attributes and yield of maize were greatest with 100% NPK was applied with farm yard manure at 10 t/ha.

Chandrashekara *et al.* (2000) reported that application of vermicompost @ 2.5 t/ha along with recommended rate of fertilizer (150 : 75 : 37.5) increase the grain yield by 16% compared to control.

Panwar (2008) reported that yield attributes of maize were best in substitution of 50% of the recommended dose of NPK through FYM, while yield was slightly more with 25% substitution, but was comparable to the 50% substitution through FYM.

Sewa *et al.* (1998) reported that the application of recommended NPK + 5 t FYM / ha in rabi gave maximum yield of maize.

Mahajan *et al.* (1997) reported that the application of NP (140 – 150 + 30.5 – 37 kg/ha) + 10 t FYM gave the maximum return.

Brar *et al.* (2001) reported that highest grain yield (4.25 t/ha) obtained in plots receiving inputs 43.6 kg P along with 100 kg N, 43.8 kg K and 10 t FYM / ha.

Shabana and Imyavaramban (2008) reported that application of 50% more than recommended dose of NPK along with enriched FYM @ 750 kg / ha recorded maximum yield attributes resulting in higher grain and stover yield.

Singh *et al.* (1998) reported that mean maize yield ranged from 410 kg/ha in unfertilized control to 2448 kg from 100% PK + 75% N + 25% N as FYM.

Application of NPK at 150: 75 : 40 kg / ha + 10 t of FYM was found to be optimum for obtaining high babycorn and green fodder yield with good quality (Ramachandrappa *et al.*, 2004).

Nanjappa *et al.* (2001) reported that combined application of 75% NPK with 12 t FYM causes higher productivity in maize compared to only inorganic fertilizer application.

Kumar and Puri (2001) reported that application of 90 kg N and 15 t FYM / ha resulted in the maximum cob length, grains / cob, grain weight, harvest index and thereby higher yield.

Luikham *et al.* (2003) reported that the yield determinants of babycorn like number of cobs per plant, cob length and cob weight showed significant increased in the treatment which received 100% recommended dose of N + FYM at 10 t/ha.

2.1.6 Effect of organic matter on the changes in soil characteristics

In recent days, utilization of organic matter as a source of plant nutrients in the multiple cropping system has become a matter of consideration because of the high cost of fertilizer and introduction of high fertilizer responsive varieties. Organic matter not only contains all nutrients for crop plants whatever may be the quantity, it also improves the physical and chemical properties of the soil on incorporation. The presence of high organic matter in the soil helped to build up the physical condition and increasing the microbial activities (Srinivasan, 1942).

The Farm Yard Manure, besides its capacity to contribute NPK, is a store house of several nutrients. Its regular application prevented the occurance of Zn (Katyal and Randhawa, 1983) and S-deficiencies (Nambiar and Abrol, 1989). However, organic matter may have an indirect effect also on nutrient availability. Application of organic manures influenced the bacterial population greatly in an alluvial soil at CRRI, Cuttack, India. Among different sources of organic manure, FYM (with 2% organic carbon) increased the bacterial population from 32.08 million/g soil in control plots to 141.18 million/g soil in manured plots, and wheat or rice straw (with 2% carbon) incorporation reached the bacterial population to as high as 197.76 million/g soil (Guar *et al.*, 1984).

Nambiar, K.K.M. and Ghosh A.B. (1984) showed that FYM applied for 12 consecutive years (1971 – 1982) improved soil properties like bulk density, hydraulic conductivity and available moisture as compared to control or inorganic alone.

Hazra (1986) observed that FYM consistently increased the ammonical and nitrate nitrogen, available phosphate through its provision for favourable condition towards mineralization and solubilization of phosphorus.

Varughese and Pillai, (1990) reported that for steady yields, application of cattle manure appears to be essential for high yielding varieties @ 5 t/ha/season and for local varieties @ 2.5 t/ha/season of rice. Application of $(NH_4)_2SO_4$ has aggravated soil acidity and cattle manure acts as a good buffer besides increasing water holding capacity of the soil. Among the nutrients nitrogen seems to limit production the least, followed by potassium. Soil organic matter and K-content remained un-affected by the treatments for nearly 25 years where as soil P status reduced in P lacking plots.

More (1994) reported that the application of farm wastes and organic manures reduced the pH of the soil from 9.0 to 8.4, reduced bulk density and increased infiltration rate. They further reported that organic carbon, available N, P and K of the soil was also increased.

Babhulkar *et al.* (2000) reported that the application of 7.5 t/ha FYM with half dose of N and P fertilizers (15 kg N and 30 kg P per ha) increased CEC, organic carbon, total nitrogen, available P and K content of the soil.

Bellakki and Badanur (1997) reported that the application of organic sources of nutrients either alone or in combination with fertilizers increased significantly the available phosphorus potassium and micronutrients status of the soil.

According to Gupta *et al.* (1999) apart from increase in yield of pearl millet and wheat, the organic carbon and available P content of the soil was improved to N at all the FYM doses ranging from 0 to 90 t/ha/year. They further suggested that continuous application of FYM can eliminate the application of phosphatic fertilizers.

Srikanth *et al.* (2000) reported that the application of enriched composts, FYM, vermicomposts and fertilizers improves soil properties and available nutrient status of the soil.

Singh and Chauhan (2002) reported that organic nutrition improved soil properties particularly organic carbon, available N, P and K content of the soil.

Singh *et al.* (2006) reported the application of FYM decreased bulk density and particle density but increased water holding capacity, organic carbon and available NPK status of the soil.

Majumdar *et al.* (2000) reveal that application of FYM increased various forms of N in soil of acidic Alfisol.

Neeraj *et al.* (2007) reported that application of organic manures improved the physical, chemical and biological properties of soil.

2.1.7 Effect of integrated nutrient management on the changes in soil characteristics

Mathew and Nair (1997) reported that application of cattle manure along with NPK fertilizers recorded highest value of water holding capacity.

Suresh *et al.* (1999) reported that combined application of nitrogenous fertilizers and organic sources of N viz. U (N_{20}) + FYM (N_{20}), sustained the availability of NPK in vertisols under sorghum and cumbu crop rotation.

Melewar *et al.* (2000) reported that there was beneficial effect on nutrients availability with the application of 10 tonnes FYM plus recommended dose of NPK.

Singh *et al.* (2001) reported that in rice-wheat cropping system integrated use of FYM, green manure and fertilizer N increased the organic carbon, total hydrolysable N, available and total S and K content of the soil. They further suggested that the application of 5t FYM per 6t green manure saved 70 – 80 kg/ha/year without any adverse effect on productivity and soil health.

Gami *et al.* (2001) reported that the treatments receiving organic sources, combination of NPK with FYM and wheat chopped straw increased total soil N from 18 – 62% over NPK treated plots.

Tiwari *et al.* (2002) reported that the combined application of N, P, K, Zn and FYM helped in sustaining the yield of wheat and soybean. They further reported that the application of N, P and K with manure @ 15 t/ha improved the organic carbon status as well as available N, P, K and S content in soil.

According to Tolanur and Badanur (2003) inorganic fertilizers coupled with organic and green manures in pearl millet-pigeon pea cropping system significantly improved the organic carbon content, available N, P and K status of the soil.

Vyas *et al.* (2003) reported that the combined application of 5 Kg Zn and 10 t FYM / ha not only increased grain yield but also improved N,P and K status of the soil.

Krishna and Lourduraj (1997) reported that the availability of N, P, K, Fe, Cu, Zn and Mn content in the soils increased with increasing level of fertilizer in maize. Addition of organic wastes significantly increased the availability of P, K and micronutrients, but reduced nitrogen availability.

Paliwal *et al.* (1999) reported that N, P and K uptake by maize increased with increasing N rates.

Thakur *et al.* (1998) reported that N uptake by plans increased significantly upto 150kg N/ha, whereas N uptake by baby corn increased significantly upto 200kg N/ha.

2.1.8 Effect of nutrient management on economics of baby corn

Thakur *et al.* (1997) reported that the maximum net returns of Rs. 59,938/ha obtained with 200kg N/ha which were 5.2, 23.8, 57.6 and 117.7% higher than that of 150, 100, 50 and 0 kg N/ha. The maximum net returns/rupee invested (kg. 2.84) were realized with 150kg N/ha.

Kumar *et al.* (2002) reported that benefit: cost ratio was maximum with 150% recommended fertilizer application (2.92), followed by recommended fertilizer + 10 t FYM/ha.

Tank *et al.* (2006) reported that 120kg N/ha recorded the highest net realization of Rs. 26,367/ha with benefit cost ratio of 3.13 followed by 180kg N/ha.

Chandrashekhara *et al.* (2000) reported that the net returns and benefits obtained were lowest in vermicompost due to the high cost of vermicompost (Rs. 2000/tonne).

Kumar *et al.* (2005) reported that the highest net return per rupee invested was recorded for 100% NPK in maize.

2.1.9 Effect of nutrient management on quality of babycorn

Rao *et al.* (1992) reported that, a survey of fruit quality and yield was conducted in sweet orange plantations (Sathgudi and Mosambi) on three soil types. The soils were non-saline, sandy loam to clay in texture, slightly to strong alakaline, with low to medium contents of available N and K and low to high contents of available P. Crops produced on inceptisols were superior to those produced on the other soil types with respect to fruit weight, juice percentage, TSS and percentage of total sugar. The percentage of juice, TSS and sugar showed a significant positive correlation with soil content of available N. The percent of reducing sugar were correlated with both N and P content of the soil.

Banerjee *et al.*, 2004 reported that increasing levels of N up to 150 kg/ha significantly increased the protein content.

Keskin *et al.*, 2005 reported that crude protein rate, crude protein yield increased with increasing N level.

Khadtare *et al.*, 2006 reported that the higher values of protein content in sweet corn was observed under the treatment of application of recommended dose of fertilizer (150 : 50 : 50 kg NPK / ha) and TSS content of sweet corn under the treatment 75% RDN + 25% N through vermicompost was 22% higher over treatment 75% RDN + FYM @ 10 t/ha.

Meena *et al.*, 2007 reported that an application of 120 kg N/ ha resulted in significantly more protein content of maize compared with 80, 40 and 0 kg N/ha and also reported that the application of vermicompost @ 1.5 t/ha recorded higher protein content than the application of vermicompost of 1.0, 0.5 t/ha and control.

Xie *et al.*, 2003 reported that protein, amino acid, soluble sugar, crude fat, oil, N, P, K, S and micro element content in the grain increased with N. N also increased starch content of the grain.

Tank *et al.*, 2006 reported that application of both 180 kg N and 120 kg N/ha produced significantly higher protein content over control and 60 kg N/ha.

Raja, 2001 reported that the quality parameters of super sweet corn kernels viz., total sugars, reducing sugars, non-reducing sugars and proteins improved with nitrogen application. However significant difference among N levels was observed from 80 kg N/ha and there was no significant difference between 80 kg and 120 kg N/ha.

Raja *et al.*, 1989 reported improvement in the quality of maize with nitrogen nutrition.

Sundarsingh, 2001 reported that application of both 150 and 180 kg N/ha were found to yield comparable amount of crude protein in babycorn and thus indicated the sufficiency of 150 kg N/ha and also reported that excess N and water decrease the ascorbic acid content. This is confirmative with Mozafatr (1993).

2.2 Experiment – II: Weed management in babycorn

Weeds completely invaded the arena of basic requirements of crops since they both simultaneously originated. Extensive researches have been conducted in every quarters of the world to control weeds and provide a non-competitive condition for growth of economic crops. The researches which have been conducted in India and abroad so far on weed problem, agro-ecology and types of weed flora, weed control methods, effect of weed management on growth, yield, nutrient uptake and economics of weed management in addition with influence of herbicides on soil microflora have been discussed in this chapter.

2.2.1 Types of weed flora in maize

Rabi maize which is popular in Bihar, parts of U.P., A.P., Tamilnadu, Karnataka and Maharastra gives higher yield compared to kharif crop and one of the reasons behind it is lower weed infestation. During kharif season the occurrence of heavy rainfall and higher application of fertilizer both are congineal for higher weed infestation.

Important weeds found in winter maize on sandy loam soil IARI in an experiment by Yaduraju and Ahuja (1993) were *Avena ludoviciana, Spergula arvensis, Chenopodium album, Melilotus indica, Rumex dentatus, Cyperus rotundus and Coronopus didymus.*

Angirus and Singh (1989) observed the following weeds in kharif maize field which are *Cyperus esculentus, Echinochloa colona, Panicum dichotomiflorum, Ageratum conyzoides, Polygonum alatuma* and *Digitaria sanguinalis*. These were the dominant weeds in the maize field in order of importance. Reports from North and East India on the prevalence of weed species in maize fields showed that *Echinochloa colona, Echinochloa crusgalli, Dactyloctenium aegyptium, Brachiaria* sp., *Eleusine indica, Cyperus rotundus* and *Digera arvensis* were the predominant weed species in kharif maize field (Mukhopadhyay, 1968, Majumdar and Goutam, 1968 and Gupta and Dhupia, 1970).

According to Meggit (1970), perennial weeds were not as prevalent but generally would produce greater yield reductions. The dominant perennial weeds were *Agropyron repens, Cirsium arvense, Convolvulus arvensis, Cyperus esculentus* and *Cyperus rotundus.*

Chinnusamy *et al.* (2000) noticed *Trianthema portulacastrusm* as the dominant broad - leaf weed in maize field followed by *Parthenium hysterophorus* and *Gynandropsis pentaphylla.* Among grasses, *Cynodon dactylon, Chloris barbata* and *Dactyloctenium aegyptium* and in sedges, *Cyperus rotundus* were dominant weeds.

In a field experiment on maize at Killikulum, Bhuvaneshwari *et al.* (2002) observed the following dominant weed flora, *Cyperus esculentus* and *Cyperus rotundus* among sedges, *Cynodon dactylon* and *Echinochloa colona* among grasses and *Digera arvensis, Phyllanthus niruri, Eclipta alba,* *Corchorus trilocularis, Boerhaevia diffusa* and *Trianthema portulacastrum* among the broad-leaf weeds.

Hamill *et al.* (1997) observed that important weeds in maize field at woodslee, Ontario were *Abutilon theophresti, Amaranthus retroflexus, Ambrosia aretemisiifolia, Chenopodium album* and *Polygonum persicaria.*

Singh *et al.* (2003) reported the major weeds found in winter maize c.v. Ganga Safed – 2 field on sandy loam soils of Allahabad were *Chenopodium album, Chenopodium murale, Anagallis arvensis, Melilotus alba, Euphorbia hirta* etc.

2.2.2 Effect of atrazine to control weed in babycorn

Sairam *et al.* (1991) reported that Atrazine @ 0.5 kg/ha as postemergence decreased weed growth markedly and dry matter production of maize.

Varshney (1991) opined that weed density and biomass were greater and weed control efficiency was lower in plots treated with postemergence (10 days after maize emergence) rather than pre-emergence Atrazine. The lowest weed density resulted from the application of Atrazine alone (2 kg/ha).

On sandy loam soil at Indian Agricultural Research Institute, an experiment of rabi maize was conducted Yaduraj and Ahuja (1993) where they found that both the pre and post-emergence application of Atrazine (0.75 and 1.5 kg/ha) gave excellent control of weeds and resulted in higher grain yield of maize.

In an experiment on kharif maize at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan), Mundra *et al.* (2003) reported that pre-emergence application of Atrazine at 0.5 kg/ha + intercultivation once at 35 DAS resulted in minimum dicot weed density and total dry weight.

Buhler *et al.* (1994) observed that Atrazine @ 1.1 kg/ha or cyanazine @ 2.2 kg/ha when applied within 1 day of maize sowing greatly reduced weed density compared with no herbicide use, but did not control annual weeds. 1 or 2 interrow cultivations following Atrazine or cyanazine application increased the control of annual weeds to over 90%.

Pre-emergence application of atrazine and lasso was the more effective treatment on the wide range of weeds than eradicane application during entire growing season. This treatment effectively control *Echinochloa crusgalli, Cyperus roturdus, Cyperus arvensis* and other weeds 93, 78 – 83, 99% respectively (Fathi, 2005).

Sharma *et al.* (2000) reported that atrazine applied as pre-emergence reduced weed population at 15 days of growth significantly (74.8-83.6%) compared with control (75 – 80 no/m^2). The loss in grain yield due to unchecked weed growth was to the extent of 32.4 – 42.3%.

Norsworthy & Frederick (2005) reported that pre-emergence application of atrazine + S – metalachlor both resulted in greater than 90% control of all weed species and similar weed biomass and yields.

On loamy sand soil of Ludhiana, both Simazine and Atrazine, both @ 1.25 and 1.875 kg/ha as pre-emergence gave good control of annual weeds, but at this rate Simazine was found to be phytotoxic to maize than atrazine (Gill *et al.*, 1988).

Hamill *et al.* (1997) opined that control of weed density depends upon rate and time of application of Atrazine / Bentazone and the best time for the application of these post-emergence herbicide was a few days prior to the onset of critical period of weed control. According to them, application of these herbicides of about 7 DAS @ 1.6 or 0.8 kg a.i./ha maintained low weed densities.

Singh *et al.* (2003) reported that minimum weed population and dry weight was obtained in plots treated with a combination of pre-emergence application of Alachlor @ 3.5 kg/ha followed by post-emergence application of Atrazine @ 0.75 kg/ha. The weeds are controlled to the extent of 96.08%.

2.2.3 Effect of mulching on weeds

A multi location field trial conducted by Wick *et al.* (1994) at Wilber, N. Platte and Sidney (all in Nebraska) revealed that the response of crop to mulching levels varied with climate and location. In general, early maize growth was retarded by increasing mulching level (1.7 to 6.8 t/ha) due to reduced soil temperature, but after tasseling of maize grew taller under greater mulch level because of increase in soil moisture. Soil water content, kernel moisture at harvest, stover dry matter, total dry matter and the number of ears per plant and kernel weight increased with increasing mulch levels.

Zink and Hurle (1989) demonstrated that cover crops generally reduced weed biomass more than weed density. Rye (frost resistant) sown in autumn and treated with glyphosate when maize was sown, gave long lasting. Complete weed suppression, moreover, it helped to reduce soil erosion and leaching of nutrients while improving weed management.

Ghorai *et al.* (2004) opined that the weed controlling efficiency of rice straw mulch @ 10.0 t/ha in addition with two hand weedings was about 55% in jute at Barrackpore, West Bengal condition. On the other hand, Bazaya *et al.* (2004) have found that polythene mulch (black polythene with 25 μ thickness) produced at par seed yield of mustard and significantly improved all the growth and yield attributes over other weed controlling treatments in R.S. Pura, Jammu; Similarly, Singh *et al.* (2005) reported that in Tripura, the weed dry weight was reduced by 52.5 and 31.8% over untreated control with polythene mulch and paddy straw, respectively in black gram.

Wahab *et al.* (2000) reported from an experiment on clay loam soil of Tamil Nadu with pH 7.9 that irrigation and mulching practices had significant effect on weed count and weed biomass. The least weed count by 48.5 and 63.5 and weed biomass of 24.23 and 254.4 kg/ha in the rainy and summer season crop of maize, respectively were brought about by irrigation at an IW/CPE ratio of 0.6 along with sugarcane trash mulching at 10 cm thickness.

2.2.4 Effect of atrazine and other triazine herbicides on soil microflora

Effect of herbicides on biomass and abundance of microorganisms were significantly increased or reduced, depending upon the type of herbicide, dose and time of assay. According to Michalcewiez (2001) most herbicides, particularly Traizines reduced the microbial biomass when doses higher than those used in a regular agricultural practice. Reduced abundance were mostly recorded among fungi, and proteolytic and cellulolytic microorganisms.

In a field experiment on maize, Pandagare *et al.* (2003) observed that Atrazine at 0.75, 1.00 and 1.25 kg/ha as pre-emergence application reduced the non-symbiotic bacteria and fungi population at 25 DAS, but microbial population was increased at harvest.

Atrazine is being dechlorinated and degraded by *Pseudomonas* sp., *Pseudoaminobacter* sp. and *Nocardioides* sp., which utilize it as carbon and nitrogen source (Topp, etal. 2000).

Konstantinovic *et al.* (1999) reported that the herbicides Alachlor and Atrazine reduced the total number of bacteria, number of ammonifiers, *Azotobacter* and dehydrogenase activity and increased the number of fungi and actinomycetes. Atrazine was found to be less inhibitory to microorganisms than Alachlor.

In an experiment on maize in Yugoslavia, Tambur and Levic (1995) noticed that Atrazine inhibited fungal growth, but stimulated bacteria, increasing numbers of bacteria were correlated with a decrease in fungi in the genera *Aspergillus, Microdohlium, penicillium* and *Verticillium.*

According to Topp *et al.* (2000) the wide spread distribution of the Atrazine degrading *Pseudoaminobacter* sp. in agricultural soils exposed to Atrazine is due to characteristic ability of this organism to utilize alkylamines, and therefore Atrazine, as sole source of carbon.

The effects of 10, 50, 100, 200 and 300 μg simazine / g of soil were studied under aerobic conditions. Compared with control soil, simazine did not affect bacterial populations, fungi, aerobic dinitrogen fixing bacteria, denitrifying bacteria and nitrogenase activity. However, nitrifying bacteria were decreased at concentration of 50 to 300 μg/g (Martinez *et al.*, 1996).

Tu (1996) opined that indigenous soil microorganisms can tolerate the effect of some chemical used for controlling weeds. In an experiment on sandy loam soil and organic soil, simazine was found to stimulate the growth of fungi in the organic soil after 2 weeks of application. On sandy loam soil it showed on inhibitory effect on bacterial colony for the first week. Denitrification and sulphur oxidation were stimulated by the use of simazine after 2 weeks and 4 weeks respectively in the organic soil. Nitrification is inhibited after 2 weeks in both the soils.

Normally, the quantities of common herbicides applied at recommended rates to soils or which reach the soil from above ground spraying operations are not sufficient to appreciably depress the growth and activity of specific soil microbes (Randhawa and Bhalla, 1976; Atlas *et al.*, 1978; Lewis *et al.*, 1978; Olsen *et al.*, 1984; Cullimore, 1969), instead of them exert a stimulatory effect on them (Balieve, 1973; Dey and Ganguly, 1984).

Application of herbicides at normal field rates had no effect on nitrogen fixation (Singh *et al.*, 1981). But some herbicides exerted stimulation on nitrogen fixing power of soil (Nelsdon and Hedrick, 1976).

Dukie *et al.* (1997) reported the effect of simazine (another S – Triazine herbicide like Atrazine) also induced a considerable decrease in the number of amylolytic microorganisms primarily during the first 3 months after application (@ 4. l/ha). Among the 3 herbicides, simazine, paraquat and Napropamide, simazine was found to cause highest decrease in number of Azotobacter in soil.

In an experiment, 3 herbicides, Diuron, Simazine and Terbacil were applied annually @ 4 lb/acre on a soil microbe community in West Virginia. Diuron, simazine resulted in higher number of colony – forming units of bacteria and actinomycetes than Terbacil (Tworkoski *et al.*, 1996).

In maize, simazine has been found to reduce the number of soil microorganisms as reported by Keshelava (2000) in the Republic of Georgia.

From the results of an experiment Barman *et al.* (2002) revealed that fluchloralin and pendimethalin had no significant effect on total bacteria population in soil at 40 and 60 DAS even upto 5 times of their recommended level of application. Metolachlor, at recommended level, was not toxic to bacteria. Meribuzin showed toxic effect on total bacteria population even at its recommended dose. All of these herbicides were toxic to fungal population. However, the toxic effect of these herbicides on total microbial activity disappeared by 60 days of their application at recommended level.

The population of non-symbiotic N – fixing bacteria increased in unweeded, twice hand weeded and pendimenthalin treated plots but both pendimethalin and metribuzin significantly reduced the population of phosphate solubilizing microorganisms (Ghosh *et al.*, 2003).

Ayansina and Oso (2006) reported that herbicide treatments at both recommended and one and half (1.5) of recommended rates resulted in decreases in microbial counts. Higher concentrations of herbicides treatments resulted in much lower microbial counts compared to soils treated with recommended herbicide dose.

Nayak *et al.* (1994) reported that herbicides reduced microbial populations than two hand weedings.

Petkova and Donkova (2000) reported that a negative effect on the quantity and activity of soil microflora was observed immediately upon the Metribuzin application. Metribuzin had a strong negative effect on cellulose degrading microorganisms and actinomycetes, which could serve as indicators of soil contamination with this herbicide.

2.2.5 Effect of mulching on soil micro-flora

Singh and Rana (2003) reported that the highest mean population of bacteria, fungi, actinomycetes and microbial biomass carbon was recorded under trash mulching + interculture compared to weedy condition.

Hundal *et al.* (2000) reported that the population of bacteria, fungi and Actinomycetes was greater in plots having some type of mulching as compared to bare soil.

2.2.6 Effect of weed management on growth parameters

Sinha *et al.* (2001) reported that application of atrazine @ 1.5 kg a.i./ha (pre-emergence) + 2, 4-D @ 0.8 kg a.i./ha (pre-emergence) recorded maximum plant height than two hand weedings at 25 and 45 DAS. Higher LAI, dry matter accumulation was recorded at two hand weedings.

Sharma *et al.* (2000) reported that plant height was significantly more when atrazine was applied, irrespective of its time and method of application due to effective control.

Sinha *et al.* (2001) reported that maximum plant height, dry matter accumulation, crop growth rate were higher under hand weeding twice. This result supports works of Sharma (1988) and Prasad *et al.* (1990).

Pandey *et al.* (2002) reported that the highest plant height was recorded under weed free treatment, which was significantly higher than that recorded under lower dose of pre-emergence herbicides but did not differ significantly with that records under lower dose of herbicides applied in integration with hand weeding 30 days after sowing.

2.2.7 Effect of weed management on yield and yield attributing Characters

Singh *et al.* (2003) reported that the maximum grain yield was obtained in weed free plots (11.9 t/ha) but next to highest grain yield was 11.25 t/ha was obtained in the Alachlor + Atrazine treated plots.

Saha and Srivastava (1992) reported that length of cob, grains /cob and weight of grains / cob were highest in hand weeding twice.

Cob yield with husk, babycorn yield and green fodder yield were higher with treatment which received pre-emergence atrazine @ 1 kg ai/ha + one hand weeding at 30 DAS which was at par with treatment that received two hand weeding 20 and 40 DAS and lowest was recorded with weedy check (Prasad *et al.*, 1990; Talatala Sinco and Ranchez, 1990).

Mandal *et al.* (2004) reported that yield components like cobs / plant, cob weight with husk and cob weight without husk, babycorn yield and green fodder yield significantly higher with treatment which received pre-emergence application of atrazine @ 1 kg ai/ha + one hand weeding 30 days after sowing which was at pr with treatment that received two hand weedings at 20 and 40 DAS.

Sinha *et al.* (2001) reported that higher grain yield was recorded at two hand weedings. Similar findings were also observed by Saha and Srivastava (1992), Prusty *et al.* (1987) and Singh *et al.* (1995).

Pandey *et al.* (2002) reported that the application of Atrazine @ 1.25 kg / ha + 1 hand weeding at 30 DAS significantly improved yield Atributes and babycorn and green fodder yield.

Incase of maize grown as fodder crop, pre-emergence application of atrazine (1 kg a.i./ha) gave higher fodder yield of 372.1 q/ha over weedy check (304.1 q/ha) (Agrawal *et al.*, 1994).

Walia *et al.* (2003) reported that the maize grain yields tended to increase with increasing N applied from 60 – 120 kg/ha and were highest on plots treated with Atrazine (1 kg/ha) at all N levels.

2.2.8 Effect of weed management on economics of babycorn

Application of pre-emergence herbicide followed by one hand weeding gave highest net return than any annual and chemical weed control (Angiras and Singh, 1991 and Sharma *et al.*, 1998).

Porwal (2000) reported that application of atrazine @ 1 kg a.i./ha as pre-emergence recorded the highest grain yield, gross and net returns over mechanical weeding and control and benefit : cost ratio over mechanical weeding.

Pandey *et al.* (2002) reported that the application of atrazine @ 1.25 kg/ha + 1 HW at 30 DAS enhanced monetary returns compared with weedy control.

Mandal *et al.* (2004) reported that the highest gross return, net return and benefit : cost ratio were recorded with atrazine at 1 kg a.i./ha + one hand weeding at 30 DAS.

CHAPTER 3

Materials and Methods

Materials and Methods

3.1 Experimental site

The field experiment entitled, "Studies on nutrient and weed management in winter babycorn (*Zea mays*) under the Gangetic Alluvium of West Bengal was conducted at the Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during rabi season of 2005 - 2006 and 2006 - 2007.

The experimental field was situated at 22°N latitude, 89°E longitude at an altitude of 9.75 meter above the mean see level (MSL) and the land topography was medium.

3.2 Details of the experimental soil

The experimental soil was Gangetic new alluvium (Inceptisol) with sandy clay loam in texture, good irrigation cum drainage facility and medium soil fertility status, having neutral soil pH. The physico-chemical properties of the experimental soil has been depicted in Table 3.1.

Table 3.1: Physico-chemical properties of the experimental soil

Sl. No.	Particulars	Result	Methods followed
A.	**Mechanical composition of soil**		
a.	Sand (%)	46.13	International pipette method (Piper, 1966)
b.	Silt (%)	24.60	
c.	Clay (%)	29.27	
B.	**Chemical composition of soil**		
a.	Soil pH	6.9	pH meter method (Jackson, 1973)
b.	Organic carbon (%)	0.64	Volumetric Redox Titration (Walkley and Black) Method (Jackson, 1973)

Sl. No.	Particulars	Result	Methods followed
c.	Total N (%)	0.055	Modified Macrokjeldahl Distillation Method (Jackson, 1973)
d.	Available P_2O_5 (kg ha^{-1})	13.70	Olsen's Method (Jackson, 1973)
e.	Available K_2O (kg ha^{-1})	126.50	Flame photometer Method (Jackson, 1973)

3.3 Climatic condition

Table – 3.2 showed the atmospheric temperature (maximum and minimum) relative humidity (maximum and minimum), rainfall, Bright sunshine hour and evaporation during the period of experimentation.

Table 3.2: Climatic condition during the period of experimentation

Months	Temperature (°C)		Rainfall (mm)	Relative humidity (%)		BSH (hr.)	Evaporation (mm)
	Max.	Min.		Max.	Min.		
2005							
Nov.	29.8	13.4	0.0	98.6	43.7	8.2	1.0
Dec.	27.6	10.9	1.2	98.8	45.7	9.2	1.1
2006							
Jan.	25.4	8.4	0.0	98.7	45.4	7.4	1.3
Feb.	34.2	17.0	0.0	95.7	35.4	8.0	2.3
Nov.	29.58	18.15	0.04	98.16	53.53	6.72	1.86
Dec.	26.70	12.35	0.0	98.93	48.06	7.24	1.75
2007							
Jan.	25.10	9.48	0.0	96.96	43.25	7.93	1.71
Feb.	27.28	14.90	2.52	95.96	53.92	6.77	1.67

Source: AICRP on Agro-meteorology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal.

The new alluvial zone falls under sub-tropical humid climate which is not subjected to extreme climatic condition. In this region, the seasons are broadly classified as

i) Summer (*pre-kharif*) – dry and warm (February to May)

ii) Rainy (*kharif*) – wet and warm (June to September) and

iii) Winter (*rabi*) – dry and cool (October to January)

It has been clearly observed from table – 3.2 that the lowest average minimum temperature is found in January (8.4 and 9.48°C) both the years of experimentation. The monthly mean maximum temperature was recorded in the month of February 2006 (34.2°C). The average minimum and maximum temperature starts to decrease gradually from November to January. From February, it rises gradually.

The highest average maximum relative humidity is noticed in the month of December. It decreases gradually from January onwards.

Rainfall usually occurs in this region from May to October. Sometimes, November or even December also receives some amounts of rainfall (1.2 mm in December 2005 and 0.04 mm in November 2006). The amount of rainfall received in February 2007 is 2.52mm.

The highest monthly mean BSH of 9.2 hr. was recorded during December 2005 where as 7.24 hr. during the same period in next season.

The maximum mean monthly pan evaporation of 2.30 mm and minimum of 1.0 mm was recorded during February 2006 and November 2005 respectively.

3.4 Previous cropping history of the experimental field

The crops grown in the experimental field (Table – 3.3) were as follows –

Table 3.3: Previous cropping history of the experimental field

Year	Crops grown		
	Pre-kharif	Kharif	Rabi
2003 – 2004	Fallow	Fallow	Rapeseed
2004 – 2005	Greengram	Fallow	Potato
2005 – 2006	Fallow	Fallow	Babycorn (crops under experimentation)
2006 – 2007	Fallow	Fallow	Babycorn (crops under experimentation)

3.5 Experimental details

3.5.1 Experiment – 1: Nutrient management in babycorn

3.5.1.1 Design of the experiment

Experiment – 1 was carried out in a split plot design with five main plot treatments (organic manure) and four sub-plot treatments (inorganic nitrogen), replicated thrice. The total number of plots was 60 with 4m × 3m net plot size. The plan and specification of layout of this experiment have been given in figure – 3.1.

3.5.1.2 Experimental treatments

Main plot: 5

M_0 – No organic manure

M_1 – Vermicompost @ 2 t ha^{-1}

M_2 – Vermicompost @ 4 t ha^{-1}

M_3 – FYM @ 5 t ha^{-1}

M_4 – FYM @ 10 t ha^{-1}

Sub-plot : 4

N_0 – Without nitrogen application

N_1 – 60 kg N ha^{-1}

N_2 – 120 kg N ha^{-1}

N_3 – 180 kg N ha^{-1}

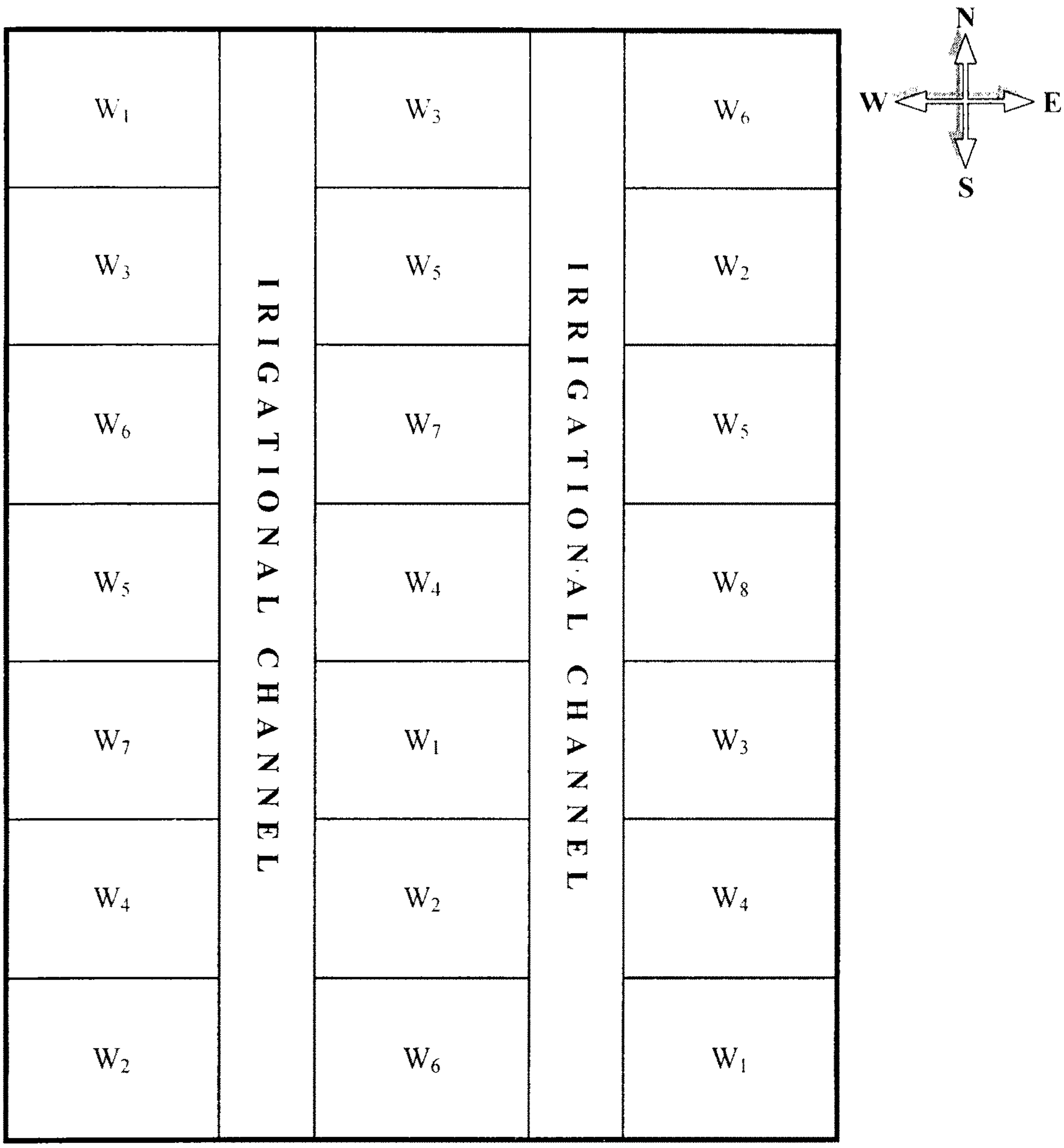
Note: Nitrogen to be applied in two splits – 1/2 as basal and rest 1/2 at 30 DAS.

3.5.2 Experiment – 2: Weed management in babycorn

3.5.2.1 Design of the experiment

Experiment-2 was carried out in a randomized block design (RBD) with seven treatments replicated thrice having a net plot size of 4m × 3m

Layout of the Experiment – 2



Scale: Plot size : 4m × 3m

Bund : 0.5m width

Irrigation-cum-drainage channel – 1.0 m width

Fig. 3.2: Plan of layout for the experiment – 2

and total number of plot was 21. The plan and specification of layout of this experiment have been given in figure - 3.2.

3.5.2.2 Experimental treatments

W_1 – Atrazine @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS)

W_2 – Metribuzin @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS)

W_3 – Paddy straw mulch @ 10 t ha^{-1}

W_4 – Hand weeding (HW) twice at 20 DAS and 40 DAS

W_5 – Atrazine @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS

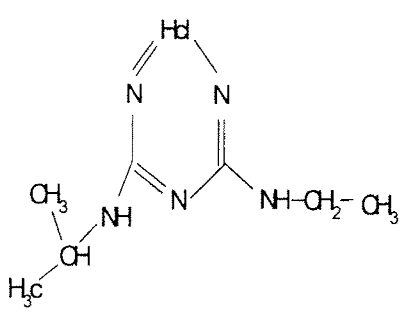
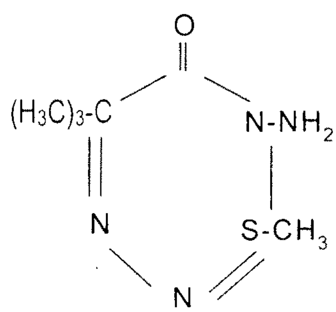
W_6 – Metribuzin @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS

W_7 – Weedy cheek

3.5.2.3 Details of the herbicides used in the experiment

Chemical information of the herbicides used in the experiment in the table – 3.4.

Table 3.4: Details of the herbicides used in babycorn

Name of the herbicide	Chemical formula	Chemical structure	Chemical group	Formulation	Trade name
Atrazine	6 chloro-N-ethyl-N-(1-methyl-ethyl)-1, 3, 5-triazine-2, 4-diamine		Triazine (Symmetrical triazine)	50 WP	Atrataf
Metribuzin	4-amino-6-tert-butyl-3 (methyl thio)-1,2,4-triazin-5 (4H)-one		Triazine	70 WP	Sencor

Herbicide application

The required quantity of herbicide was calculated by using the formula

$$Q = \frac{\text{Dose}}{\text{a.i.}} \times 100$$

Where,

Q = Quantity of chemical in g or ml per ha

Dose = Rate (kg a.i. ha^{-1})

a.i. = Percentage of the chemical in herbicide (active ingredient)

The spraying was done by knapsack sprayer with nozzle type flood-jet WFN 040 using spray volume @ 500 litre ha^{-1}.

Table 3.5: Details of the crop grown

Crop	Cultivar	Scientific name	Family
Babycorn	Early composite	*Zea mays*	Poaceae

3.6 Calendar of operation

The calendar of operation for experiment – 1 and 2 are presented in table – 3.6 and 3.7 respectively.

Table 3.6: Calendar of operation for experiment – 1

Sl. No.	Operations	Date		Details of operation
		2005 – 06	2006 – 07	
1.	Land preparation	14.11.05 to 16.11.05	13.11.06 to 15.11.06	Ploughing twice by tractor with laddering was given for pulverization and leveling in order to get a fine tilth.
2.	Layout	17.11.05	16.11.06	After leveling, the field was laid out with the help of a long tape, pegs and rope. The ridges, path and irrigation channel were made

Sl. No.	Operations	Date		Details of operation
		2005 – 06	2006 – 07	
				properly.
3.	Sowing	18.11.05	17.11.06	The seeds were sown in lines at a depth of 3cm below the soil surface the rate of 40 kg ha^{-1}. The row to tow spacing was 45cm and plant to plant spacing was 30cm.
4.	Thinning and gap filling	02.12.05	01.12.06	Gap filling was found to be hardly required here and in case of requirement it was done with left over seedlings from thinning with great care.
5.	Fertilizer Management	18.11.05	17.11.06	Full dose of P_2O_5 @ 60 kg ha^{-1} as SSP and K_2O @ 40 kg ha^{-1} as MOP and half dose of N as per treatment were applied as basal and rest $^1/_2$ of N were applied at 30 DAS. Organic manures like farmyard manure and vermicompost as per schedule were applied during the time of land preparation.
6.	Hand weeding	08.12.05 and 28.12.05	07.12.06 and 27.12.06	Two hand weedings were done at 20 and 40 DAS
7.	Detasseling	02.01.06 and continued	01.01.07 and continued	Detasseling was done regularly, started from 45 DAS
8.	Water Management	8.11.05	07.11.06	Pre-sowing irrigation for maintenance of proper soil moisture condition for good germination by flooding method.
		02.12.05 16.12.06 02.01.06	01.12.06 15.12.06 01.01.07	At seedling stage (15 DAS), 2^{nd} irrigation was given at knee height stage (30 DAS), 3^{rd} irrigation at tasseling stage (45 DAS)
9.	Plant protection measures	–	–	No plant protection measure was required

Sl. No.	Operations	Date		Details of operation
		2005 – 06	2006 – 07	
10.	Harvesting	18.01.06 to 08.02.06	17.01.07 to 07.02.07	Harvesting was done by simply picking the cobs from the plants. After wards, plans are cut to be used as green forage

Table 3.7: Calendar of operation for experiment – 2

Sl. No.	Operations	Date		Details of operation
		2005 – 06	2006 – 07	
1.	Land preparation	10.11.05 to 12.11.05	09.11.06 to 11.11.06	The land was ploughed and cross ploughed thrice followed by laddering to obtain proper tilth and to get a uniform surface
2.	Layout	14.11.05	13.11.06	The whole experimental field was divided into 3 blocks each of which contained 7 plots. Each of the total 21 plots was demarcated with the help of bunds. 2 channels for irrigation and drainage were provided in between 1st and 2nd, 2nd and 3rd blocks. The bunds and irrigation channels were 0.5m and 1m wide respectively.
3.	Sowing	15.11.05	14.11.06	The seeds were sown in lines at a depth of 3 cm below the soil surface at the rate of 40 kg ha^{-1}. The row to row spacing was 45cm and plant to plant spacing was 30 cm.
4.	Thinning and gap filling	25.11.05	24.11.06	Gap filling was found to be hardly required here and in case of requirement it was done with left over seedlings from thinning with great care.
5.	Fertilizer management	15.11.05	14.11.06	A general recommended dose of 150 : 60 : 40 kg N, P_2O_5 and K_2O ha^{-1} was applied.
		15.12.05	14.12.06	Out of this 50%N (75 kg ha^{-1}), full of each of P_2O_5 and K_2O were applied as basal after layout

Sl. No.	Operations	Date		Details of operation
		2005 – 06	2006 – 07	
				has been done. Rest 50% of N (75 kg N/ha) was applied at 30 DAS. The sources of N, P_2O_5 and K_2O were Urea, SSP and MOP respectively.
6.	Detasseling	30.12.06 and continued	29.12.06 and continued	Detasseling was done in a regular way from 45 DAS.
6.	Water management	04.11.05	03.11.06	Pre-sowing irrigation for maintenance of proper soil moisture condition for good germination by flooding method.
		30.11.05	29.11.06	1st irrigation at seedling stage (15 DAS)
		15.12.05	14.12.06	2nd irrigation at knee height stage (30 DAS)
		30.12.06	29.12.06	3rd irrigation was given at tasseling stage (45 DAS)
7.	Plant protection measures	–	–	No plant protection measure was required
8.	Treatment application			
a.	Herbicide application	13.11.05	17.11.06	The required quantity of commercial formulation was accurately measured and was applied with back pack sprayer with nozzle WFN 0.040. Proper care was taken to ensure uniform application
b.	Hand weeding	05.12.05 to 26.12.05	11.12.06 to 25.12.06	Two hand weedings were done at 20 and 40 DAS in 3 plots for 3 replications
9.	Harvesting	16.01.06 to 06.02.06	15.01.07 to 05.02.07	Harvesting was done by simply picking the cobs from the plants. Afterwards, plants are cut to be used as green forage

3.7 Methods of recording different biometrical observations on growth attributes

3.7.1 Plant height

The height of the plants (cm) was measured with a scale of one meter length at different dates of observation (20, 40, 60 DAS and at harvest).

3.7.2 Leaf area index (LAI)

A circular punch of known area was taken from twenty leaves randomly selected from each plot at 20, 40, 60 DAS and at harvest of babycorn. The punched leaves were then dried in hot air oven at a temperature of 65°C till a constant weight was reached and weighed in sensitive digital balance and LAI was calculated on area-weight relationship basis (Radford, 1967).

$$LAI = \frac{\text{Total leaf area } (m^2) \text{ of plants for a given land area}}{\text{Area of land } (m^2)}$$

3.7.3 Dry matter accumulation

To determine the dry mater accumulation by different parts of plants at successive growth stages, destructive plant samplings were made from each plot. For sampling the plants were cut at the ground level randomly from 0.5 m x 0.5 m area from each plot demarcated for sampling. The plant parts were separated into different parts and then dried into hot air oven at a temperature of about 80°C till constant weights were obtained. These weights were converted into g m^{-2}.

3.7.4 Crop growth rate (CGR)

Crop growth rate of crop plant was calculated (Watson, 1958) with the help of the following formula.

$$CGR\ (g\ m^{-2}\ day^{-1}) = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 were the weight of the total dry matter accumulation in g m^{-2} and t_2 and t_1 time interval in days between second and first sampling, respectively.

3.8 Yield attributes and yield

3.8.1 Number of cobs per plant

Ten plants were randomly selected from each plot. cobs were collected, counted and average was worked out.

3.8.2 Length of cob (cm)

Ten cobs were collected randomly from each plot. Length of each cob (cm) with husk and without husk was taken by a measuring scale and the average value was taken.

3.8.3 Diameter of cob (cm)

Ten cobs were collected randomly from each plot. Diameter of each cob (cm) with husk and without husk was taken by a measuring tape and the average value was taken.

3.8.4 Yield

After harvesting the cob's weight with husk and without husk was recorded.

3.9 Experiment – 2. Weed management in babycorn

3.9.1 Weed studies

3.9.1.1 Weed population

Weed population count was made by placing an iron quadrate measuring 50cm × 50cm at two places in each plot at random. Weed count was taken at 25, 50, 75 DAS and at harvest stage of the crop. The weeds so recorded were further grouped into three categories i.e., grass, sedge and broadleaf, and converted to square meter basis.

3.9.1.2 Dry weight of weeds

The weeds counted from the sampling unit were removed for recording their dry matter accumulation. After removing the root portion of the weed, the above ground portion was dried in hot air oven at 65°C temperature till a constant weight was obtained. Then their weight was recorded separately. These observations were recorded at 25 DAS, 50 DAS, 75 DAS and at harvest stage of the crop in order to know the dry matter accumulation (g m^{-2}) of different categories of weeds i.e., grass, sedge, broadleaf and also for total weed.

3.9.1.3 Weed control efficiency (WCE)

The weed control efficiency (WCE) of different treatment was completed on the basis of dry weight of total weeds (g m^{-2}) at 25, 50, 75 DAS and at harvest stage of the crop and expressed in percentage with the help of the formula as follows.

$$\text{WCE (\%)} = \frac{\text{Dry weight of weeds in control plot – dry weight of weeds in treated plot}}{\text{Dry weight of weed in control plot}} \times 100$$

3.9.2 Phytotoxicity on crop plant

The phytotoxicity observations on crop plant were made by following the European Weed Research Council Rating System in Form No. 'B' with a 1 - 9 scale as shown in table 8.8 at 7, 14 and 21 days after application of the herbicides. The parameters considered for visual phytotoxicity observations on babycorn plant were leaf epinasty, hyponasty, leaf necrosis, leaf tip or surface injury, stunting growth and stand loss.

Table 3.8: Qualitative description of treatment effects on crop in the visual scoring scale of 1 to 9

From 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

3.9.3 Methods of analysis for study on soil micro-flora

3.9.3.1 Viable count of the microorganisms

The enumeration of the microbial population was done on agar plates containing appropriate media following serial dilution technique and pour plate method (Pramer and Schmidt, 1965). Plates were incubated at 30°C. The counts were taken at 5th day of incubation. The results were reported as number of cells per gram of soil. The media were as follows –

3.9.3.1.1 Aerobic non-symbiotic nitrogen fixing bacteria

Jensen's agar medium (Jensen, 1930) was used for counting aerobic non-symbiotic nitrogen fixing bacteria.

Jensen's agar medium

Sucrose	$C_{12}H_{22}O_{11}$	10.0g
Dipotassium hydrogen phosphate	K_2HPO_4	1.0g
Magnesium sulphate	$MgSO_4.\ 7H_2O$	0.5g
Sodium chloride	Nacl	0.5g
Ferrous sulphate	$FeSO_4.\ 7H_2O$	0.1g
Sodium molybdate	Na_2MoO_4	0.005g
Calcium carbonate	$CaCO_3$	2.0g
Agar		15.0g
Distilled water		1000 ml

pH of the medium was maintained at 7.0 and the medium was sterilized at 15 lbs steam pressure for 20 minutes.

3.9.3.1.2 Phosphate solubilizing microorganisms

Total number of phosphate solubilizing micro-organisms was estimated in pikovskaia's agar medium.

Pikovskaia's medium

Sucrose	$C_{12}H_{22}O_{11}$	10.0g
Tricalcium phosphate	$Ca_3(PO_4)_2$	5.0g
Ammonium sulphate	$(NH_4)_2SO_4$	0.5g
Sodium chloride	Nacl	0.2g
Magnesium sulphate	$MgSO_4\ 7H_2O$	0.1g
Yeast extract		0.5g
Potassium chloride	Kcl	0.2g
Ferrous sulphate	$FeSO_4\ 7H_2O$	Trace
Agar		15.0g
Distilled water		1000ml

pH of the medium was adjusted at 7.4 and the medium was sterilized at 15 lbs steam pressure for 20 minutes.

3.10 Chemical analysis of organic manures

Before application in the field, a very small amount was collected randomly from the heap. They were chemically analyzed like soil analysis to estimate the nitrogen, phosphorus and potash content. The amount of major nutrient present in farm yard manure (FYM) and vermicompost are expressed interms of percentage value (Table 3.9).

Table 3.9: Chemical composition of organic manures applied (dry-weight basis)

Source	Year					
	2005 – 2006			2006 – 2007		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
FYM	0.57	0.18	0.45	0.61	0.25	0.54
Vermicompost	1.78	0.60	1.20	1.82	0.70	1.35

3.11 Soil analysis

Composite soil samples were collected from the experimental field at a depth of 30cm. Then the samples were dried in shade, pulverized to pass through 0.2mm sieve and were used for chemical analysis.

3.11.1 Mechanical analysis of soil

Mechanical analysis of soil particularly the content of fine sand, coarse sand, clay and silt was done by International pipette method (Piper, 1966).

3.11.2 Chemical analysis of soil

3.11.2.1 Soil pH

The pH was determined by using electronic digital pH meter with glass electrode, calomel reference electrode and salt bridge at soil : water ratio of 1 : 2.5, stirred till the reading (at 20°C) was recorded (Jackson, 1973).

3.11.2.2 Organic carbon content in soil

Organic carbon was determined in percentage, according to the Walkley and Black (1934) method, as stated by Jackson (1973), taking 2 g soil using diphenylamine as indicator.

3.11.2.3 Total nitrogen content in soil

Total nitrogen content of soil was determined in percentage, according to 7 modified Kjeldahl Method as described by Jackson (1973).

3.11.2.4 Available phosphate (P_2O_5) content in soil

Available phosphate in kg ha^{-1} was determined by Bray and Kurtz (1954) Method, as described by Jackson (1973).

3.11.2.5 Available potash (K_2O) content in soil

Available potash in kg ha^{-1} was determined from 5g of soil by Flame photometer Method Muhr *et al.* 1965.

3.12 Plant analysis

3.12.1 Total N

Total N of the oven dried grain and straw samples were determined by the micro Kjeldahl digestion method (Jackson, 1973).

3.12.2 Total P

For the estimation of P from grain and straw material one gram powdered dry samples was taken in 100ml conical flask made up of corning glass and digested till the acid liquid has been completely volatilized, a colourless solution is obtained as described by Jackson (1973). The solution was then filtered and concentration of P was determined with the help of spectrophotometer described by Black (1965).

3.12.3 Total K

For the estimation of K from straw and grain, sample was prepared by the method described above like phosphorus. The concentration of K by flame photo meter was described by Hesse (1971).

3.12.4 Nutrient uptake (kg/ha)

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%) (grain/straw)}}{100} \times \text{yield (kg/ha)}$$

3.13 Biochemical parameters

3.13.1 Reducing sugar (%)

The sugar levels of babycorn i.e., reducing and total sugar were also determined by taking different parts of fruit using copper reduction method described by Ranganna, 2000. Known quality of sample was finely homogenized with distilled water using mortars with pestles and aqueous extracts were strained through fine cloth. For complete recovery of the extractable slurry was washed repeatedly with distilled water. The filtered extract against diluted to known quantity with distilled water for quantitative estimation. Aliquot of diluted juice was titrated against a mixture of equal quantity of Fehling's A and B. The titrations were carried out under boiling condition using methylene blue as an indicator. The reading was expressed as percentage.

3.13.2 Total sugar (%)

In order to estimate the total sugar levels of babycorn known quantity of juice, containing non-reducing sugar, were taken and converted in to reducing sugars by acid hydrolysis. For acid hydrolysis extracts were treated with known quantity of concentrated HCl. The acidified juice extracts were heated up to boil (10 minutes) and cooled, there by ensuring conversion of non-reducing sugars in to the reducing forms without interfering the reducing sugars already present in them. After cooling little quantity sodium hydroxide solution was added till the reaction came to neutral or slightly alkaline and this was tested with litmus paper. The solutions were made upto known volume by adding distilled water and titrated against Fehling's solutions as described in case of reducing sugar. The reading was expressed as percentage (Ranganna, 2000).

3.13.3 Analysis of total soluble protein

Soluble protein content was determined following the procedure of Lowry *et al.* (1951). 500mg fresh sample was ground in 10ml boric-borate buffer at pH 6.8. The titrated sample was centrifuged at 10,000 rpm for 30 minutes. The supernatant was used as protein source. Protein was precipitated from 5ml portion of the supernatant by adding 5ml of 20% trichloro acetic acid. The precipitate obtained after centrifugation at 10,000 rpm for 30 minutes was dissolved in 10ml 0.1N NaOH and was used for protein analysis.

0.2ml of each extract was diluted to 1ml with distilled water in pyrex tubes. A separate tube containing 1ml distilled water was used as blank. 5ml of alkaline copper solution was added to each tube, mixed thoroughly and was allowed to stand for 10 minutes (alkaline copper solution was prepared by mixing 50ml 2% Na_2Co_3 in 0.1N NaOH and 1ml of 0.5% $CuSo_4$, 5 H_2O in 1% potassium sodium tartrate). The 0.5ml of Folin-ceocalteau reagent (diluted to 1N solution by water) was added and mixed thoroughly. The tubes were kept in dark for 30 minutes for the development of colour. The absorbance was read subsequently at 660nm. The amount of protein was estimated from the standard prepared by using standard solutions of albumin (20 – 100 μg/ml).

3.13.4 Total soluble solids (°Brix)

In order to estimate the total soluble solid contents, a hand refractometer was used. It was washed properly with distilled water and dried. The observed shadow level was adjusted to '0' reading with a drop of distilled water. Subsequently the water was blotted out, the refractometer was dried and a drop of freshly squeezed and strained juice was instilled on the place to record the refractometer reading. The reading was expressed as °Brix.

3.14 Economic analysis

3.14.1 Gross return

Gross return was calculated from the total output of all the main products and by products before deducting the cost of cultivation.

3.14.2 Net return

Net return was computed from the total output of all the main products and by products after deducting the total cost of cultivation.

3.14.3 Benefit: cost ratio

Benefit : cost ratio was computed by dividing the net return with total cost of cultivation.

3.15 Statistical analysis

Analysis of variance method (Cochran and Cox, 1967; Gomez and Gomez, 1984; Panse and Sukhatme, 1985) was used for statistical analysis. The significance of difference for sources of variation was tested by error mean square by Fisher Snedecor's 'F' test at probability level of 0.05. For comparison of 'F' values and computation of critical difference (CD) at 5% level of significance, Fisher and Yates' tables were consulted.

CHAPTER 4

Results

Results

Two separate field experiments were conducted for two consecutive years (2005 – 2006 and 2006 – 2007) during rabi season in each year to study "Nutrient and Weed management on babycorn (*Zea mays* L.) in the sub-humid subtropical climatic condition of West Bengal at the Instructional Farm, Jaguli, Nadia, West Bengal. Results of both the experiments (year wise and pooled data) have been presented in this chapter.

4.1 Experiment 1: Nutrient management in babycorn

4.1.1 Growth attributes

4.1.1.1 Plant height

Effect of organic manure

The plant height of babycorn recorded under different nutrient management treatments showed a significant variation during both the experimental years (Table 4.1). Application of vermicompost @ 4 t ha^{-1} (M_2) produced the tallest plant (44.92 – 161.09 cm), closely followed by FYM @ 10 t ha^{-1} (M_4) at all the dates of observations. However, vermicompost @ 2 t ha^{-1} (M_1) produced significantly higher plant height (40.58 – 153.62 cm) than FYM @ 5 t ha^{-1} (M_3) and Control (M_0). The shortest plant was observed in M_0 (32.95 – 144.25 cm) throughout the growth period of the crop.

Effect of inorganic nitrogen

Highest plant height (45.66 – 160.75 cm) was obtained with 180 kg N ha^{-1} (N_3), which was statistically at par with 120 kg N ha^{-1} (N_2) throughout the growth period of the babycorn (Table 4.1). However, application of 60 kg N ha^{-1} (N_1) produced significantly higher plant height (38.77 – 153.10 cm) than N_0 (Control). During both the years, N_0 showed poor performance.

Table 4.1: Effect of nutrient management on plant height (cm) of babycorn

Treatment	20 DAS			40 DAS			60 DAS			Harvest		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	31.08	34.83	32.95	96.81	100.17	98.49	139.19	141.10	140.15	141.28	147.23	144.25
M_1	38.85	42.30	40.58	107.69	112.98	110.34	149.27	151.64	150.46	150.88	156.37	153.62
M_2	42.65	47.20	44.92	113.57	118.24	115.91	156.14	158.67	157.41	159.03	163.16	161.09
M_3	37.38	40.70	39.04	105.49	110.57	108.03	146.78	148.88	147.83	148.56	154.66	151.61
M_4	41.32	45.35	43.33	111.18	116.33	113.75	154.24	155.70	154.97	156.67	160.69	158.68
S. Em. (±)	0.3372	0.2828	0.2629	0.3847	0.3281	0.3500	0.3328	0.3367	0.3154	0.3872	0.3907	0.3616
C.D. (P = 0.05)	0.973	0.819	0.742	1.114	0.953	0.991	0.962	0.972	0.892	1.121	1.130	1.023
Inorganic nitrogen												
N_0	29.06	33.51	31.29	94.60	99.50	97.05	137.22	139.65	138.44	140.39	143.04	141.72
N_1	36.58	40.96	38.77	106.14	110.95	108.55	148.73	150.46	149.60	151.97	153.52	152.75
N_2	43.33	46.56	44.95	113.03	117.73	115.38	154.80	156.69	155.75	155.87	157.76	156.82
N_3	44.05	47.26	45.66	114.02	118.45	116.24	155.75	157.64	156.70	156.90	158.81	157.86
S. Em. (±)	0.3023	0.4047	0.3279	0.3465	0.2990	0.3593	0.3042	0.3098	0.3007	0.3515	0.3546	0.3513
C.D. (P = 0.05)	0.986	1.319	0.982	1.127	0.977	1.075	0.991	1.012	0.902	1.142	1.530	1.053

Table 4.2: Interaction effect of nutrient management on plant height (cm) of babycorn

Treatment	2005-2006					2006-2007					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Plant height at 20 DAS**									
N_0	24.12	28.84	33.33	27.25	31.76	28.07	34.30	37.55	31.97	35.68	26.10	31.57	35.44	29.61	33.72
N_1	30.29	37.26	40.29	35.96	39.08	35.04	41.51	45.55	38.86	43.83	32.67	39.39	42.92	37.41	41.46
N_2	34.71	44.39	48.06	42.76	46.73	37.68	46.27	52.53	45.68	50.65	36.20	45.33	50.30	44.22	48.69
N_3	35.18	44.92	48.91	43.56	47.69	38.54	47.11	53.15	46.30	51.23	36.86	46.02	51.03	44.93	49.46
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.3908			0.4304		0.3942			0.4016		0.4008			0.4379	
C.D. (P = 0.05)	1.127			1.132		1.139			1.141		1.134			1.137	
Inorganic nitrogen						**Plant height at 40 DAS**									
N_0	84.95	94.13	102.53	92.04	99.34	88.27	99.47	107.66	97.45	104.63	86.61	96.80	105.10	94.75	101.99
N_1	97.06	107.06	112.19	104.16	110.23	101.02	112.20	117.53	108.75	115.25	99.04	109.63	114.86	106.46	112.74
N_2	102.15	114.31	119.17	112.42	117.12	105.24	119.81	123.54	117.70	122.38	103.70	117.06	121.36	115.06	119.75
N_3	103.08	115.27	120.04	113.35	118.01	106.16	120.43	124.23	118.39	123.06	104.62	117.85	122.32	115.87	120.54
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.3927			0.4299		0.3964			0.4324		0.3990			0.4378	
C.D. (P = 0.05)	1.131			1.136		1.142			1.150		1.129			1.143	
Inorganic nitrogen						**Plant height at 60 DAS**									
N_0	125.05	138.16	144.92	134.23	143.73	127.01	141.34	146.85	136.34	145.62	126.03	139.75	145.89	135.29	144.68
N_1	140.08	149.52	154.35	147.36	152.34	142.05	151.65	158.39	149.43	152.62	141.07	150.59	156.37	148.40	152.48
N_2	145.32	154.22	162.16	152.30	159.99	147.15	156.42	164.29	154.46	161.98	146.24	155.32	163.23	153.38	160.99
N_3	146.31	155.19	163.12	153.24	160.91	148.20	157.15	165.16	155.29	162.56	147.26	156.17	164.14	154.27	161.74
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.3782			0.4058		0.4019			0.4475		0.3777			0.4341	
C.D. (P = 0.05)	1.092			1.115		1.160			1.172		1.068			1.127	
Inorganic nitrogen						**Plant height at harvest**									
N_0	127.16	140.26	150.03	137.32	147.18	130.11	143.28	152.95	140.36	149.20	128.64	141.77	151.49	138.84	148.19
N_1	144.19	151.63	158.46	149.13	156.42	145.14	154.66	160.49	152.49	158.39	144.67	153.15	159.48	150.81	157.41
N_2	146.41	155.33	163.17	153.37	161.06	156.37	163.39	169.12	162.42	167.10	151.39	159.36	166.15	157.90	164.08
N_3	147.35	156.28	164.45	154.42	162.01	157.29	164.15	170.08	163.36	168.06	152.32	160.22	167.27	158.89	165.04
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.4032			0.4471		0.4011			0.4535		0.4091			0.4475	
C.D. (P= 0.05)	1.165			1.176		1.161			1.169		1.154			1.162	

Interaction effect of organic manure and inorganic nitrogen

The data pertaining to plant height at various growth stages influenced significantly by interaction effect of organic manure and inorganic nitrogen during both the years of experimentation as well as in pooled data (Table 4.2). The plant height was gradually increased from 20 DAS to harvest stage of the crop and the maximum plant height (167.26 cm) was recorded where crop received vermicompost @ 4 t ha^{-1} along with 180 kg N ha^{-1} (M_2N_3). However, the M_2N_3 treatment was statistically on a par with vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2). The minimum plant height was recorded in control plot (M_0N_0) during both the years of experimentation as well as in pooled data.

4.1.1.2 Leaf area index (LAI)

Effect of organic manure

LAI of babycorn plant ... influenced significantly by the different organic manures (Table 4.3). The LAI was gradually increased from 20 DAS, maximum at 60 DAS, thereafter it was decreased. The higher LAI (0.90 to 3.15) was recorded with application of vermicompost @ 4 t ha^{-1} (M_2), closely followed by FYM @ 10 t ha^{-1} (M_4). However, vermicompost @ 2 t ha^{-1} (M_1) was significantly superior to application of FYM @ 5 t ha^{-1}(M_3) and control (M_0). Control treatment (M_0) gave minimum LAI (0.63 to 2.11). This trend was followed in both the experimental years as well as in pooled data.

Effect of inorganic nitrogen

The data pertaining to LAI at various growth stages was influenced significantly by the different doses of nitrogen during both the years of experimentation as well as in pooled data (Table 4.3). Application of nitrogen fertilizer increased LAI up to 60 DAS and thereafter it was decreased. The maximum LAI (0.91 to 3.26) was recorded under the

Table 4.3: Effect of nutrient management on leaf area index (LAI) of babycorn

Treatment	20DAS			40 DAS			60DAS			Harvest		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	0.60	0.67	0.63	1.67	1.86	1.76	2.81	2.93	2.87	1.97	2.25	2.11
M_1	0.76	0.83	0.80	1.93	2.14	2.04	3.73	3.79	3.76	2.64	2.94	2.79
M_2	0.87	0.93	0.90	2.01	2.25	2.13	4.06	4.15	4.10	3.00	3.29	3.15
M_3	0.73	0.79	0.76	1.90	2.11	2.00	3.64	3.68	3.66	2.60	2.87	2.73
M_4	0.83	0.90	0.86	1.98	2.19	2.08	3.97	4.05	4.01	2.96	3.24	3.10
S. Em. (±)	0.0037	0.0034	0.0036	0.0054	0.0081	0.0050	0.0098	0.0077	0.0083	0.0065	0.0072	0.0079
C.D. (P = 0.05)	0.0102	0.0113	0.0107	0.0134	0.0162	0.0150	0.0245	0.0257	0.0248	0.0210	0.0253	0.0237
Inorganic nitrogen												
N_0	0.57	0.64	0.61	1.62	1.85	1.74	2.27	2.38	2.33	1.90	2.17	2.04
N_1	0.70	0.77	0.74	1.84	2.05	1.95	3.49	3.56	3.53	2.42	2.70	2.56
N_2	0.87	0.94	0.90	2.06	2.26	2.16	4.40	4.46	4.43	3.10	3.39	3.25
N_3	0.88	0.95	0.91	2.07	2.28	2.17	4.42	4.48	4.45	3.12	3.40	3.26
S. Em. (±)	0.0041	0.0040	0.0040	0.0047	0.0089	0.0057	0.0075	0.0089	0.0091	0.0075	0.0090	0.0091
C.D. (P= 0.05)	0.0112	0.0116	0.0114	0.0156	0.0178	0.0162	0.0251	0.0262	0.0257	0.0244	0.0265	0.0257

Table 4.4: Interaction effect of nutrient management on leaf area index (LAI) of babycorn

Treatment	2005-2006					2005-2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**LAI at 20 DAS**									
N_0	0.48	0.57	0.64	0.54	0.61	0.56	0.63	0.71	0.61	0.68	0.52	0.60	0.68	0.58	0.65
N_1	0.59	0.71	0.78	0.68	0.76	0.66	0.77	0.84	0.74	0.82	0.63	0.74	0.81	0.71	0.79
N_2	0.66	0.88	1.02	0.84	0.96	0.72	0.95	1.07	0.9	1.04	0.69	0.92	1.05	0.87	1.00
N_3	0.67	0.89	1.03	0.85	0.97	0.73	0.96	1.08	0.91	1.05	0.70	0.93	1.06	0.88	1.01
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0045		0.0052			0.0050		0.0058			0.0042		0.0050	
C.D. (P = 0.05)		0.0132		0.0137			0.0146		0.0152			0.0125		0.0129	
Inorganic nitrogen						**LAI at 40 DAS**									
N_0	1.43	1.64	1.73	1.60	1.69	1.65	1.86	1.98	1.82	1.92	1.54	1.75	1.86	1.71	1.81
N_1	1.68	1.86	1.95	1.82	1.90	1.89	2.06	2.16	2.03	2.13	1.79	1.96	2.06	1.93	2.02
N_2	1.77	2.11	2.18	2.08	2.15	1.94	2.32	2.42	2.29	2.35	1.86	2.22	2.30	2.19	2.25
N_3	1.78	2.12	2.19	2.09	2.16	1.96	2.33	2.43	2.30	2.36	1.87	2.23	2.31	2.20	2.26
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0075		0.0082			0.0079		0.0082			0.0074		0.0079	
C.D. (P = 0.05)		0.0213		0.0215			0.0215		0.0219			0.0210		0.0217	
Inorganic Nitrogen						**LAI at 60 DAS**									
N_0	1.73	2.37	2.49	2.33	2.43	2.03	2.41	2.57	2.36	2.51	1.88	2.39	2.53	2.35	2.47
N_1	2.40	3.60	3.96	3.58	3.89	2.46	3.67	4.10	3.63	3.95	2.43	3.64	4.03	3.61	3.92
N_2	3.55	4.47	4.89	4.32	4.78	3.61	4.53	4.95	4.36	4.85	3.58	4.50	4.92	4.34	4.82
N_3	3.57	4.49	4.90	4.33	4.79	3.62	4.55	4.97	4.38	4.87	3.60	4.52	4.94	4.36	4.83
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0122		0.0136			0.0168		0.0196			0.0119		0.0139	
C.D. (P = 0.05)		0.0348		0.0356			0.0492		0.0512			0.0357		0.0362	
Inorganic Nitrogen						**LAI at harvest**									
N_0	1.52	1.88	2.15	1.84	2.10	1.80	2.17	2.41	2.14	2.35	1.66	2.03	2.28	1.99	2.23
N_1	1.92	2.31	2.82	2.25	2.78	2.23	2.61	3.12	2.50	3.02	2.08	2.46	2.97	2.38	2.90
N_2	2.20	3.18	3.51	3.14	3.48	2.47	3.49	3.81	3.42	3.78	2.34	3.34	3.66	3.28	3.63
N_3	2.23	3.19	3.52	3.15	3.49	2.48	3.50	3.82	3.43	3.79	2.35	3.35	3.67	3.29	3.64
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0117		0.0126			0.0106		0.0120			0.0113		0.0124	
C.D. (P = 0.05)		0.0329		0.0331			0.0315		0.0318			0.0321		0.0322	

treatment N_3 which received 180 kg N ha^{-1}, followed by application of 120 kg N ha^{-1} (N_2) and 60 kg N ha^{-1} (N_1) respectively, whereas, the minimum LAI (0.60 to 2.04) was in control plot (N_0).

Interaction effect of organic manure and inorganic nitrogen

Interaction effect between organic manure and inorganic nitrogen for LAI was significant throughout the crop growth period (Table 4.4). The maximum LAI (1.06, 2.31, 4.94 and 3.67 at 20, 40, 60 DAS and at harvest respectively) obtained with vermicompost @ 4 t coupled with 180 kg N ha^{-1} (M_2N_3) was statistically at par with vermicompost @ 4 t +120 N kg ha^{-1} (M_2N_2). The minimum LAI was observed in control plot (M_0N_0).

4.1.1.3 Dry matter accumulation (g m^{-2})

Effect of organic manure

Dry matter accumulation of babycorn recorded under different nutrient management treatments showed a significant variation during both the experimental years (Table 4.5). Application of vermicompost @ 4 t ha^{-1} (M_2) produced the higher dry matter accumulation (139.09 – 520.94 g m^{-2}) closely followed by FYM @ 10 t ha^{-1} (M_4) at all the dates of observation. However, vermicompost @ 2 t ha^{-1} (M_1) produced significantly higher dry matter accumulation (128.95 – 461.20 g m^{-2}) than FYM @ 5 t ha^{-1} (M_3) and Control (M_0). The lower dry matter accumulation was observed in M_0 (103.28 – 361.18 g m^{-2}) throughout the growth period of the crop.

Effect of inorganic nitrogen

Highest dry matter accumulation (142.97 – 533.11 g m^{-2}) was obtained with 180 kg N ha^{-1} (N_3), which was statistically at par with 120 kg N ha^{-1} (N_2) throughout the growth period of the babycorn (Table 4.5). However, application of 60 kg N ha^{-1} (N_1) produced significantly higher dry

Table 4.5: Effect of nutrient management on drymatter accumulation (g m^{-2}) of babycorn

Treatment	20 DAS			40 DAS			60 DAS			Harvest		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	101.38	105.18	103.28	159.13	206.63	182.88	272.23	356.43	314.33	308.93	413.43	361.18
M_1	126.45	131.45	128.95	204.05	260.95	232.50	350.00	443.80	396.90	404.90	517.00	461.20
M_2	136.85	141.33	139.09	235.20	288.18	261.69	397.00	487.43	442.21	465.50	576.38	520.94
M_3	122.50	127.05	124.78	194.50	250.35	222.43	337.00	429.95	383.48	389.55	499.70	444.63
M_4	132.53	137.03	134.78	226.08	277.38	251.73	383.18	473.83	428.50	448.58	559.53	504.05
S. Em. (±)	0.2987	0.3566	0.3709	0.8957	1.4213	1.1534	1.0972	1.6593	1.5801	1.6575	2.4352	2.1157
C.D. (P = 0.05)	0.974	1.162	1.112	2.913	4.635	3.458	3.374	5.484	4.737	5.449	7.924	6.343
Inorganic nitrogen												
N_0	96.10	100.68	98.39	148.74	193.88	171.31	245.34	330.32	287.83	279.82	383.84	331.83
N_1	119.16	123.40	121.28	193.48	245.88	219.68	329.92	423.04	376.48	383.28	494.84	439.06
N_2	139.80	144.30	142.05	235.40	292.78	264.09	406.56	498.54	452.55	473.64	585.54	529.59
N_3	140.70	145.24	142.97	237.54	294.24	265.89	409.70	501.24	455.47	477.22	589.00	533.11
S. Em. (±)	0.3955	0.5297	0.4719	1.2504	1.9825	1.6253	1.8023	2.4675	2.2195	2.6272	3.4973	3.2658
C.D. (P = 0.05)	1.141	1.534	1.335	3.621	5.726	4.598	5.209	7.146	6.279	7.612	10.115	9.239

Table 4.6: Interaction effect of nutrient management on drymatter accumulation (g m^{-2}) of babycorn

Treatment	2005-2006					2006-2007					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Dry matter accumulation at 20 DAS**									
N_0	82.30	96.10	107.30	92.60	102.20	86.10	101.20	112.50	97.40	106.20	84.20	98.65	109.90	95.00	104.20
N_1	99.40	120.20	132.50	115.30	128.40	103.30	125.10	137.30	119.10	132.20	101.35	122.65	134.90	117.20	130.30
N_2	111.50	144.30	153.40	140.60	149.21	115.20	149.30	157.20	145.50	154.30	113.35	146.80	155.30	143.05	150.75
N_3	112.30	145.20	154.20	141.50	150.30	116.10	150.20	158.30	146.20	155.40	114.20	147.70	156.25	143.85	152.85
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.5289		0.7311			0.7317		0.9204			0.6179		0.7641	
C.D. (P = 0.05)		1.526		1.923			2.114		2.504			1.748		1.984	
Inorganic nitrogen						**Dry matter accumulation at 40 DAS**									
N_0	114.30	148.50	175.10	141.20	164.60	157.70	195.00	225.30	281.40	210.00	136.00	171.75	200.20	161.30	187.30
N_1	156.60	197.60	218.70	185.90	208.60	202.10	249.70	272.30	241.30	264.00	179.35	233.65	245.50	213.60	236.50
N_2	181.50	233.90	272.60	224.40	244.40	232.60	298.90	326.80	288.70	316.90	207.05	266.40	299.70	256.65	290.65
N_3	184.10	236.20	274.40	226.30	266.70	234.10	300.20	328.30	290.00	318.60	209.00	268.20	301.35	258.15	292.65
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		1.8390		2.1877			2.5371		2.9934			2.2054		2.5854	
C.D. (P = 0.05)		5.297		5.662			7.328		7.872			6.239		6.713	
Inorganic nitrogen						**Dry matter accumulation at 60 DAS**									
N_0	186.50	244.10	289.30	231.80	275.00	269.10	331.60	380.50	309.00	361.40	227.80	287.85	334.90	270.40	318.20
N_1	262.20	339.80	267.90	325.70	354.00	345.30	432.90	462.50	422.10	452.40	307.75	386.35	415.20	373.90	403.20
N_2	318.30	406.30	464.00	394.00	450.20	403.40	504.50	552.10	493.50	539.30	360.85	455.40	508.00	443.75	494.75
N_3	321.90	409.80	466.80	396.50	453.50	407.90	506.20	554.70	495.20	542.20	364.90	458.00	510.75	445.85	497.85
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		2.9145		3.2896			3.1578		3.6458			3.0916		3.4362	
C.D. (P = 0.05)		8.416		8.627			9.115		9.549			8.746		8.922	
Inorganic nitrogen						**Dry matter accumulation at harvest**									
N_0	215.40	278.50	327.70	265.20	311.80	316.70	383.20	440.30	360.80	418.40	266.20	330.85	384.00	313.00	365.10
N_1	298.20	389.40	435.90	373.10	419.80	402.50	497.70	551.90	485.3	536.80	350.35	443.55	493.90	429.20	478.30
N_2	358.50	473.90	547.60	458.40	529.80	464.80	593.30	655.00	575.10	639.50	411.65	533.60	601.30	516.75	584.65
N_3	363.10	477.80	550.80	461.50	532.90	469.90	595.80	658.30	577.60	643.40	416.50	536.80	604.55	519.55	588.15
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		3.9479		4.3521			4.6433		5.2128			4.3277		4.8272	
C.D. (P = 0.05)		11.329		11.447			13.441		13.711			12.243		10.560	

matter accumulation (121.28 - 439.06 g m^{-2}) than N_0 (Control). During both the years, N_0 showed poor performance.

Interaction effect of organic manure and inorganic nitrogen

The data pertaining to dry matter accumulation at various growth stages influenced significantly by interaction effect of organic manure and inorganic nitrogen during both the years of experimentation as well as in pooled data (Table 4.6). The dry matter accumulation was gradually increased from 20 DAS to harvest stage of the crop and the maximum dry matter accumulation (604.55 g m^{-2}) was recorded where crop received vermicompost @ 4 t ha^{-1} along with 180 kg N ha^{-1} (M_2N_3). However, the M_2N_3 treatment was statistically at par with vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2). The minimum dry matter accumulation was recorded in control plot (M_0N_0) during both the years of experimentation as well as in pooled data.

4.1.1.4 Crop growth rate (g m^{-2} day^{-1})

Effect of organic manure

Perusal of data in the Table 4.7 revealed that at the rate of crop growth was maximum (6.13, 9.03 and 3.94 g m^{-2} day^{-1} at 20-40 DAS, 40-60 DAS and 60 DAS-harvest respectively) with application of vermicompost @ 4 t ha^{-1} (M_2), followed by application of FYM @ 10 t ha^{-1} (M_4). Application of vermicompost @ 2 t ha^{-1} (M_1) was significantly superior over application of FYM @ 5 t ha^{-1} (M_3) and control (M_0) during both the years of experimentation as well as in pooled data.

Effect of inorganic nitrogen

From the Table 4.7 it was cleared that CGR was significantly varied with different doses of nitrogen and it was increased (6.99, 9.48 and 3.88 g m^{-2} day^{-1} at 20-40 DAS, 40-60 DAS and 60 DAS to harvest respectively) up

Table 4.7: Effect of nutrient management on crop growth rate (g m^{-2} day^{-1}) of babycorn

Treatment	20 – 40 DAS			40 – 60 DAS			60 DAS – harvest		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure									
M_0	2.89	5.07	3.98	5.66	7.49	6.58	1.84	2.85	2.35
M_1	3.88	6.48	5.18	7.30	9.09	8.20	2.75	3.74	3.25
M_2	4.92	7.34	6.13	8.09	9.96	9.03	3.43	4.45	3.94
M_3	3.60	6.17	4.89	7.13	8.98	8.05	2.63	3.49	3.06
M_4	4.68	7.02	5.85	7.86	9.82	8.84	3.27	4.30	3.79
S. Em. (±)	0.0457	0.0637	0.0630	0.0374	0.0704	0.0584	0.0114	0.0130	0.0087
C.D. (P = 0.05)	0.148	0.207	0.189	0.121	0.227	0.175	0.037	0.043	0.026
Inorganic nitrogen									
N_0	2.63	4.66	3.65	4.83	6.78	5.81	1.72	2.72	2.22
N_1	3.72	6.12	4.92	6.82	8.86	7.84	2.67	3.59	3.13
N_2	4.78	7.42	6.10	8.56	10.29	9.43	3.35	4.35	3.85
N_3	4.84	7.45	6.15	8.61	10.35	9.48	3.38	4.39	3.89
S. Em. (±)	0.0545	0.0935	0.0870	0.0427	0.7933	0.0679	0.0154	0.0167	0.0147
C.D. (P = 0.05)	0.157	0.272	0.246	0.124	0.229	0.192	0.045	0.047	0.042

Table 4.8: Interaction effect of nutrient management on crop growth rate (g m^{-2} day^{-1}) of babycorn

Treatment	2005 – 2006					2006 – 2007					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Crop growth rate at 20-40 DAS**									
N_0	1.60	2.62	3.39	2.43	3.12	3.58	4.69	5.64	4.20	5.19	2.59	3.66	4.52	3.32	4.66
N_1	2.86	3.87	4.31	3.53	4.01	4.94	6.23	6.61	6.11	6.59	3.90	5.05	5.53	4.82	5.30
N_2	3.50	4.48	5.96	4.20	5.76	5.87	7.48	7.16	7.16	8.13	4.69	5.98	7.22	5.68	6.95
N_3	3.59	4.55	6.01	4.24	5.82	5.90	7.50	7.19	7.19	8.16	4.75	6.03	7.26	5.72	6.99
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0576			0.0684		0.1021			0.1234		0.0586			0.0662	
C.D. (P= 0.05)	0.166			0.175		0.295			0.316		0.166			0.172	
Inorganic nitrogen						**Crop growth rate at 40 – 60 DAS**									
N_0	3.61	4.78	5.71	4.53	5.52	5.57	6.63	7.76	6.38	7.57	4.59	5.71	6.74	5.46	6.55
N_1	5.28	7.11	7.46	6.99	7.27	7.16	9.16	9.51	9.04	9.42	6.27	8.14	8.49	8.02	8.35
N_2	6.84	8.62	9.57	8.47	9.29	8.54	10.28	11.26	10.24	11.12	7.69	9.45	10.42	9.36	10.21
N_3	6.89	8.68	9.62	8.51	9.34	8.69	10.3	11.32	10.26	11.18	7.79	9.49	10.47	9.39	10.26
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0443			0.0531		0.0386			0.0473		0.0403			0.0454	
C.D. (P = 0.05)	0.128			0.136		0.112			0.121		0.114			0.118	
Inorganic nitrogen						**Crop growth rate at 60 DAS – harvest**									
N_0	1.47	1.72	1.92	1.67	1.84	2.37	2.78	2.99	2.59	2.85	1.92	2.25	2.46	2.13	2.34
N_1	1.80	2.48	3.40	2.37	3.29	2.86	3.24	4.47	3.16	4.22	2.33	2.86	3.94	2.77	3.76
N_2	2.01	3.38	4.18	3.22	3.98	3.07	4.44	5.15	4.08	5.01	2.54	3.91	4.67	3.65	4.50
N_3	2.06	3.40	4.20	3.25	3.97	3.10	4.48	5.18	4.12	5.06	2.58	3.94	4.69	3.69	4.52
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0345			0.0363		0.0360			0.0414		0.0249			0.0312	
C.D. (P = 0.05)	0.100			0.103		0.104			0.106		0.070			0.081	

to 180 kg N ha^{-1} (N_3), but there was no significant difference between N_3 and N_2 (120 kg N ha^{-1}). The minimum CGR was recorded in control (N_0) during both the years of experimentation as well as in pooled data.

Interaction effect of organic manure and inorganic nitrogen

Interaction effect between organic manure and inorganic nitrogen on CGR was significant throughout the growth stages of the crop (Table 4.8). The highest CGR (7.26, 10.47 and 4.69 at 20-40 DAS, 40-60 DAS and 60 DAS-harvest respectively) was obtained with application of vermicompost @ 4 t + 180 N kg ha^{-1} (M_2N_3).The M_2N_3 treatment was at par with vermicompost @ 4 t + 120 N kg ha^{-1} (M_2N_2). Similarly there was no significant difference between FYM @ 10 t + 180 kg N ha^{-1} (M_4N_3) and FYM @ 10 t ha^{-1} + 120 kg N ha^{-1} (M_4N_2). The lowest CGR was obtained in control plot (M_0N_0).

4.1.2 Yield attributes

4.1.2.1 Number of cobs plant^{-1}

Effect of organic manure

Data on number of cobs plant^{-1} (Table 4.9) revealed that treatment M_0 (no organic manure) produced significantly lower number of cobs plant^{-1} (1.56). However, application of vermicompost @ 4 t ha^{-1} (M_2) gave significantly highest number of cobs plant^{-1} (2.25) over other treatments. Between M_1 (vermicompost @ 2 t ha^{-1}) and M_3 (FYM @ 5 t ha^{-1}), M_1 provided significantly higher values (2.02) than M_3 (1.91).

Effect of inorganic nitrogen

The maximum number of cobs plant^{-1} (2.27) provided by 180 kg N ha^{-1} (N_3) as in Table 4.9. The minimum and significantly lower number of cobs plant^{-1} (1.53) was obtained from no nitrogen (N_0). N_3 treatment was which

Table 4.9: Effect of nutrient management on number of cobs plant^{-1}, cob weight and husk: babycorn ratio

Treatment	Number of cobs plant^{-1}			Cob weight with husk(g)			Cob weight without husk(g)			Husk: babycorn ratio		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	1.44	1.67	1.56	28.13	29.89	29.01	4.91	6.76	5.83	5.02	4.73	4.88
M_1	1.90	2.15	2.02	33.45	34.83	34.14	6.77	7.87	7.32	4.53	4.42	4.48
M_2	2.12	2.38	2.25	35.96	37.90	36.93	7.44	8.44	7.94	4.33	4.20	4.28
M_3	1.80	2.03	1.91	32.32	33.74	33.03	6.43	7.62	7.02	4.65	4.46	4.56
M_4	2.04	2.27	2.15	34.83	36.62	35.73	7.19	8.23	7.71	4.44	4.32	4.38
S. Em. (±)	0.0057	0.0173	0.0091	0.0443	0.0422	0.0474	0.0396	0.0422	0.0447	0.0088	0.0110	0.0110
C.D. (P= 0.05)	0.018	0.056	0.027	0.146	0.137	0.142	0.129	0.136	0.134	0.029	0.036	0.033
Inorganic nitrogen												
N_0	1.43	1.63	1.53	27.22	29.85	28.54	4.79	6.44	5.62	5.05	4.91	4.98
N_1	1.74	2.01	1.88	32.01	33.31	32.66	6.33	7.39	6.86	4.67	4.51	4.59
N_2	2.11	2.36	2.24	36.20	37.58	36.89	7.49	8.63	8.06	4.34	4.16	4.25
N_3	2.15	2.38	2.27	36.32	37.65	36.99	7.57	8.67	8.12	4.31	4.12	4.22
S. Em. (±)	0.0143	0.0137	0.0180	0.0495	0.0491	0.0534	0.0454	0.0468	0.0484	0.0107	0.0181	0.0170
C.D. (P = 0.05)	0.042	0.062	0.051	0.154	0.142	0.151	0.131	0.142	0.137	0.031	0.052	0.048

Table 4.10: Interaction effect of nutrient management on number of cobs plant^{-1}, cob weight and husk: babycorn ratio

Treatment	2005-2006					2005-2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Number of cobs plant^{-1}**									
N_0	1.15	1.42	1.65	1.35	1.56	1.33	1.64	1.89	1.52	1.78	1.24	1.53	1.77	1.44	1.67
N_1	1.49	1.70	1.97	1.62	1.90	1.70	2.04	2.24	1.94	2.13	1.60	1.87	2.11	1.78	2.02
N_2	1.55	2.21	2.40	2.09	2.32	1.81	2.44	2.68	2.31	2.57	1.68	2.33	2.54	2.20	2.45
N_3	1.58	2.25	2.44	2.13	2.36	1.83	2.46	2.70	2.33	2.60	1.71	2.36	2.57	2.23	2.48
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0153		0.0175			0.0224		0.0233			0.0172		0.0209	
C.D. (P = 0.05)		0.044		0.046			0.065		0.066			0.055		0.059	
Inorganic nitrogen						**Cob weight with husk (g)**									
N_0	24.19	27.51	29.48	26.18	28.73	26.54	29.97	32.94	28.63	31.17	25.37	28.74	31.21	27.41	29.95
N_1	27.71	31.58	35.87	30.43	34.44	30.25	33.83	35.31	32.88	34.29	28.98	32.71	35.59	31.66	34.37
N_2	30.26	37.28	39.19	36.25	38.04	31.36	37.73	41.65	36.70	40.47	30.81	37.51	40.42	36.48	39.26
N_3	30.34	37.42	39.31	36.41	38.12	31.42	37.80	41.71	36.76	40.56	30.88	37.61	40.51	36.59	39.34
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0638		0.0725			0.0609		0.0695			0.0608		0.0666	
C.D. (P = 0.05)		0.184		0.187			0.176		0.178			0.172		0.173	
Inorganic nitrogen						**Cob weight without husk (g)**									
N_0	4.16	4.79	5.42	4.49	5.10	5.77	6.44	6.98	6.21	6.78	4.97	5.62	6.20	5.35	5.94
N_1	4.95	6.37	7.30	5.91	7.11	6.64	7.35	8.01	7.11	7.86	5.80	6.86	7.66	6.51	7.49
N_2	5.25	7.91	8.46	7.62	8.23	7.29	8.82	9.35	8.56	9.12	6.27	8.37	8.91	8.09	8.68
N_3	5.27	8.00	8.57	7.70	8.32	7.33	8.86	9.40	8.59	9.16	6.30	8.43	8.99	8.15	8.74
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0460		0.0528			0.0535		0.0611			0.0516		0.0585	
C.D. (P = 0.05)		0.133		0.139			0.155		0.161			0.146		0.152	
Inorganic nitrogen						**Husk: babycorn Ratio**									
N_0	5.27	5.06	4.82	5.15	4.93	5.12	4.93	4.71	5.01	4.80	5.20	5.00	4.77	5.08	4.87
N_1	4.99	4.58	4.41	4.83	4.52	4.88	4.51	4.29	4.46	4.41	4.94	4.55	4.35	4.65	4.47
N_2	4.91	4.25	4.05	4.32	4.16	4.48	4.13	3.93	4.21	4.05	4.70	4.19	3.99	4.27	4.11
N_3	4.89	4.22	4.03	4.29	4.14	4.45	4.11	3.88	4.17	4.01	4.67	4.17	3.96	4.23	4.08
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0174		0.0199			0.0214		0.0237			0.0191		0.0220	
C.D. (P = 0.05)		0.0521		0.0525			0.0620		0.0623			0.0540		0.0570	

statistically at par with 120 kg N ha^{-1} (N_2), but N_2 exhibited significantly higher value (2.24) than 60 kg N ha^{-1} (1.87).

Interaction effect of organic manure ad inorganic nitrogen

The interaction effect of organic manure and inorganic nitrogen was significant on number cobs $plant^{-1}$ (Table 4.10). The maximum number of cobs $plant^{-1}$ (2.57) was obtained by the application vermicompost @ 4 t + 180 N kg ha^{-1} (M_2N_3), which was statistically at par with vermicompost @ 4 t + 120 N kg ha^{-1} (M_2N_2). Similarly application of FYM @ 10 t + 180 kg N ha-1 (M4N3) was statistically at par with application of FYM @ 10 t + 120 kg N ha^{-1} (M_4N_2). The control treatment (M_0N_0) recorded the minimum value (1.24) as found in pooled data.

4.1.2.2 Cob weight

Effect of organic manure

Table 4.9 revealed that vermicompost @ 4 t ha^{-1} (M_2) provided maximum cob weight with and without husk (36.93 and 7.94 g respectively) whereas these were minimum (29.01 and 5.83 g respectively) under without organic manure (M_0). M_2 showed significantly higher cob weight with and without husk than FYM @ 10 t ha^{-1} (M_4). Both vermicompost @ 2 t ha^{-1} (M_1) and FYM @ 5 t ha^{-1} (M_3) revealed significantly higher value of these parameters than no manure application (M_0).

Effect of inorganic nitrogen

Application of 180 N kg ha^{-1}(N_3) recorded the highest cob weight with and without husk (36.99 and 8.12 g respectively) than other treatments, but statistically at par with 120 N kg ha^{-1} (N_2) as stated in Table 4.9. N_2 treatment was significantly higher than N_1 (60 kg N ha^{-1}) and N_0 (no nitrogen). However, N_0 recorded the minimum value of these parameters.

Interaction effect of organic manure and inorganic nitrogen

The interaction effect between organic manure and inorganic nitrogen on cob weight with and without husk was significant (Table 4.10). Pooled data exhibited that the maximum value of cob weight with husk (40.51 g) and without husk (8.99 g) under vermicompost @ 4 t along with 180 kg N ha^{-1} (M_2N_3), followed by application of vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2). The control plot (M_0N_0) resulted the minimum cob weight with husk (25.37 g) and without husk (4.97 g).

4.1.2.3 Husk: babycorn ratio

Effect of organic manure

It is evident from the Table 4.9 that no organic manure (M_0) treatment recorded highest husk: babycorn ratio (4.87). Application of vermicompost @ 4 t ha^{-1} (M_2) showed significantly lowest husk: babycorn ratio (4.27) in pooled data. Results of both years also revealed the similar trend.

Effect of inorganic nitrogen

Among the different levels of nitrogen, 180 N kg ha^{-1} (N_3) recorded lowest husk: babycorn ratio (4.22) than other treatments (Table 4.9), followed by 120 N kg ha^{-1} (N_2). Whereas, the control plot (N_0) recorded significantly highest husk: babycorn ratio (4.98), followed by 60 kg N ha^{-1} (N_1). There are no significant difference between N_2 and N_3.

Interaction effect of organic manure and inorganic nitrogen

The interaction effect between organic manure and inorganic nitrogen was significant (Table 10). Application of vermicompost @ 4 t along with 180 kg N ha^{-1} (M_2N_3) recorded the lowest husk : babycorn ratio (3.96) which was statistically at par with vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2) with ratio of 3.99.

4.1.2.4 Length and diameter of cob

Effect of organic manure

Maximum cob length with husk (18.86 cm) and without husk (7.65 cm) was recorded in case of treatment of vermicompost @ 4 t ha^{-1} (M_2), which was significantly higher than FYM @ 10 t ha^{-1} (M_4). Application of vermicompost @ 2 t ha^{-1} (M_1) and FYM @ 5 t ha^{-1} (M_3) provided significantly higher values of cob length with husk (18.19 and 17.97 cm respectively) and without husk (6.73 and 6.54 cm respectively) than no organic manure (M_0), which showed the minimum values (16.78 and 5.77 cm respectively). The treatment differences due to manure application were significant (Table 4.11).

Regarding diameter of cob, there was a significant variation among the different treatments of organic manure only in cob diameter with husk (Table 4.11). Vermicompost @ 4 t ha^{-1} (M_2) gave significantly highest cob diameter with husk (1.87 cm) than other treatments and also produced the maximum cob diameter without husk (1.31 cm). No manure treatment (M_0) recorded the minimum value (1.46 and 1.17 cm respectively).

Effect of inorganic nitrogen

Among the different doses of nitrogen, the length and diameter of cob with and without husk was highest in 180 N kg ha^{-1} (N_3), which was statistically at par with 120 kg N ha^{-1} (N_2) (Table 4.11). The lowest value of these parameters was obtained in control (N_0). Regarding cob diameter without husk, there was no significant difference among the different rates of nitrogen.

Interaction effect of organic manure and inorganic nitrogen

Pooled data showed that the treatment differences due to interaction between organic manure and inorganic nitrogen were significant except cob diameter without husk (Table 4.12). Vermicompost @ 4 t coupled with 180

Table 4.11: Effect of nutrient management on length and diameter of cob

Treatment	Cob length with husk (cm)			Cob length without husk (cm)			Cob diameter with husk (cm)			Cob diameter without husk (cm)		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	16.34	17.22	16.78	5.01	6.53	5.77	1.29	1.63	1.46	1.16	1.18	1.17
M_1	17.56	18.82	18.19	5.92	7.54	6.73	1.53	1.86	1.69	1.24	1.30	1.27
M_2	18.38	19.34	18.86	6.91	8.39	7.65	1.70	2.04	1.87	1.29	1.34	1.31
M_3	17.34	18.60	17.97	5.74	7.34	6.54	1.47	1.79	1.63	1.22	1.27	1.25
M_4	18.19	19.16	18.67	6.77	8.25	7.51	1.63	1.96	1.79	1.28	1.32	1.30
S. Em. (±)	0.0274	0.0201	0.0247	0.0312	0.0318	0.0250	0.0029	0.0033	0.0021	0.0310	0.0230	0.0290
C.D. (P = 0.05)	0.090	0.065	0.074	0.101	0.105	0.075	0.008	0.009	0.006	NS	NS	NS
Inorganic nitrogen												
N_0	15.64	16.60	16.12	4.88	6.48	5.68	1.26	1.57	1.42	1.13	1.16	1.15
N_1	17.67	18.51	18.09	5.76	7.05	6.41	1.42	1.80	1.61	1.23	1.27	1.25
N_2	18.43	19.66	19.05	6.78	8.42	7.60	1.70	2.02	1.86	1.28	1.34	1.31
N_3	18.50	19.73	19.12	6.85	8.49	7.67	1.71	2.03	1.87	1.30	1.35	1.32
S. Em. (±)	0.0316	0.0298	0.0279	0.0355	0.0385	0.0293	0.0049	0.0055	0.0035	0.0329	0.0280	0.0315
C.D. (P = 0.05)	0.092	0.086	0.079	0.102	0.111	0.083	0.016	0.018	0.010	NS	NS	NS

Table 4.12: Interaction effect of nutrient management on length and diameter of babycorn

Treatment	2005-2006					2005-2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Cob length with husk (cm)**									
N_0	14.06	15.51	16.75	15.33	16.54	15.21	16.80	17.30	16.57	17.12	14.64	16.16	17.03	15.95	16.83
N_1	16.93	17.52	18.39	17.36	18.14	16.92	18.76	19.28	18.50	19.11	16.93	18.14	18.84	17.93	18.63
N_2	17.14	18.57	19.14	18.30	19.01	18.32	19.82	20.35	19.64	20.17	17.73	19.20	19.75	18.97	19.59
N_3	17.23	18.63	19.22	18.37	19.05	18.41	19.90	20.42	19.70	20.24	17.82	19.27	19.82	19.04	19.65
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0385		0.0415			0.0364		0.0426			0.0336		0.0377	
C.D. (P = 0.05)		0.111		0.118			0.105		0.109			0.095		0.098	
Inorganic nitrogen						**Cob length without husk (cm)**									
N_0	4.50	4.85	5.26	4.68	5.12	6.18	6.46	6.80	6.29	6.66	5.34	5.66	6.03	5.49	5.89
N_1	4.98	5.56	6.52	5.39	6.37	6.50	7.14	7.42	6.90	7.29	5.74	6.35	6.97	6.15	6.83
N_2	5.25	6.60	7.89	6.41	7.75	6.67	8.25	9.63	8.06	9.49	5.96	7.43	8.76	7.24	8.62
N_3	5.31	6.67	7.96	6.47	7.82	6.75	8.32	9.71	8.12	9.56	6.03	7.50	8.84	7.30	8.69
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0388		0.0469			0.0412		0.0492			0.0283		0.0424	
C.D. (P = 0.05)		0.112		0.120			0.119		0.126			0.081		0.110	
Inorganic nitrogen						**Cob diameter with husk (cm)**									
N_0	1.15	1.26	1.36	1.22	1.32	1.43	1.58	1.70	1.50	1.65	1.29	1.42	1.53	1.36	1.49
N_1	1.29	1.42	1.54	1.38	1.49	1.61	1.81	1.94	1.76	1.86	1.45	1.62	1.74	1.57	1.68
N_2	1.35	1.72	1.95	1.64	1.85	1.73	2.01	2.26	1.95	2.15	1.54	1.87	2.11	1.80	2.00
N_3	1.36	1.73	1.96	1.65	1.86	1.74	2.02	2.27	1.96	2.16	1.55	1.88	2.12	1.81	2.01
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0065		0.0083			0.0065		0.0084			0.0046		0.0055	
C.D. (P = 0.05)		0.019		0.022			0.019		0.022			0.013		0.015	
Inorganic nitrogen						**Cob diameter wthout husk (cm)**									
N_0	1.05	1.14	1.19	1.11	1.17	1.08	1.17	1.22	1.15	1.19	1.07	1.16	1.21	1.13	1.18
N_1	1.15	1.24	1.26	1.22	1.28	1.18	1.28	1.32	1.25	1.30	1.17	1.26	1.29	1.24	1.29
N_2	1.20	1.29	1.34	1.27	1.32	1.23	1.36	1.40	1.34	1.38	1.22	1.33	1.37	1.31	1.35
N_3	1.22	1.30	1.35	1.28	1.33	1.24	1.37	1.41	1.35	1.39	1.23	1.34	1.38	1.32	1.36
		M × N		N × M			M × N		N × M			M × N		N × M	
S. Em. (±)		0.0735		0.0746			0.058		0.0590			0.0369		0.0371	
C.D. (P = 0.05)		NS		NS			NS		NS			NS		NS	

kg N ha^{-1} (M_2N_3) showed highest cob length and diameter with and without husk, however, which was statistically at par with vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2), followed by FYM @ 10t + 180 kg N ha^{-1}(M_4N_3). The control (M_0N_0) recorded the lowest cob length and diameter.

4.1.2.5 Yield

4.1.2.5.1 Babycorn yield

Effect of organic manure

It appears from the Table 4.13 that the babycorn yield varied significantly due to different organic manure treatments. The lowest babycorn yield with husk (5368 kg ha^{-1}) and without husk (1108 kg ha^{-1}) obtained when the crop received no organic manure (M_0). The babycorn yield with husk (7694 kg ha^{-1}) and without husk (1521 kg ha^{-1}) recorded with vermicompost @ 4 t ha^{-1} (M_2) was significantly highest than other treatments. M_2 was closely followed by the treatment FYM @ 10 t ha^{-1} (M_4).

Effect of inorganic nitrogen

Among the different levels of nitrogen, application of 180 N kg ha^{-1} (N_3) produced significantly highest babycorn yield with husk (7888 kg ha^{-1}) and without husk (1570 kg ha^{-1}) than other treatments (Table 4.13), except N_2 (120 kg N ha^{-1}) which had a yield of 7839 kg and 1542 kg ha^{-1} respectively. No application of nitrogen (N_0) recorded lowest babycorn yield with and without husk (4956 kg and 1025 kg ha^{-1} respectively). Similar trend was obtained in both the years of experimentation and also in pooled data.

Interaction effect of organic manure and inorganic nitrogen

The interaction effect between organic manure and inorganic nitrogen on babycorn yield was significant in pooled data as well as in both the years of experiment (Table 4.14). Application of vermicompost @ 4 t along with 180 kg N ha^{-1} (M_2N_3) recorded maximum cob yield with husk (8697 kg ha^{-1}) and without husk (1728 kg ha^{-1}), which was at par with vermicompost @ 4 t

Table 4.13: Effect of nutrient management on corn and green fodder yield of babycorn

Treatment	Babycorn yield with husk (kg ha^{-1})			Babycorn yield without husk (kg ha^{-1})			Green fodder yield (t ha^{-1})		
	2005-2006	**2006-2007**	**Pooled**	**2005-2006**	**2006-2007**	**Pooled**	**2005-2006**	**2006-2007**	**Pooled**
Organic manure									
M_0	5289	5447	5368	993	1223	1108	31.88	33.79	32.83
M_1	6682	6845	6763	1275	1502	1388	40.91	43.15	42.03
M_2	7612	7776	7694	1434	1608	1521	45.48	47.42	46.45
M_3	6589	6754	6671	1226	1449	1337	39.28	41.30	40.29
M_4	7515	7678	7596	1369	1544	1456	43.81	45.90	44.85
S. Em. (±)	14.628	14.867	15.473	8.7988	9.0441	9.1381	0.3523	0.3850	0.3482
C.D. (P = 0.05)	47.714	48.454	46.389	28.701	29.501	27.396	1.025	1.110	0.985
Inorganic nitrogen									
N_0	4874	5037	4956	918	1131	1025	30.34	32.35	31.35
N_1	6510	6672	6591	1183	1441	1312	38.28	40.30	39.29
N_2	7757	7921	7839	1453	1631	1542	45.92	47.98	46.95
N_3	7807	7969	7888	1481	1658	1570	46.54	48.62	47.58
S. Em. (±)	17.6452	17.9324	18.6611	10.2482	10.5598	10.034	0.3380	0.3418	0.3369
C.D. (P = 0.05)	50.963	51.796	49.812	29.606	30.502	28.386	1.112	1.115	1.010

Table 4.14: Interaction effect of nutrient management on corn and green fodder yield of babycorn

Treatment	2005-2006					2005-2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Babycorn yield with husk (kg ha^{-1})**									
N_0	3191	4656	6039	4548	5938	3347	4820	6203	4715	6101	3269	4738	6121	4632	6020
N_1	5603	6336	7224	6249	7137	5760	6499	7388	6414	7299	5682	6418	7306	6332	7218
N_2	6155	7842	8568	7754	8466	6315	8008	8732	7920	8629	6235	7925	8650	7837	8548
N_3	6205	7892	8615	7804	8518	6365	8054	8779	7966	8682	6285	7973	8697	7885	8600
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	18.7660			21.2439		19.4536			22.3989		18.7876			20.8901	
C.D. (P = 0.05)	54.18			55.25		56.32			57.62		53.15			54.24	
Inorganic nitrogen						**Babycorn yield without husk (kg ha^{-1})**									
N_0	720	897	1107	836	1032	918	1154	1277	1089	1216	819	1025.5	1192	962.5	1124
N_1	916	1211	1336	1183	1269	1195	1476	1591	1418	1523	1056	1344	1464	1301	1396
N_2	1152	1482	1632	1428	1572	1378	1676	1768	1631	1704	1265	1579	1700	1530	1638
N_3	1182	1509	1660	1455	1601	1402	1701	1795	1658	1734	1292	1605	1728	1557	1668
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	12.1629			13.7040		12.9282			14.7487		12.1739			13.5721	
C.D. (P = 0.05)	35.13			36.18		37.36			38.27		34.44			35.24	
Inorganic nitrogen						**Green fodder yield (t ha^{-1})**									
N_0	24.50	30.17	34.89	28.60	33.52	26.46	32.48	36.64	30.77	35.40	25.48	31.33	35.77	29.69	34.46
N_1	31.47	38.03	43.55	36.58	41.77	33.60	40.15	45.53	38.5	43.70	32.54	39.09	44.54	37.54	42.74
N_2	35.41	47.33	51.34	45.73	49.78	37.10	49.82	53.33	47.78	51.86	36.26	48.58	52.34	46.76	50.82
N_3	36.12	48.10	52.14	46.19	50.17	38.00	50.15	54.16	48.15	52.62	37.06	49.13	53.15	47.17	51.40
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.3907			0.4473		0.3875			0.4488		0.3892			0.4256	
C.D. (P = 0.05)	1.123			1.145		1.125			1.149		1.101			1.105	

+ 120 kg N ha^{-1} (M_2N_2). The control (M_0N_0) treatment recorded minimum babycorn yield with husk (3269 kg ha^{-1}) and without husk (819 kg ha^{-1}). No application of nitrogen fertilizer (N_0) in combination with different manurial treatment recorded significantly lower babycorn yield than that of other combinations employed.

4.1.2.5.2 Green fodder yield

Effect of organic manure

Regarding green fodder yield of babycorn (Table 4.13), it was found that the lowest fodder yield (32.83 t ha^{-1}) was recorded with no organic manure (M_0). The highest green fodder yield (46.45 t ha^{-1}) was obtained with the application of vermicompost @ 4 t ha^{-1} (M_2), followed by FYM @ 10 t ha^{-1} (M_4), vermicompost @ 2 t ha^{-1} (M_1) and FYM @ 5 t ha^{-1} (M_3). All the treatments had significant differences so far the green fodder yield was concerned.

Effect of inorganic nitrogen

Table 4.13 revealed that the lowest green fodder yield (31.34 t ha^{-1}) recorded from the treatment of no nitrogen (N_0). Treatment received highest dose of nitrogen i.e., 180 kg N ha^{-1} (N_3) produced maximum fodder yield (47.58 t ha^{-1}), followed by 120 kg N ha^{-1} (N_2) and N @ 60 kg ha^{-1} (N_1) respectively. However, there was no significant variation between N_2 and N_3. The similar trend was obtained during both the years of experimentation.

Interaction effect of organic manure and inorganic nitrogen

The variation of green fodder yield was significant due to interaction of organic manure and inorganic nitrogen (Table 4.14). Application of vermicompost @ 4 t + 180 kg N ha^{-1} (M_2N_3) recorded highest green fodder yield (53.15 t ha^{-1}) followed vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2). However, both the treatments were statistically at par to each other. The lowest green fodder yield (25.48 t ha^{-1}) was recorded from control (M_0N_0). Under different manurial treatment, 120 kg N ha^{-1} (N_2) recorded significantly higher green fodder yield than 60 kg N ha^{-1} (N_1) and no nitrogen (N_0) in combination with different rates of organic manures.

4.1.3 Uptake of nutrients

Effect of organic manure

Data on uptake of nutrients (Table 4.15) revealed that treatment M_0 (no organic manure) produced significantly lower uptake of N, P and K (61.75, 15.90 and 38.43 Kg ha^{-1} respectively). However, application of vermicompost @ 4 t ha^{-1} (M_2) recorded significantly highest uptake of N, P and K (82.58, 26.03 and 57.93 Kg ha^{-1} respectively) over other treatments. Between M_1 (vermicompost @ 2 t ha^{-1}) and M_3 (FYM @ 5 t ha^{-1}), M_1 provided significantly higher values than M_3.

Effect of inorganic nitrogen

The highest uptake of N, P and K (84.82, 27.13 and 60.91 Kg ha^{-1} respectively) provided by 180 N kg ha^{-1} (N_3) as in Table 4.15. The minimum and significantly lower uptake of N, P and K (59.71, 14.67 and 35.08 Kg ha^{-1} respectively) was obtained from no nitrogen (N_0). N_3 treatment was which statistically at par with 120 kg N ha^{-1} (N_2), but N_2 exhibited significantly higher values of N, P and K (83.84, 26.79 and 59.89 Kg ha^{-1} respectively) than 60 kg N ha^{-1}.

Interaction effect of organic manure ad inorganic nitrogen

The interaction effect of organic manure and inorganic nitrogen was significant on uptake of N, P and K (Table 4.16). The highest uptake of N, P and K (92.81, 31.03 and 68.32 Kg ha^{-1} respectively) was obtained by the application vermicompost @ 4 t + 180 N kg ha^{-1} (M_2N_3), which was statistically at par with vermicompost @ 4 t + 120 N kg ha^{-1} (M_2N_2). There

Table 4.15: Effect of nutrient management on nutrient uptake of babycorn

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure									
M_0	60.21	63.29	61.75	15.31	16.49	15.90	37.07	39.79	38.43
M_1	73.47	79.12	76.29	22.02	24.19	23.10	50.75	54.09	52.42
M_2	79.83	85.33	82.58	24.87	27.20	26.03	56.47	59.90	57.93
M_3	71.61	77.14	74.37	20.90	23.31	22.10	48.61	51.86	50.24
M_4	77.70	83.15	80.42	23.85	26.21	25.03	54.67	57.97	56.32
S. Em. (±)	0.2624	0.2802	0.2882	0.0657	0.1276	0.1084	0.2244	0.2622	0.2382
C.D. (P = 0.05)	0.857	0.915	0.864	0.219	0.416	0.325	0.739	0.845	0.714
Inorganic nitrogen									
N_0	57.40	62.02	59.71	14.09	15.25	14.67	34.21	35.94	35.08
N_1	69.22	74.71	71.97	20.17	22.11	21.14	47.12	50.06	48.59
N_2	81.31	86.36	83.84	25.51	28.07	26.79	57.82	61.96	59.89
N_3	82.31	87.32	84.82	25.78	28.48	27.13	58.91	62.91	60.91
S. Em. (±)	0.3819	0.4289	0.3517	0.1303	0.1944	0.1562	0.3892	0.4289	0.3754
C.D. (P = 0.05)	1.102	1.246	0.995	0.381	0.562	0.442	1.112	1.238	1.062

Table 4.16: Interaction effect of nutrient management on nutrient uptake of babycorn

Treatment	2005 – 2006					2005 – 2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**N uptake (kg ha^{-1})**									
N_0	50.26	57.12	63.15	55.23	61.24	51.15	62.25	69.21	60.16	67.34	50.71	59.69	66.18	57.70	64.29
N_1	59.29	69.35	76.45	67.54	73.48	64.52	74.39	82.58	72.62	79.46	61.91	71.87	79.52	70.08	76.47
N_2	65.16	83.24	89.34	81.26	87.55	68.28	89.46	94.29	87.36	92.43	66.72	86.35	91.82	84.31	89.99
N_3	66.12	84.16	90.36	82.40	88.53	69.21	90.38	95.25	88.40	93.35	67.67	87.27	92.81	85.40	90.94
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.4309			0.5513		0.5298			0.6431		0.4758			0.5831	
C.D. (P = 0.05)	1.245			1.436		1.532			1.675		1.346			1.514	
Inorganic nitrogen						**P uptake (kg ha^{-1})**									
N_0	9.45	14.26	17.32	13.18	16.27	10.32	15.52	18.64	14.49	17.28	9.89	14.89	17.98	13.84	16.78
N_1	15.12	20.39	23.36	19.42	22.54	16.56	22.36	25.44	21.58	24.62	15.84	21.38	24.40	20.50	23.58
N_2	18.19	26.58	29.28	25.34	28.16	19.32	29.25	32.16	28.34	31.26	18.76	27.92	30.72	26.84	29.71
N_3	18.48	26.84	29.52	25.64	28.43	19.74	29.63	32.54	28.82	31.68	19.11	28.24	31.03	27.23	30.06
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.1794			0.2742		0.2151			0.3129		0.1919			0.2808	
C.D. (P = 0.05)	0.516			0.714		0.621			0.815		0.543			0.729	
Inorganic nitrogen						**K uptake (kg ha^{-1})**									
N_0	26.46	34.28	40.24	31.49	38.58	27.29	36.35	42.29	33.37	40.42	26.88	35.32	41.27	32.43	39.50
N_1	36.38	47.27	54.26	45.19	52.52	38.34	50.46	57.52	48.38	55.59	37.36	48.87	55.89	46.79	54.06
N_2	42.16	60.14	65.19	58.34	63.28	46.27	64.23	69.34	62.44	67.50	44.22	62.19	67.27	60.39	65.39
N_3	43.28	61.32	66.20	59.43	64.30	47.24	65.30	70.43	63.24	68.36	45.26	63.31	68.32	61.34	66.33
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.4726			0.5465		0.5604			0.6583		0.5507			0.6286	
C.D. (P = 0.05)	1.364			1.426		1.617			1.721		1.558			1.632	

was no significant difference between FYM @ 10 t + 180 kg N ha-1 (M4N3) and FYM @ 10 t + 120 kg N ha^{-1} (M_4N_2). The control treatment (M_0N_0) recorded the minimum value of N, P and K (50.71, 9.89 and 26.88 Kg ha^{-1} respectively) as found in pooled data.

4.1.4 Nutrient status of soil

Effect of organic manure

So far as the availability of nutrient in soil after harvesting of babycorn is concerned the maximum value of total nitrogen percentage (0.077%), available P and K (23.98 and 139.86 Kg ha^{-1} respectively) was obtained when the crop received vermicompost @ 4 t ha^{-1} (M_2) which was significantly higher than other treatments. M_2 was closely followed by the treatment FYM @ 10 t ha^{-1} (M_4). Between M_1 (vermicompost @ 2 t ha^{-1}) and M_3 (FYM @ 5 t ha^{-1}), M_1 provided significantly higher values than M_3. Treatment M_0 (no organic manure) produced significantly lower total N percentage (0.061%) and available P and K (16.21 and 128.22 Kg ha^{-1} respectively) in the table 4.17.

Effect of inorganic nitrogen

Table 4.17 revealed that the lowest percentage of total N (0.059%) and available P and K (15.82 and 127.30 Kg ha^{-1}) recorded from the treatment of no nitrogen (N_0). Treatment received highest dose of nitrogen i.e., 180 N kg ha^{-1} (N_3) produced highest percentage of total N (0.079%) and available P and K (25.05 and 141.18 Kg ha^{-1}) followed by 120 kg N ha^{-1} (N_2) and N @ 60 kg ha^{-1}(N_1) respectively. The similar trend was obtained during both the years of experimentation.

Interaction effect of organic manure ad inorganic nitrogen

The percentage of total nitrogen and available phosphorus and potassium in soil after harvest of babycorn has been shown in the table

Table 4.17: Effect of nutrient management on nutrient status of soil after harvest of babycorn

Treatment	Total N (%)			Available P (kg ha^{-1})			Available K (kg ha^{-1})		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure									
M_0	0.061	0.062	0.061	15.75	16.66	16.21	127.74	128.70	128.22
M_1	0.071	0.073	0.072	21.11	22.15	21.63	135.98	137.60	136.79
M_2	0.075	0.079	0.077	23.42	24.53	23.98	139.09	140.64	139.26
M_3	0.069	0.071	0.070	20.01	21.29	20.69	134.95	136.54	135.74
M_4	0.073	0.077	0.075	22.46	23.54	23.00	138.03	139.64	138.83
S. Em. (±)	0.0003	0.0003	0.0037	0.0663	0.0957	0.0894	0.0788	0.1009	0.0921
C.D. (P = 0.05)	0.0010	0.0011	0.0011	0.216	0.312	0.268	0.257	0.329	0.276
Inorganic nitrogen									
N_0	0.058	0.060	0.059	15.37	16.26	15.82	126.82	127.78	127.30
N_1	0.068	0.070	0.069	19.82	20.87	20.35	134.04	135.14	134.59
N_2	0.075	0.078	0.077	23.24	24.34	23.79	139.57	141.43	140.50
N_3	0.077	0.080	0.079	23.84	25.05	24.44	140.19	142.16	141.18
S. Em. (±)	0.0004	0.0004	0.0004	0.0985	0.1111	0.1085	0.1225	0.1434	0.1315
C.D. (P = 0.05)	0.0011	0.0012	0.0011	0.284	0.321	0.307	0.354	0.414	0.372

Table 4.18: Interaction effect of nutrient management on nutrient status of soil after harvest of babycorn

Treatment	2005 – 2006					2005 – 2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Total N (%)**									
N_0	0.052	0.059	0.063	0.057	0.061	0.054	0.060	0.066	0.058	0.064	0.053	0.060	0.065	0.058	0.063
N_1	0.060	0.069	0.073	0.067	0.071	0.062	0.071	0.076	0.069	0.074	0.061	0.070	0.075	0.068	0.073
N_2	0.064	0.077	0.081	0.075	0.079	0.065	0.080	0.085	0.078	0.083	0.065	0.079	0.083	0.077	0.081
N_3	0.066	0.079	0.083	0.077	0.081	0.067	0.082	0.087	0.080	0.085	0.067	0.081	0.085	0.079	0.082
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0004			0.0005		0.0005			0.0006		0.0005			0.0005	
C.D. (P = 0.05)	0.0012			0.0013		0.0015			0.0016		0.0013			0.0014	
Inorganic nitrogen						**Available P (kg ha^{-1})**									
N_0	11.82	15.14	18.23	14.23	17.42	12.10	16.25	19.29	15.32	18.36	11.96	15.70	18.76	14.78	17.89
N_1	16.12	20.18	22.32	19.26	21.23	17.26	21.22	23.30	20.28	22.31	16.69	20.70	22.81	19.77	21.77
N_2	17.25	24.21	26.29	23.15	25.31	18.32	25.21	27.42	24.37	26.40	17.79	24.71	26.86	23.76	25.86
N_3	17.82	24.90	26.84	23.75	25.87	18.95	25.98	28.72	25.18	27.10	18.39	25.41	27.48	24.47	26.49
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.1768			0.2024		0.2119			0.2407		0.18805			0.2114	
C.D. (P = 0.05)	0.511			0.527		0.612			0.634		0.532			0.549	
Inorganic nitrogen						**Available K (kg ha^{-1})**									
N_0	116.72	128.42	131.34	127.38	130.26	117.12	129.45	132.40	128.39	131.52	116.92	128.94	131.87	127.89	130.89
N_1	129.11	134.21	137.36	133.26	136.24	130.23	135.38	138.45	134.26	137.38	129.67	134.80	137.91	133.76	136.81
N_2	132.24	140.37	143.50	139.29	142.44	133.35	142.46	145.49	141.32	144.51	132.80	141.42	144.50	140.31	143.48
N_3	132.88	140.42	143.85	139.86	143.16	134.11	143.12	146.23	142.73	145.15	133.50	142.02	145.79	141.02	144.16
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.1891			0.2205		0.2209			0.2483		0.1983			0.2268	
C.D. (P = 0.05)	0.546			0.574		0.637			0.653		0.561			0.589	

4.18. In both the years of experimentation, the nutrient status of soil after harvest of babycorn become higher from its initial value in all the treatments except control (M_0N_0). But maximum residual effect of total N (0.085 %) ,available P (27.48 kg ha^{-1}) and K (145.79 kg ha^{-1}) remained in the treatment where crop received vermicompost @ 4 t + 180 N kg ha^{-1} (M_2N_3), which was followed by FYM @ 10 t + 180 kg N ha-1 (M4N3). The control treatment (M_0N_0) recorded the minimum value of N, P and K (0.053%, 11.96 and 116.92 Kg ha^{-1} respectively) as found in pooled data.

4.1.5 Quality

Effect of organic manure

Table 4.19 revealed that vermicompost @ 4 t ha^{-1} (M_2) provided highest reducing sugar (1.54%), total sugar (2.33%), protein (1.73%) and TSS (7.43 °Brix) whereas these were minimum (0.94 1.44 1.22 % and 5.46 °Brix respectively) under without organic manure (M_0). M_2 showed significantly higher quality parameters than FYM @ 10 t ha^{-1} (M_4). Both vermicompost @ 2 t ha^{-1} (M_1) and FYM @ 5 t ha^{-1} (M_3) revealed significantly higher value of these parameters than no manure application (M_0).

Effect of inorganic nitrogen

Application of 180 N kg ha^{-1}(N_3) recorded the highest reducing sugar (1.71%), total sugar (2.58%), protein (1.77%) and TSS (7.71 °Brix) than other treatments, but statistically at par with 120 N kg ha^{-1} (N_2) as stated in Table 4.19 N_2 treatment was significantly higher than N_1 (60 kg N ha^{-1}) and N_0 (no nitrogen). However, N_0 recorded the minimum value of these parameters.

Interaction effect of organic manure and inorganic nitrogen

The interaction effect between organic manure and inorganic nitrogen on quality parameters was significant (Table 4.20). Pooled data exhibited

Table 4.19: Effect of nutrient management on quality of babycorn

Treatment	Reducing sugar (%)			Total sugar (%)			Protein (%)			TSS (°Brix)		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled
Organic manure												
M_0	0.89	0.99	0.94	1.39	1.49	1.44	1.20	1.25	1.22	5.03	5.88	5.46
M_1	1.33	1.45	1.39	2.09	2.19	2.14	1.56	1.60	1.58	6.44	7.53	6.98
M_2	1.48	1.60	1.54	2.25	2.41	2.33	1.71	1.76	1.73	6.88	7.98	7.43
M_3	1.29	1.41	1.35	2.03	2.14	2.09	1.51	1.56	1.54	6.28	7.35	6.82
M_4	1.43	1.59	1.51	2.20	2.34	2.27	1.66	1.70	1.68	6.74	7.85	7.29
S. Em. (±)	0.0057	0.0058	0.0057	0.0069	0.0083	0.0083	0.0093	0.0077	0.0090	0.0135	0.0159	0.0160
C.D. (P = 0.05)	0.018	0.019	0.017	0.022	0.027	0.025	0.035	0.025	0.027	0.044	0.052	0.048
Inorganic nitrogen												
N_0	0.60	0.70	0.65	1.22	1.36	1.29	1.11	1.15	1.13	4.66	5.56	5.11
N_1	1.25	1.38	1.32	1.72	1.83	1.77	1.50	1.55	1.53	6.14	7.24	6.69
N_2	1.63	1.77	1.70	2.51	2.63	2.57	1.74	1.78	1.76	7.13	8.23	7.68
N_3	1.65	1.78	1.71	2.52	2.64	2.58	1.75	1.80	1.77	7.16	8.26	7.71
S. Em. (±)	0.0074	0.0079	0.0078	0.0097	0.0118	0.0110	0.0137	0.0097	0.0117	0.0176	0.0221	0.0201
C.D. (P = 0.05)	0.021	0.023	0.022	0.028	0.034	0.031	0.039	0.028	0.033	0.051	0.063	0.057

Table 4.20: Interaction effect of nutrient management on quality of babycorn

Treatment	2005-2006					2005-2006					Pooled				
	Organic manure														
	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4	M_0	M_1	M_2	M_3	M_4
Inorganic nitrogen						**Reducing sugar (%)**									
N_0	0.39	0.63	0.71	0.60	0.62	0.42	0.74	0.83	0.71	0.79	0.41	0.69	0.77	0.66	0.74
N_1	0.59	1.36	1.54	1.30	1.47	0.76	1.47	1.66	1.42	1.58	0.68	1.42	1.60	1.36	1.53
N_2	1.27	1.66	1.82	1.62	1.78	1.39	1.78	1.94	1.74	1.99	1.33	1.72	1.88	1.68	1.89
N_3	1.29	1.68	1.83	1.64	1.79	1.40	1.80	1.96	1.75	2.00	1.35	1.74	1.90	1.70	1.90
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0083			0.0096		0.0093			0.0106		0.0088			0.0104	
C.D. (P = 0.05)	0.024			0.026		0.027			0.028		0.025			0.027	
Inorganic nitrogen						**Total sugar (%)**									
N_0	0.90	1.25	1.41	1.19	1.35	0.93	1.38	1.66	1.25	1.54	0.92	1.32	1.54	1.22	1.45
N_1	1.30	1.77	1.92	1.73	1.86	1.48	1.80	2.04	1.85	1.97	1.39	1.79	1.98	1.83	1.92
N_2	1.68	2.65	2.83	2.59	2.76	1.77	2.78	2.95	2.72	2.91	1.73	2.72	2.89	2.66	1.85
N_3	1.69	2.67	2.85	2.61	2.79	1.78	2.80	2.97	2.73	2.93	1.74	2.74	2.91	2.67	2.86
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0108			0.0122		0.0145			0.0167		0.0127			0.0143	
C.D. (P = 0.05)	0.031			0.032		0.042			0.044		0.036			0.037	
Inorganic nitrogen						**Protein (%)**									
N_0	0.74	1.12	1.36	1.07	1.27	0.76	1.16	1.41	1.12	1.32	0.75	1.14	1.39	1.10	1.30
N_1	1.21	1.54	1.66	1.49	1.62	1.27	1.58	1.70	1.54	1.76	1.24	1.56	1.68	1.52	1.64
N_2	1.42	1.78	1.90	1.73	1.86	1.47	1.82	1.95	1.78	1.90	1.45	1.80	1.93	1.76	1.88
N_3	1.43	1.79	1.91	1.75	1.87	1.48	1.83	1.96	1.80	1.91	1.46	1.81	1.94	1.78	1.89
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0161			0.0188		0.0114			0.0129		0.0134			0.0150	
C.D. (P = 0.05)	0.047			0.048		0.033			0.034		0.038			0.039	
Inorganic nitrogen						**TSS (°Brix)**									
N_0	3.14	4.84	5.45	4.63	5.24	3.23	5.92	6.55	5.73	6.35	3.19	5.38	6.00	5.18	5.80
N_1	5.12	6.29	6.64	6.12	6.52	6.19	7.38	7.75	7.23	7.64	5.66	6.84	7.20	6.68	7.08
N_2	5.92	7.30	7.69	7.16	7.58	7.04	8.40	8.80	8.21	8.69	6.48	7.85	8.25	7.69	8.14
N_3	5.95	7.32	7.73	7.20	7.61	7.07	8.42	8.33	8.24	8.72	6.51	7.87	8.28	7.72	8.17
	M × N			N × M		M × N			N × M		M × N			N × M	
S. Em. (±)	0.0263			0.0293		0.0291			0.0323		0.0279			0.0308	
C.D. (P = 0.05)	0.076			0.077		0.084			0.085		0.079			0.080	

Table 4.21: Effect of nutrient management on economics of babycorn

Treatment	Babycorn yield ($kg\ ha^{-1}$)			Green fodder yield ($t\ ha^{-1}$)			Common cost of cultivation ($Rs\ ha^{-1}$)	Cost of treatments ($Rs.\ ha^{-1}$)	Total cost ($Rs.\ ha^{-1}$)			Gross return ($Rs.\ ha^{-1}$)			Net return ($Rs.\ ha^{-1}$)			Benefit : cost ratio		
	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled			2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Pooled	2005-2006	2006-2007	Mean
M_0N_0	720	918	819	24.5	26.46	25.48	20562	-	20562	20562	20562	48250	59130	53690	27688	38568	33128	1.35	1.88	1.61
M_0N_1	916	1195	1056	31.47	33.6	32.54	20562	2682	23244	23244	23244	61535	76550	69043	38291	53306	45799	1.65	2.29	1.97
M_0N_2	1152	1378	1265	35.41	37.1	36.26	20562	3334	23896	23896	23896	75305	87450	81378	51409	63554	57482	2.15	2.66	2.41
M_0N_3	1182	1402	1292	36.12	38	37.06	20562	3986	24548	24548	24548	77160	89100	83130	52612	64552	58582	2.14	2.63	2.39
M_1N_0	897	1154	1026	30.17	32.48	31.33	20562	8030	28592	28592	28592	59935	73940	66938	31343	45348	38346	1.10	1.59	1.34
M_1N_1	1211	1476	1344	38.03	40.15	39.09	20562	8682	29244	29244	29244	79565	93875	86720	50321	64631	57476	1.72	2.21	1.97
M_1N_2	1482	1676	1579	47.33	49.82	48.58	20562	9334	29896	29896	29896	97765	108710	103238	67869	78814	73342	2.27	2.64	2.45
M_1N_3	1509	1701	1605	48.1	50.15	49.13	20562	9986	30548	30548	30548	99500	110125	104813	68952	79577	74265	2.26	2.60	2.43
M_2N_0	1107	1277	1192	34.89	36.64	35.77	20562	14030	34592	34592	34592	72795	82170	77483	38203	47578	42891	1.10	1.38	1.24
M_2N_1	1336	1591	1464	43.55	45.53	44.54	20562	14682	35244	35244	35244	88575	102315	95445	53331	67071	60201	1.51	1.90	1.71
M_2N_2	1632	1768	1700	51.34	53.33	52.34	20562	15334	35896	35896	35896	107270	115065	111168	71374	79169	75272	1.99	2.21	2.10
M_2N_3	1660	1795	1728	52.14	54.16	53.15	20562	15986	36548	36548	36548	109070	116830	112950	72522	80282	76402	1.98	2.20	2.09
M_3N_0	836	1089	963	28.6	30.77	29.69	20562	6030	26592	26592	26592	56100	69835	62968	29508	43243	36376	1.11	1.63	1.37
M_3N_1	1183	1418	1301	36.58	38.5	37.54	20562	6682	27244	27244	27244	77440	90150	83795	50196	62906	56551	1.84	2.31	2.08
M_3N_2	1428	1631	1530	45.73	47.78	46.76	20562	7334	27896	27896	27896	94265	105440	99853	66369	77544	71957	2.38	2.78	2.58
M_3N_3	1455	1658	1557	46.19	48.15	47.17	20562	7986	28548	28548	28548	95845	106975	101410	67297	78427	72862	2.36	2.75	2.55
M_4N_0	1032	1216	1124	33.52	35.4	34.46	20562	10030	30592	30592	30592	68360	78500	73430	37768	47908	42838	1.23	1.57	1.40
M_4N_1	1269	1523	1396	41.77	43.7	42.74	20562	10682	31244	31244	31244	84335	98000	91168	53091	66756	59924	1.70	2.14	1.92
M_4N_2	1572	1704	1638	49.78	51.86	50.82	20562	11334	31896	31896	31896	103490	111130	107310	71594	79234	75414	2.24	2.48	2.36
M_4N_3	1601	1734	1668	50.17	52.62	51.40	20562	11986	32548	32548	32548	105135	113010	109073	72587	80462	76525	2.23	2.47	2.35

that the maximum value of reducing sugar (1.90%), total sugar (2.91%), protein (1.78%) and TSS (7.72 °Brix) under vermicompost @ 4 t along with 180 kg N ha^{-1}(M_2N_3), followed by application of vermicompost @ 4 t + 120 kg N ha^{-1}(M_2N_2). The control plot (M_0N_0) resulted the minimum value of these parameters.

4.1.6 Production economics

Among the nutrient management treatments, the maximum cost was incurred for vermicompost @ 4 t + 180 kg N ha^{-1} (M_2N_3) with Rs. 36,548 ha^{-1}, followed by vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2) of Rs. 35,896 ha^{-1} and vermicompost @ 4 t + 60 kg N ha^{-1} (M_2N_1) of Rs. 35,244 ha^{-1} respectively (Table 4.21). Comparatively lowest cost was in control (M_0N_0), followed by 60 kg N ha^{-1} without organic manure (M_0N_1). The maximum net return of Rs. 76,402 ha^{-1} was recorded under vermicompost @ @ 4 t + 180 kg N ha^{-1} (M_2N_3), followed by vermicompost @ 4 t + 120 kg N ha^{-1} (M_2N_2) with Rs.75,272 ha^{-1}. However, the benefit: cost ratio of was maximum (2.58) in FYM @ 5 t + 120 kg N ha^{-1} (M_3N_2), closely followed by FYM @ 10 t + 180 kg N ha^{-1} (M_3N_3) with 2.55. Application of vermicompost @ 4 t ha^{-1} without inorganic N fertilizer (M_2N_0) recorded the lowest benefit: cost ratio of 1.24.

4.2 Experiment 2. Weed management in babycorn

Observation that recorded in course of investigation in the present experiment was analysed and presented below for discussion:

4.2.1 Studies on weeds

4.2.1.1 Weed flora in the experimental field

Survey on weed flora was made regularly to intensify different weed species intercepted in the experimental field throughout the crop season. Details of this study have been presented in the following table.

Weed flora present in the experimental field throughout the crop growing season

Botanical name	Family	English name	Common name	Characters
1. *Cynodon dactylon* (L.) Pers.	(Gramineae) Poaceae	Bermuda grass	Durba ghash	Monocot, Perennial grass, leaves flattended, ligule with a fringe of whitish hairs, stems prostate and crepping root stocks and seeds, flowering takes place from September to December and May to July, found during both *kharif* and *boro* season.
2. *Digitaria sanguinalis* (L) Scop.	Poaceae	Crab grass	Kankra ghash	The culms are stout, usually decumbent at the base, smooth, plants strike roots, when nodes touch the soil, leaves hairy; flowering between July and September, found in both *kharif* and *rabi* season.
3. *Echinochloa colona* (L) Link	Poaceae	Jungle rice	Jangli dhan	Annual grass, leaves linear, flat, narrow; margin minutely serrated; stem erect, 60 – 90 cm tall; inflorescence contracted panicle; propagated by seeds; flowers and fruits throughout the year; found during both *kharif* and *boro* season.
4. *Eleusine indica* (L) Gaertn	Poaceae	Wild finger millet or Goosegrass	Kodai ghash	Coarse tufted annual grass, 30 – 45 cm tall; leaf blades flat or floded at the base, sheath flattened and keeled; inflorescence spikes arising from the top of

Botanical name	Family	English name	Common name	Characters
				stem to form a spreading umble; flowering between June and September; propagated by seeds and old roots; found during both *kharif* and *boro* season.
B. Sedges				
1. *Cyperus rotundus* (L.)	Cyperaceae	Purple nut sedge	Motha ghash	Erect herb with triangular stem, perennial underground stem having chains or nut like tubers; aerial shoot often solitary growing tip very hard; propagated by underground tubers and stolons as well as by seeds.
C. Broad-leaf weeds				
1. *Amaranthus viridis* (L)	Amaranthaceae	Pigweed	Note shak	The stem is round and ribbed; leaves are opposite, smooth, pale green; inflorescence long slender, a terminal receme or an axillary cluster; flower unisexual, white, small and flowering time between July and November, found in both *kharif* and *rabi* season.
2. *Amaranthus spinosus* (L)	Amaranthaceae	Spiny pigweed	Kanta note	Almost same as former; only difference is that, it has a pair of straight spines up to 1cm long at the base of the petioles.
3. *Chenopodium album* (L.)	Chenopodiaceae	Lambsqua-rters	Bathua shak	Annual erect herb; can grow up to 1 – 1.5 m; leaves are small,

Botanical name	Family	English name	Common name	Characters
				greenish or grayish green, usually crowded into dense round clusters, simple, alternate and ovate to lanceolate and petioled. Inflorescence arises from leaf axils or at terminus of stems and branches reproduced by seed; found mainly during *rabi* season.
4. *Commelina benghalensis* (L.)	Commelinaceae	Dayflower or Tropical spiderwort or Wandering Jew	Kanshira	The plant is succulent or fleshy creeping annual as well as perennial herb; leaves alternate simple, parallel-veined and ovate with an entire margin contracted at the base into a narrow, stalk like portion and a sheath enclosing the stem; the broken pieces of stem can strike root; found both during *kharif* and *rabi* season.
5. *Digera arvensis*	Amaranthaceae	Digera	Tandla	Annual, dicot weed, plants are erect and slender leaves are simple, alternate, flowers red and small and flowers from July to Sep.; propagates through seeds; found in *kharif* crops mainly
6. *Melilotus alba* Medicus	Leguminosae	White sweet clover	Senji	Annual, dicot plant; leaves trifoliate, white coloured flower; 2 – 3 seeded fruit; found during *rabi* season
7. *Physalis minima*	Scrophulariaceae	–	Bon makoya	Annual dicot weed; twiner leaves petiolate, solitary flower, orange yellow seed

Botanical name	Family	English name	Common name	Characters
8. *Phyllanthus niruri*	*Euphorbiaceae*	–	Hazardana	Annual dicot weed, leaves pinnate; pale yellow flowers on the under surface of leaves
9. *Solanum nigrum* (L.)	*Solanaceae*	Black nightshade	Ban begun	Annual, dicot plant dark green, simple alternate leaves, entirely smooth: small clusters of white flowers with yellow centres and green globular berries which normally turn black; reproduces through seeds; found during *kharif* and *rabi* season.

Out of these above mentioned weeds recorded in the experimental field, the most predominant weed species were as follows:

1. *Amaranthus viridis*
2. *Chenopodium album*
3. *Commelina benghalensis*
4. *Cynodon dactylon*
5. *Cyperus rotundus*
6. *Digera arvensis*
7. *Digitaria sanguinalis*
8. *Echinochloa colona*
9. *Melilotus alba*
10. *Physalis minima*

The above mentioned weed flora recorded in babycorn field during *rabi* season is corroborated with the observation recorded by Yaduraju and Ahuja (1993) in maize field.

4.2.1.2 Population of grass weeds

Weed management brought about a decrease in grass weed. The grass population was significantly higher in weedy cheek throughout the stages of crop growth during both the years of experimentation as well as in pooled data (Table 4.22). The minimum population of grass weeds was recorded under two hand weedings at 20 and 40 DAS (W_4) during all the dates of observations, and the treatment was statistically at par with straw mulching @ 10 t ha^{-1} (W_3) at 25 DAS. At 50 DAS and onwards, there was a significant reduction of grass weeds population under pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and metribuzin @1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6) respectively compared to pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1), and metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone.

4.2.1.3 Population of broadleaf weeds

Significant effect of weed management on population of broadleaf weeds was observed during both the experimental years as well as in pooled data (Table 4.23). The broadleaf weed population was significantly lowest under two hand weeding (W_4) at all stages of observation, however, W_4 was statistically at par with straw mulching @ 10 t ha^{-1} (W_3) at 25 and 50 DAS. Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6) ensured lowest broadleaf weed population from 50 DAS onwards. The maximum population was observed under weedy cheek (W_7) throughout the growth period of the crop. At 25 DAS, the pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1) and metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone significantly lowered the broadleaf weed population than W_5, W_6 and W_7. The treatment W_4 was the best treatment that ensured 85.95% reduction of weed population over W_7 at harvest stage of the crop.

Table 4.22: Effect of weed management on grass weed population (number m^{-2}) in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	25.58	21.72	23.65	36.72	33.01	34.87	52.72	49.21	50.97	57.38	51.95	54.67
W_2	29.72	25.76	27.74	45.93	41.90	43.92	62.66	59.00	60.83	71.37	68.16	69.77
W_3	7.93	4.22	6.08	9.69	6.41	8.05	18.43	14.49	16.46	20.40	17.31	18.86
W_4	7.20	3.79	5.50	7.39	4.35	5.87	16.44	13.30	14.87	18.95	14.11	16.53
W_5	44.00	39.90	41.95	14.51	11.36	12.94	21.03	17.35	19.19	25.26	22.03	23.65
W_6	49.73	45.38	47.56	17.81	15.34	16.58	27.64	24.38	26.01	32.98	29.89	31.44
W_7	72.63	68.56	70.60	93.35	87.74	90.55	115.08	110.07	112.58	121.03	116.37	118.70
S. Em (±)	0.536	0.684	0.515	0.486	0.495	0.468	0.290	0.200	0.227	0.407	0.874	0.568
C.D. (P = 0.05)	1.648	2.117	1.587	1.498	1.525	1.442	0.893	0.616	0.699	1.254	2.692	1.750

Table 4.23: Effect of weed management on broadleaf weed population (number m^{-2}) in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	14.04	9.79	11.92	28.59	25.54	27.07	39.90	36.73	38.32	47.47	43.80	45.64
W_2	17.98	14.42	16.20	36.85	34.93	35.89	47.65	45.59	46.62	55.57	52.19	53.88
W_3	7.62	4.18	5.90	8.30	5.58	6.94	14.02	10.45	12.24	20.39	17.04	18.72
W_4	6.39	2.89	4.64	6.78	4.35	5.57	11.85	9.40	10.63	17.50	14.19	15.85
W_5	30.34	24.51	27.42	10.61	7.60	9.11	16.70	14.54	15.62	21.75	19.21	20.48
W_6	34.19	30.65	32.42	13.16	10.16	11.60	21.93	19.14	20.54	27.23	24.55	25.89
W_7	47.07	42.43	44.75	76.61	71.43	74.02	98.90	94.55	96.73	114.44	111.11	112.78
S. Em (±)	0.674	0.330	0.379	0.476	0.342	0.383	0.274	0.304	0.248	0.166	0.197	0.151
C.D. (P = 0.05)	2.077	1.016	1.168	1.466	1.054	1.180	0.846	0.938	0.764	0.511	0.609	0.465

4.2.1.4 Population of sedge weeds

The population of sedge weeds influenced significantly due to the effect of different weed control treatments during both the years of experimentation as well as in pooled data (Table 4.24). The lowest sedge weed population was recorded under two hand weeding at 20 and 40 DAS (W_4), closely followed by straw mulching @ 10 t ha^{-1} (W_3). At 25 DAS there was no significant variation between W_4 and W_3 regarding sedge weed population. Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) recorded minimum sedge weed population than pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1) or metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone from 50 DAS to harvest. The uncontrolled weedy cheek (W_7) recorded the maximum weed population as expected.

4.2.1.5 Population of total weeds

Weed management treatments influenced the total weed population during the crop period in both the years and in pooled data (Table 4.25). Two hand weeding at 20 and 40 DAS (W_4) recorded lowest population of total weeds till harvest of the crop, closely followed by straw mulching @ 10 t ha^{-1} (W_3). The highest weed density was found in weedy cheek (W_7) as expected. Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) also ensured lower weed population from 50 DAS to harvest of the crop where as the efficacy of pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1) and metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone reduced weed population considerably at early stage (25 DAS).

4.2.1.6 Dry weight of grass weeds

Significant decrease in dry weight of grass weeds was noticed due to weed control treatments during both the years of experimentation as well as

Table 4.24: Effect of weed management on sedge weed population (number m^{-2}) in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	5.80	3.85	4.83	14.87	12.38	13.63	19.11	16.48	17.80	21.79	19.17	20.48
W_2	7.86	5.99	6.93	17.81	15.31	16.56	22.77	19.86	21.32	27.82	24.20	26.01
W_3	3.20	1.12	2.16	6.09	4.11	5.10	8.16	6.54	7.10	11.12	9.60	10.36
W_4	2.39	1.05	1.72	2.45	1.39	1.67	5.64	4.04	4.59	9.05	7.41	8.23
W_5	11.28	9.27	10.28	8.10	5.93	7.02	12.15	9.53	10.84	16.19	13.63	14.91
W_6	12.86	10.69	11.78	11.14	8.52	9.83	15.32	12.68	14.00	19.30	16.71	18.01
W_7	17.87	15.76	16.82	30.08	26.77	28.18	39.70	37.53	38.37	44.67	39.85	42.26
S. Em (±)	0.446	0.416	0.426	0.474	0.807	0.582	0.312	0.304	0.299	0.388	0.454	0.416
C.D. (P = 0.05)	1.373	1.283	1.313	1.461	2.487	1.793	0.961	0.936	0.921	1.196	1.397	1.282

Table 4.25: Effect of weed management on population of total weeds (number m^{-2}) in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	45.42	35.36	40.40	80.18	70.93	75.56	111.73	102.42	107.08	126.64	111.92	119.28
W_2	55.56	46.17	50.87	100.59	92.14	96.37	133.08	123.81	128.45	154.76	144.55	149.66
W_3	18.75	9.52	14.14	24.08	16.10	20.09	40.61	31.48	34.79	51.91	43.95	47.93
W_4	15.98	7.73	11.86	16.62	10.09	13.36	33.93	26.74	29.09	45.50	35.71	40.61
W_5	85.62	73.68	79.65	33.22	24.89	29.06	49.88	41.42	45.65	63.20	54.87	59.04
W_6	96.78	86.72	91.75	42.11	34.02	38.07	64.89	56.20	60.55	79.51	71.15	75.33
W_7	137.57	126.75	132.17	200.04	185.94	191.75	253.68	242.15	246.67	280.14	267.33	272.49

in pooled data (Table 4.26). In all cases, the weedy cheek (W_7) recorded the maximum dry weight, whereas two hand weeding at 20 and 40 DAS (W_4) and straw mulching @ 10 t ha^{-1} (W_3) recorded significantly lower values during the crop period. At 25 DAS, the pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1) and metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone showed significantly lower values than pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} or metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5 or W_6) and weedy cheek (W_7). W_5 and W_6 showed considerable control efficiency of grass weeds from later stage of the crop (50 DAS to harvest).

4.2.1.7 Dry weight of broadleaf weeds

Significant influence of weed management on dry weight of broadleaf weeds was observed throughout the growth stages of crop in both the years and in pooled data (Table 4.27). Among the different weed management treatments, hand weeding twice at 20 and 40 DAS (W_4) recorded minimum dry weight of broadleaf weeds, closely followed by straw mulching @ 10 t ha^{-1} (W_3). Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) recorded considerably lower dry weight from 50 DAS onwards. However, the pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} (W_1) or metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone did not control the broadleaf weeds so effectively at the later stage of crop growth.

4.2.1.8 Dry weight of sedge weeds

Different weed management treatments had significant influence in reduction of dry weight of sedge weeds during both the years of experimentation (Table 4.28). Two hand weedings at 20 and 40 DAS (W_4) recorded lowest dry weight of sedges, closely followed by straw mulching @ 10 t ha^{-1} (W_3). The maximum dry weight of sedges was noticed under weedy

Table 4.26: Effect of weed management on dry weight (g m^{-2}) of grass weed in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	3.24	2.01	2.63	5.06	4.84	4.95	10.54	8.84	9.69	13.69	11.80	12.75
W_2	4.36	3.18	3.77	6.40	5.18	5.79	13.29	10.06	11.68	17.96	15.28	16.62
W_3	0.53	0.31	0.42	1.28	1.05	1.17	2.62	2.37	2.50	5.98	5.54	5.76
W_4	0.33	0.11	0.22	0.86	0.46	0.66	2.14	1.91	2.03	3.71	2.75	3.23
W_5	5.06	4.82	4.94	3.46	2.24	2.85	5.29	4.06	4.68	7.96	6.26	7.11
W_6	6.35	5.11	5.74	4.83	3.61	4.22	8.82	6.53	7.68	11.42	9.42	10.42
W_7	9.98	8.74	9.36	14.12	12.87	13.50	20.94	17.43	19.19	25.41	23.33	24.37
S. Em (±)	0.032	0.032	0.032	0.081	0.082	0.081	0.132	0.112	0.109	0.999	0.140	0.506
C.D. (P = 0.05)	0.100	0.098	0.099	0.249	0.251	0.250	0.407	0.345	0.336	2.078	0.432	1.559

Table 4.27: Effect of weed management on dry weight (g m^{-2}) of broadleaf weed in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	2.76	2.12	2.44	7.74	5.59	6.67	11.57	8.10	9.84	13.77	11.62	12.70
W_2	4.29	3.14	3.72	10.32	8.19	9.26	14.40	11.26	12.83	16.63	14.47	15.55
W_3	0.46	0.33	0.40	1.92	1.64	1.78	3.35	2.17	2.76	5.23	3.09	4.16
W_4	0.26	0.14	0.20	1.32	1.17	1.25	3.16	2.04	2.60	3.15	2.02	2.59
W_5	6.96	3.82	5.39	4.40	3.27	3.84	6.28	4.82	5.55	8.61	5.15	6.88
W_6	8.26	5.13	6.70	6.76	2.63	4.70	9.56	5.78	7.67	12.96	7.84	10.40
W_7	11.21	9.09	10.15	16.48	14.31	15.40	22.49	19.32	20.91	28.79	26.58	27.69
S. Em (±)	0.769	0.043	0.382	0.163	0.153	0.158	0.176	0.150	0.133	0.116	0.242	0.140
C.D. (P = 0.05)	2.371	0.133	1.177	0.502	0.470	0.487	0.541	0.462	0.410	0.358	0.746	0.431

cheek (W_7), followed by pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} (W_2) and atrazine @ 2 kg. a.i. ha^{-1} (W_1) alone from 50 DAS onwards. Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) recorded lower value of dry weight than W_1, W_2 and W_7 from 50 DAS to harvest stage of the crop.

4.2.1.9 Dry weight of total weeds

Total dry weight of grass, sedge and broadleaf weeds clearly indicated that there was a continuous increment of dry weight of weeds with advancement of crop growth (Table 4.29).

The maximum dry weight of total weeds at 25, 50 and 75 DAS and at harvest was recorded by weedy cheek (W_7). The minimum was observed under two-hand weedings at 20 and 40 DAS (W_4). Pooled data also showed that W_4 was closely followed by W_3 (straw mulching @ 10 t ha^{-1}). Pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) performed much better than pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2), at all the stages of the observations in reducing the dry weight of total weeds. Performance of pre-emergent atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) was better than pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) in both the years.

4.2.1.10 Weed control efficiency

Two hand weedings at 20 and 40 DAS (W_4) showed the maximum weed control efficiency of 97.47%, 93.12%, 98.61% and 88.39% at 25, 50 and 75 DAS and at harvest stage of the crop respectively, while the corresponding values of straw mulching @ 10 t ha^{-1} (W_3) were 95.29%, 89.05%, 86.36% and 81.16% respectively. At 25 DAS, the weed-control

Table 4.28: Effect of weed management on dry weight (g m^{-2}) of sedge weed in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	0.24	0.19	0.22	1.52	1.40	1.46	2.83	2.77	2.80	4.73	3.68	4.21
W_2	0.33	0.27	0.30	1.67	1.59	1.63	3.95	3.79	3.87	5.91	4.35	5.13
W_3	0.18	0.13	0.16	0.48	0.39	0.44	0.91	0.84	0.88	1.29	1.17	1.23
W_4	0.14	0.08	0.11	0.26	0.19	0.23	0.53	0.47	0.50	1.10	1.04	1.07
W_5	0.56	0.41	0.49	0.54	0.42	0.48	1.38	1.23	1.31	1.66	1.40	1.53
W_6	0.72	0.51	0.62	0.71	0.60	0.66	1.76	1.53	1.65	3.27	2.01	2.64
W_7	0.90	0.84	0.87	1.93	1.88	1.91	5.23	4.17	4.70	7.48	6.39	6.94
S. Em (±)	0.010	0.011	0.010	0.046	0.047	0.046	0.043	0.044	0.043	0.027	0.028	0.028
C.D. (P = 0.05)	0.031	0.034	0.031	0.141	0.145	0.142	0.131	0.135	0.132	0.084	0.086	0.086

Table 4.29: Effect of weed management on dry weight of total weeds (g m^{-2}) in babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	6.24	4.32	5.28	14.32	11.83	13.08	24.94	19.71	22.33	32.19	27.10	29.65
W_2	8.98	6.59	7.79	18.39	14.96	16.68	31.64	25.11	28.38	40.50	34.10	37.30
W_3	1.17	0.77	0.97	3.68	3.08	3.38	6.88	5.38	6.13	12.50	9.80	11.15
W_4	0.73	0.33	0.53	2.44	1.82	2.13	5.83	4.42	5.13	7.96	5.81	6.89
W_5	12.58	9.05	10.82	8.40	5.93	7.17	12.95	10.11	11.53	18.23	12.81	15.52
W_6	15.33	10.75	13.04	12.30	6.84	9.57	20.14	13.84	16.99	27.65	19.27	23.46
W_7	22.09	18.67	20.38	32.53	29.06	30.80	48.66	40.92	44.79	61.68	56.30	58.99

Table 4.30: Effect of weed management on weed control efficiency (%) in babycorn (on dry weight basis)

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	71.75	76.86	74.31	55.98	59.29	57.64	48.75	51.83	50.29	47.81	51.87	49.84
W_2	59.35	64.70	62.03	43.47	48.52	45.99	34.98	38.64	36.81	34.34	39.43	36.89
W_3	94.70	95.88	95.29	88.69	89.40	89.05	85.86	86.85	86.36	79.73	82.59	81.16
W_4	96.70	98.23	97.47	92.50	93.74	93.12	88.02	89.20	88.61	87.09	89.68	88.39
W_5	43.05	51.53	47.29	74.18	79.59	76.89	73.39	75.29	74.34	70.44	77.25	73.85
W_6	30.60	42.42	36.51	62.19	76.46	69.33	58.61	66.18	62.40	55.17	65.77	60.47
W_7	–	–	–	–	–	–	–	–	–	–	–	–

efficiency of atrazine @ 2 kg. a.i. ha^{-1} (W_1) or metribuzin @ 2 kg. a.i. ha^{-1} (W_2) alone was higher than the respective pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) or metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6); but from 50 DAS onwards, the trend was reverse (Table 4.30).

4.2.2 Population of soil micro-flora

4.2.2.1 Aerobic non-symbiotic N-fixing bacteria

At 25 DAS, the pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2), followed by pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1), exhibited significantly lower population of aerobic non-symbiotic N-fixing bacteria than other treatments (Table 4.31). At 25 DAS to harvest, straw mulching @ 10 t ha^{-1} (W_3) showed significantly higher population of the bacteria than other treatments, followed by two hand weeding at 20 and 40 DAS (W_4). Pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) recorded significantly higher population of non-symbiotic N-fixing bacteria than pre-emergence application of metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding @ 1 kg. a.i. ha^{-1} at 30 DAS (W_6), from 25 DAS to harvest. Weedy cheek (W_7) plots showed the lower population from 50 DAS onwards.

4.2.2.2 P-solubilizing bacteria

At 25 DAS, the pre-emergence application of metribuzin alone (W_2) provided significantly lower population than other treatments, followed by pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1). From 50 DAS to harvest, weedy cheek (W_7) exhibited minimum population of P-solubilizing bacteria, while the maximum was found in two hand weeding (W_4) plots, followed by straw mulching @ 10 t ha^{-1} (W_3) followed by two hand weedings at 20 and 40 DAS (W_4). Between pre-emergence application of

Table 4.31: Effect of weed management on the population of aerobic non-symbiotic N-fixing bacteria (CFU × 10^4) in the rhizosphere soil of babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	25.47	21.50	23.49	53.23	49.90	51.57	92.35	88.01	90.18	104.10	99.56	101.83
W_2	23.43	19.44	21.44	48.42	45.41	46.92	86.50	82.44	84.47	99.38	95.36	97.37
W_3	46.71	43.68	45.20	78.85	75.75	77.30	120.22	116.07	118.15	160.34	155.29	157.82
W_4	44.80	41.66	43.23	67.9	64.87	66.38	110.63	107.42	109.03	134.05	129.27	131.66
W_5	42.61	39.51	41.06	64.7	61.26	62.98	103.57	98.99	101.28	119.02	114.01	116.52
W_6	41.80	36.97	39.39	58.53	54.43	56.48	99.70	96.61	98.15	112.53	108.79	110.66
W_7	37.64	34.58	36.11	37.45	33.35	35.40	55.05	50.28	52.67	63.37	58.98	61.18
S. Em (±)	0.568	0.439	0.364	0.440	0.449	0.431	6.257	0.265	0.240	0.501	0.546	0.471
C.D. (P = 0.05)	1.751	1.353	1.122	1.357	1.383	1.328	0.792	0.817	0.740	1.545	1.683	1.451

Table 4.32: Effect of weed management on the population of P-solubilizing bacteria (CFU × 10^4) in the rhizosphere soil of babycorn

Treatment	25 DAS			50 DAS			75 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	13.37	9.60	11.49	38.85	34.47	36.66	69.84	66.50	68.17	85.77	81.83	83.80
W_2	10.36	7.39	8.88	29.42	25.72	27.57	53.82	49.77	51.80	72.82	68.73	70.78
W_3	29.67	25.27	27.47	72.20	68.84	70.52	128.34	123.35	125.85	144.54	140.86	142.70
W_4	33.92	29.56	31.74	64.89	61.22	63.06	114.00	109.41	111.71	132.92	128.27	130.60
W_5	21.66	17.15	19.41	59:62	56.61	58.12	101.24	97.27	99.26	120.67	116.17	118.42
W_6	18.75	14.65	16.70	50.99	46.96	48.98	85.65	81.46	83.56	104.15	98.85	101.50
W_7	14.25	12.10	13.18	18.17	14.35	16.26	30.70	26.53	28.62	52.61	50.01	51.31
S. Em (±)	0.326	0.333	0.310	0.335	0.580	0.428	0.260	0.313	0.253	0.377	0.996	0.586
C.D. (P = 0.05)	1.003	1.025	0.955	1.031	1.788	1.319	0.802	0.963	0.780	1.161	3.068	1.806

atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5) and pre-emergence application of metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6), W_5 proved better than W_6 (Table 4.32).

4.2.3 Growth attributes

4.2.3.1 Plant height

Pooled data (Table 4.33) showed that at all the stages of observation, the weedy cheek (W_7) plots recorded minimum plant height of 30.13, 89.35, 131.32 and 135.45 cm at 20, 40, 60 DAS and at harvest respectively, whereas the maximum was in two hand weedings at 20 and 40 DAS (W_4) with 47.13, 126.36, 166.23 and 166.43 cm at 20, 40, 60 DAS and at harvest respectively. The tallest plant recorded in W_4 was closely followed by straw mulching @ 10 t ha^{-1} (W_3), pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6). There was no significant difference in plant height between W_3 and W_4 treatments at 20 DAS, but from 60 DAS to harvest, W_4 resulted more height than W_3. Pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) also enhanced the plant height over pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2). The trend was also same in both the years.

4.2.3.2 Leaf area index (LAI)

Significant improvement in LAI by different weed management methods was noticed throughout the growth period of the crop during both the years of experimentation as well as in pooled data (Table 4.34). At all the stages of observations, the value of leaf area index was in weedy cheek (W_7) was significantly lower than any other weed control treatments. At 20 DAS of crop, straw mulching @ 10 t ha^{-1} (W_3) recorded maximum LAI (0.73), closely followed by two hand weeding at 20 and 40 DAS (W_4), however, at 40 and 60 DAS and at harvest the maximum LAI (1.86, 3.66 and 1.97

Table 4.33: Effect of weed management on plant height (cm) of babycorn

Treatment	20 DAS			40 DAS			60 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	33.76	39.71	36.74	108.35	116.28	112.32	142.21	147.97	145.09	145.13	151.08	148.11
W_2	31.04	37.02	34.03	101.32	107.28	104.30	136.37	142.32	139.34	138.35	144.48	141.42
W_3	41.96	51.26	46.61	120.20	126.18	123.19	160.17	166.14	163.16	162.45	168.43	165.44
W_4	44.14	50.12	47.13	123.37	130.35	126.36	163.25	169.22	166.23	164.44	170.42	167.43
W_5	40.13	46.07	43.10	116.31	122.23	119.27	154.41	160.38	157.40	156.32	162.30	159.31
W_6	36.35	42.28	39.32	113.33	119.29	116.31	148.45	154.43	151.44	150.38	156.35	153.37
W_7	27.17	33.08	30.13	85.55	93.14	89.35	128.35	134.28	131.32	132.64	138.26	135.45
S. Em (±)	1.271	0.074	0.642	0.651	0.749	0.537	0.140	0.179	0.156	0.144	0.148	0.129
C.D. (P = 0.05)	3.915	0.228	1.978	2.007	2.308	1.655	0.432	0.552	0.481	0.444	0.455	0.397

Table 4.34: Effect of weed management on leaf area index (LAI) of babycorn

Treatment	20 DAS			40 DAS			60 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	0.58	0.66	0.62	1.63	1.71	1.67	3.44	3.52	3.48	1.74	1.83	1.78
W_2	0.55	0.63	0.59	1.60	1.65	1.63	3.29	3.37	3.33	1.70	1.79	1.75
W_3	0.68	0.77	0.73	1.75	1.87	1.81	3.57	3.66	3.62	1.87	1.96	1.91
W_4	0.66	0.75	0.71	1.78	1.93	1.86	3.62	3.71	3.66	1.93	2.01	1.97
W_5	0.64	0.72	0.68	1.72	1.82	1.77	3.53	3.61	3.57	1.83	1.92	1.88
W_6	0.61	0.69	0.65	1.69	1.77	1.73	3.49	3.57	3.53	1.80	1.89	1.84
W_7	0.52	0.59	0.56	1.40	1.56	1.52	2.83	2.90	2.86	1.58	1.65	1.61
S. Em (±)	0.004	0.004	0.004	0.005	0.015	0.009	0.007	0.007	0.007	0.007	0.007	0.007
C.D. (P = 0.05)	0.013	0.013	0.012	0.015	0.046	0.028	0.023	0.023	0.022	0.022	0.022	0.021

respectively) were recorded with W_4. Both pre-emergernt atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6) resulted significantly higher values of LAI than pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) and metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2), however, W_5 was superior to W_6. Between W_1 and W_2, W_1 showed significantly higher values than W_2.

4.2.3.3 Dry matter accumulation

Significant improvement in dry matter accumulation by different weed management methods was noticed throughout the growth period of the crop during both the years of experimentation as well as in pooled data (Table 4.35). At all the stages of observation, the value of dry matter accumulation was in weedy cheek (W_7) was significantly lower than any other weed control treatments. At 20, 40 and 60 DAS and at harvest the maximum dry matter accumulation (135.95, 248.25, 450.35 and 494.25 g m^{-2} respectively) were recorded with W_4 which was closely followed by straw mulching @ 10 t ha^{-1} (W_3). Both pre-emergernt atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6) resulted significantly higher values of dry matter accumulation than pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) and metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2), however, W_5 was superior to W_6. Between W_1 and W_2, W_1 showed significantly higher values than W_2.

4.2.3.4 Crop growth rate (CGR)

Weed management resulted in increased CGR (Table 4.36). The maximum CGR (5.62 g m^{-2} day^{-1}) was obtained with two hand weeding (W_4) at 20 to 40 DAS, while at 40 to 60 DAS, the maximum CGR (10.11 g m^{-2} day^{-1}) was obtained with two hand weeding (W_4) followed by straw

Table 4.35: Effect of weed management on dry matter accumulation (g m^{-2}) of babycorn

Treatment	20 DAS			40 DAS			60 DAS			Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	93.60	98.40	96.00	171.60	195.40	183.50	310.60	354.00	332.30	338.00	401.00	369.50
W_2	88.30	92.20	90.25	150.50	173.80	162.15	274.30	317.00	295.65	299.10	361.40	330.25
W_3	129.80	134.70	132.25	228.60	253.30	240.95	412.80	457.10	434.95	447.20	510.50	478.85
W_4	133.40	138.50	135.95	235.80	260.70	248.25	428.00	472.70	450.35	471.66	526.90	494.25
W_5	121.10	125.40	123.25	213.10	236.80	224.95	372.30	415.60	393.95	404.50	467.00	435.75
W_6	117.20	121.10	119.15	207.80	231.30	219.55	361.60	404.50	383.05	391.60	453.90	422.75
W_7	82.70	87.30	85.00	127.10	150.70	138.90	233.10	273.50	253.50	252.70	312.50	282.60
S. Em (±)	0.7660	1.0094	0.8577	1.8895	1.4142	1.5526	2.7022	3.0737	2.8389	3.9405	4.3028	4.0721
C.D. (P = 0.05)	2.357	3.124	2.643	5.824	4.357	4.784	8.321	9.467	8.742	12.141	13.253	12.546

Table 4.36: Effect of weed management on crop growth rate (g m^{-2} day^{-1}) of babycorn

Treatment	20 – 40 DAS			40 – 60 DAS			60 DAS – Harvest		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	3.90	4.85	4.38	6.95	7.93	7.20	1.37	2.35	1.86
W_2	3.11	4.08	3.60	6.19	7.16	6.68	1.24	2.22	1.73
W_3	4.94	5.93	5.44	9.21	10.19	9.70	1.72	2.67	2.20
W_4	5.12	6.11	5.62	9.61	10.60	10.1	2.18	2.71	2.45
W_5	4.60	5.57	5.09	7.96	8.94	8.45	1.61	2.57	2.09
W_6	4.53	5.51	5.02	7.69	8.66	8.18	1.50	2.47	1.99
W_7	2.22	3.17	2.70	5.30	6.14	5.72	0.98	1.95	1.47
S. Em (±)	0.062	0.061	0.061	0.046	0.062	0.05	0.053	0.052	0.053
C.D. (P = 0.05)	0.190	0.187	0.188	0.141	0.191	0.154	0.163	0.161	0.163

mulching @ 10 t ha^{-1} (W_3). Adoption of weed management recorded significantly higher CGR than weedy cheek (W_7) during all dates of observations. On an average, the CGR gradually declined in all the cases from 60 DAS.

4.2.4 Yield Attributes

4.2.4.1 Number of cobs plant^{-1}

The maximum number of cobs plant^{-1} (2.29) was showed by W_4 (twice hand weeding at 20 and 40 DAS), closely followed (2.16) by the W_3 (straw mulching @ 10 t ha^{-1}) and they were statistically superior to the other methods employed (Table 4.37). Between W_1 (pre-emergent atrazine @ 2 kg. a.i. ha^{-1} alone) and W_2 (pre-emergent metribuzin @ 2 kg. a.i. ha^{-1} alone) W_1 showed higher number of cobs per plant than W_2. In contrast to W_5 (pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS), W_6 (pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS) showed significantly lower number of cobs plant^{-1}.

4.2.4.2 Cob weight

Weed management treatments influenced cob weight with husk and without husk significantly during both the years of experimentation and in pooled data (Table 4.37). Among the different weed management practices, hand weeding twice at 20 and 40 DAS (W_4) recorded significantly higher cob weight with and without husk (38.47 and 6.63 respectively), followed by paddy straw mulching @ 10 t ha^{-1} (W_3). While weedy cheek (W_7) recorded the lowest cob weight that was 46.44% and 43.13% lower in cob weight with husk than W_4 and W_3 respectively.

4.2.4.3 Husk: babycorn ratio

The highest husk: babycorn ratio (5.22) was found in weedy cheek (W_7) treatment (Table 4.37) followed by pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} (W_1) and atrazine @ 2 kg. a.i. ha^{-1} (W_2) alone as

Table 4.37: Effect of weed management on no. of cobs plant^{-1}, cob weight and husk: corn ratio of babycorn

Treatment	No. of cobs plant^{-1}			Cob weight with husk (g)			Cob weight without husk (g)			Husk: babycorn ratio		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	1.29	1.88	1.59	29.34	34.02	31.68	6.07	6.42	6.25	5.12	4.92	5.02
W_2	1.20	1.79	1.50	26.65	31.43	29.04	5.83	6.15	5.99	5.20	5.14	5.17
W_3	1.87	2.46	2.16	35.14	40.07	37.60	6.33	6.71	6.52	4.29	4.27	4.28
W_4	2.00	2.59	2.29	35.99	40.95	38.47	6.44	6.82	6.63	4.21	4.17	4.19
W_5	1.55	2.13	1.84	33.02	37.66	35.34	6.23	6.58	6.41	4.39	4.36	4.38
W_6	1.39	1.97	1.68	21.28	35.95	33.41	6.16	6.52	6.34	4.60	4.57	4.59
W_7	1.11	1.67	1.39	24.14	28.39	26.27	5.64	5.98	5.81	5.23	5.20	5.22
S. Em (±)	0.028	0.029	0.028	0.034	0.161	0.085	0.026	0.027	0.025	0.005	0.016	0.007
C.D. (P = 0.05)	0.087	0.089	0.086	0.104	0.496	0.262	0.081	0.083	0.077	0.015	0.041	0.022

revealed by the pooled data. The lowest husk: babycorn ratio (4.19) was obtained in twice hand weeding at 20 and 40 DAS (W_4) which followed by straw mulching @ 10 t ha^{-1} (W_3). Between pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_5) and metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS (W_6) W_5 showed lower husk : babycorn ratio than W_6. The trend was similar in both the years of experiment.

4.2.4.4 Cob length

Table 4.38 clearly showed that the maximum cob length with husk (20.17) in W_4 (2 hand weedings at 20 and 40 DAS) was significantly higher than all other treatments employed. The minimum length of cob (17.44) was observed in W_7 (weedy cheek). The treatments W_5 (pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS) and W_6 (pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS) recorded considerably higher values of cob length than W_1 (pre-emergent atrazine @ 2 kg. a.i. ha^{-1} alone) and W_2 (pre-emergent metribuzin @ 2 kg. a.i. ha^{-1} alone). This trend was observed during both the years and in pooled data also.

Regarding cob length without husk, the W_3 and W_4, which did not show any significant variation to each other, recorded considerably higher values than W_5, W_6, W_1, W_2 and W_7. W_5 and W_6 were also statistically at par providing higher values of cob length without husk than other treatments like W_1, W_2 and W_7. W_7 recorded the minimum value (5.61). Between W_1 and W_2, W_1 showed significantly higher values than W_2.

4.2.4.5 Cob diameter

Significant influence of weed management practices on cob diameter with and without husk was observed during both the years and in pooled data (Table 4.38). Among the different weed management treatments, two-hand weeding at 20 and 40 DAS (W_4) recorded the highest cob diameter

Table 4.38: Effect of weed management on length and diameter of cob in babycorn

Treatment	Cob length with husk (cm)			Cob length without husk (cm)			Cob diameter with husk (cm)			Cob diameter without husk (cm)		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	19.21	20.17	19.69	5.56	6.51	6.04	1.29	1.87	1.58	1.05	1.23	1.14
W_2	19.01	19.98	19.50	5.35	6.31	5.83	1.25	1.83	1.54	1.01	1.18	1.10
W_3	19.60	20.58	20.09	5.88	6.85	6.37	1.39	1.98	1.69	1.16	1.35	1.25
W_4	19.68	20.66	20.17	5.96	6.94	6.45	1.42	2.01	1.72	1.22	1.41	1.32
W_5	19.52	20.52	20.02	5.75	6.72	6.23	1.37	1.95	1.66	1.12	1.31	1.22
W_6	19.43	20.41	19.92	5.67	6.66	6.17	1.32	1.9	1.61	1.08	1.27	1.18
W_7	16.96	17.91	17.44	5.13	6.08	5.61	1.21	1.78	1.50	0.98	1.17	1.08
S. Em (±)	0.024	0.025	0.023	0.031	0.033	0.031	0.004	0.004	0.004	0.010	0.011	0.009
C.D. (P = 0.05)	0.074	0.076	0.071	0.095	0.102	0.096	0.011	0.011	0.012	0.031	0.035	0.028

Table 4.39: Effect of weed management on corn and green fodder yield of babycorn

Treatment	Babycorn yield with husk (kg ha^{-1})			Babycorn yield without husk (kg ha^{-1})			Green fodder yield (t ha^{-1})		
	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled	2005–2006	2006–2007	Pooled
W_1	6052	6110	6081	1265	1292	1279	32.37	34.44	33.41
W_2	5997	6055	6026	1214	1242	1228	32.01	34.06	33.04
W_3	6996	7055	7026	1420	1449	1435	36.56	38.63	37.60
W_4	7052	7111	7082	1449	1478	1464	37.37	39.45	38.41
W_5	6557	6614	6586	1370	1398	1384	34.58	36.65	35.61
W_6	6503	6565	6534	1323	1351	1337	34.44	36.42	35.43
W_7	4846	4903	4874	920	945	933	28.55	30.52	29.54
S. Em (±)	16.937	14.209	15.169	2.345	2.323	2.333	0.040	0.055	0.047
C.D. (P = 0.05)	52.187	43.784	46.740	7.226	7.157	7.189	0.125	0.169	0.145

with husk (1.72 cm) and without husk (1.32 cm), closely followed (1.69 and 1.25 cm respectively) by straw mulching @ 10 t ha^{-1} (W_3). However, the lowest values of cob diameter (1.50 and 1.08 cm with and without husk respectively) were observed in weedy cheek (W_7).

4.2.4.6 Babycorn yield

The different methods of weed management exerted significant effect on increasing the yield of babycorn (Table 4.39). Hand weeding twice at 20 and 40 DAS (W_4) recorded the highest babycorn yield with husk (7082 kg ha^{-1}) and without husk (1464 kg ha^{-1}), closely followed by straw mulching @ 10 t ha^{-1} (W_3) with 7026 kg and 1435 kg ha^{-1} respectively. They found statistically superior over other weed management treatments. Weedy cheek (W_7) recorded the lowest yield, providing 56.91% and 53.80% decrease in corn yield (without husk) as compared to W_4 and W_3 respectively. Both W_5 (pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS) and W_6 (pre-emergent metribuzin @ 1 kg. a.i. ha^{-1} + one hand weeding at 30 DAS) revealed significantly higher values of babycorn yield with husk and without husk than W_1 (pre-emergent atrazine @ 2 kg. a.i. ha^{-1} alone) and W_2 (pre-emergent metribuzin @ 2 kg. a.i. ha^{-1} alone); of which W_5 was superior to W_6. However between the herbicide treatments W_1 and W_2, W_1 showed significantly higher values of yield than W_2.

4.2.4.7 Green fodder yield

Significant effect of weed management practices on green fodder yield of babycorn was observed during the both the years of experiment as well as in pooled data (Table 4.39). Among the different weed management treatments, twice hand weeding at 20 and 40 DAS (W_4) recorded significantly highest green fodder yield (38.41 t ha^{-1}) than all other treatments. The lowest green fodder yield (29.54 t ha^{-1}) was observed in weedy cheek (W_7) during both the years as well as in pooled data. However, W_4 increased the green fodder yield by 30.03% over W_7.

4.2.4.8 Production economics

Among the weed management treatments, the maximum cost was incurred for straw mulching @ 10 t ha^{-1} (W_3) with Rs. 26,570 ha^{-1}, followed by two hand weeding at 20 and 40 DAS (W_4) of Rs. 25,475 ha^{-1} and pre-emergence application of metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) of Rs. 24,917 ha^{-1}. Comparatively lower cost was in weedy cheek (W_7) and pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) as stated in Table no. 4.40. The maximum net return of Rs. 66,905 ha^{-1} was recorded under W_4, followed by W_3 (Rs. 63,953 ha^{-1}). The benefit: cost ratio of was maximum (2.63) in W_4, closely followed by the pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5), pre-emergence application of atrazine @ 2 kg. a.i. ha^{-1} alone (W_1) and straw mulching @ 10 t ha^{-1} (W_3) with a value of 2.62, 2.59 and 2.41 respectively. Pre-emergence application of metribuzin @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_6) and pre-emergence application of metribuzin @ 2 kg. a.i. ha^{-1} alone (W_2) produced a benefit: cost ratio of 2.39 and 2.22 respectively. Weedy cheek treatment (W_7) recorded the lowest benefit: cost ratio of 1.89.

Table 4.40: Production economics of babycorn cultivation under different weed management practices

Treatment	Babycorn yield (kg ha^{-1})			Green fodder yield (t ha^{-1})			Common cost of cultivation (Rs. ha^{-1})	Cost of treatm-ents (Rs.)	Total cost (Rs. ha^{-1})			Gross return (Rs. ha^{-1})			Net return (Rs. ha^{-1})			Benefit : cost ratio		
	2005-2006	2006-2007	Mean	2005-2006	2006-2007	Mean			2005-2006	2006-2007	Mean	2005-2006	2006-2007	Mean	2005-2006	2006-2007	Mean	2005-2006	2006-2007	Mean
W_1	1265	1292	1279	32.37	34.44	33.41	21,215	1222	22,437	22,437	22,437	79,435	81,820	80,628	56,998	59,383	58,191	2.54	2.65	2.59
W_2	1214	1242	1228	32.01	34.06	33.04	21,215	3002	24,217	24,217	24,217	76,705	79,130	77,918	52,488	54,913	53,701	2.17	2.27	2.22
W_3	1420	1449	1435	36.56	38.63	37.60	21,215	5355	26,570	26,570	26,570	89,280	91,765	90,523	62,710	65,195	63,953	2.36	2.45	2.41
W_4	1449	1478	1464	37.37	39.45	38.41	21,215	4260	25,475	25,475	25,475	91,135	93,625	92,380	65,660	68,150	66,905	2.58	2.68	2.63
W_5	1370	1398	1384	34.58	36.65	35.62	21,215	2812	24,027	24,027	24,027	85,790	88,225	87,008	61,763	64,198	62,981	2.57	2.67	2.62
W_6	1323	1351	1337	34.44	36.42	35.43	21,215	3702	24,917	24,917	24,917	83,370	85,760	84,565	58,453	60,843	59,648	2.35	2.44	2.39
W_7	920	945	933	28.55	30.52	29.54	21,215	–	21,215	21,215	21,215	60,275	62,510	61,393	39,060	41,295	40,178	1.84	1.95	1.89

CHAPTER 5

Discussion

Discussion

From the results, as presented in the page number 87 to 101 and Table 4.1 to 4.40 of the "Nutrient and weed management in winter babycorn", the followings are discussed below –

5.1 Experiment 1. Nutrient management of babycorn

5.1.1 Growth attributes

Plant height and leaf area index (LAI) increased at an increasing rate up to 60 DAS, thereafter the rate of increase in a decreasing trend (Table 4.1 & 4.3). Higher growth rate during 40 – 60 DAS [illegible] was due to partitioning of the greater portion of photosynthates towards linear growth leading to greater increase in plant height and leaf area. This trend was observed in all the treatments in both the years of experimentation and in pooled data. Among the organic manures, application of vermicompost @ 4 t ha^{-1} (M_2) showed the tallest plant than FYM @ 10 t ha^{-1} (M_4) at all dates of observations. The similar trend of result was also noticed by Howrdhra (2006). This might be attributed to the continuous supply of available nutrients, amino acids and growth promoting substances by vermicompost throughout the growth period leading to more production of dry matter (carbohydrate) and its assimilation for vegetative growth. Hence, LAI was increased continuously upto 60 DAS and thereafter it declined, resulting maximum crop growth rate (CGR) recorded at 40 – 60 DAS might be due to higher interception of solar radiation and more CHo metabolism leading to greater dry matter accumulation irrespective of years of experimentation and pooled data (Table 4.7). Significantly higher CGR in babycorn as observed with higher rate of vermicompost (4 t ha^{-1}) supported the similar findings of Sharma *et al.* (2000) in sorghum.

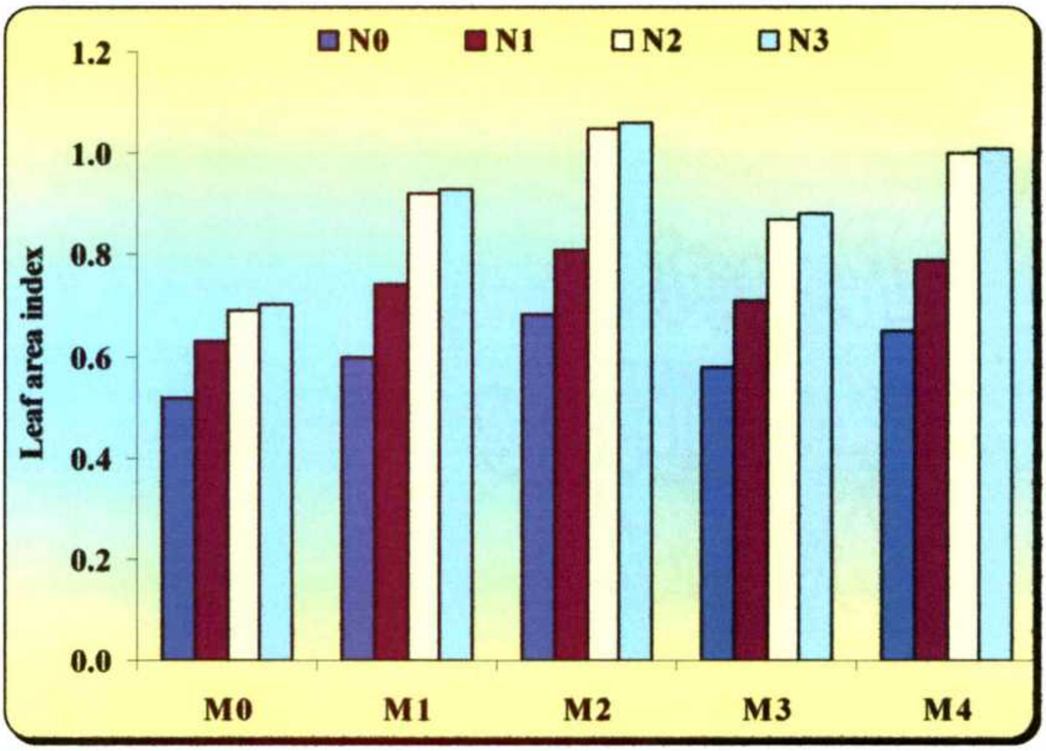


Figure 1. Effect of nutrient management on leaf area index of babycorn at 20 DAS

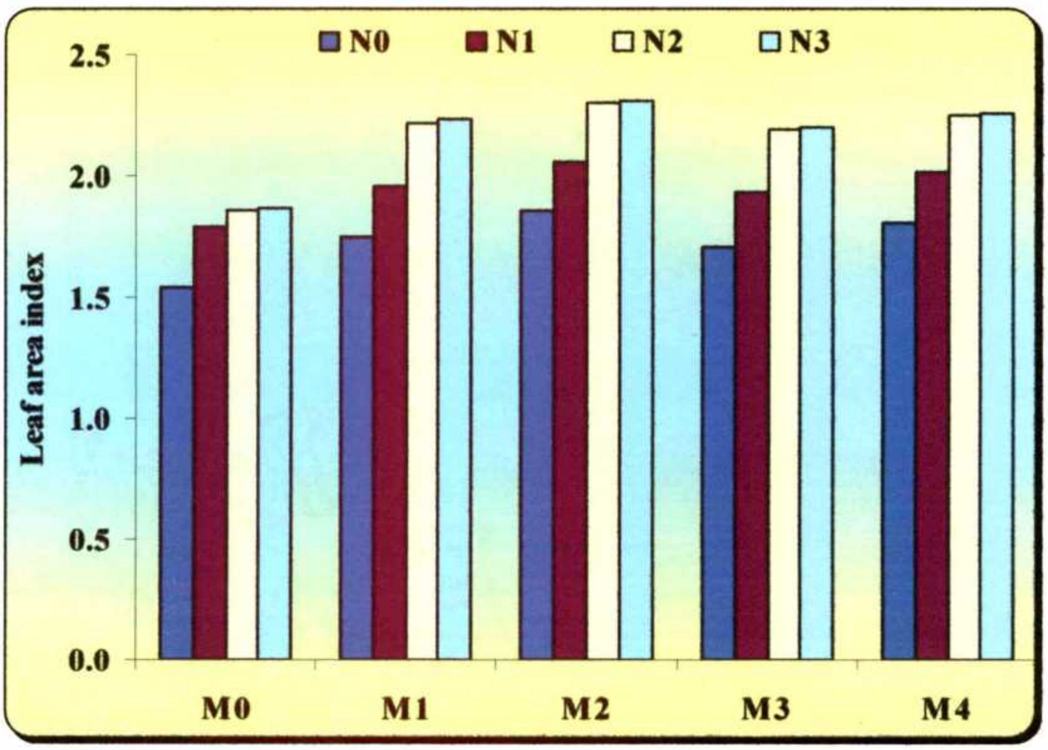


Figure 2. Effect of nutrient management on leaf area index of babycorn at 40 DAS

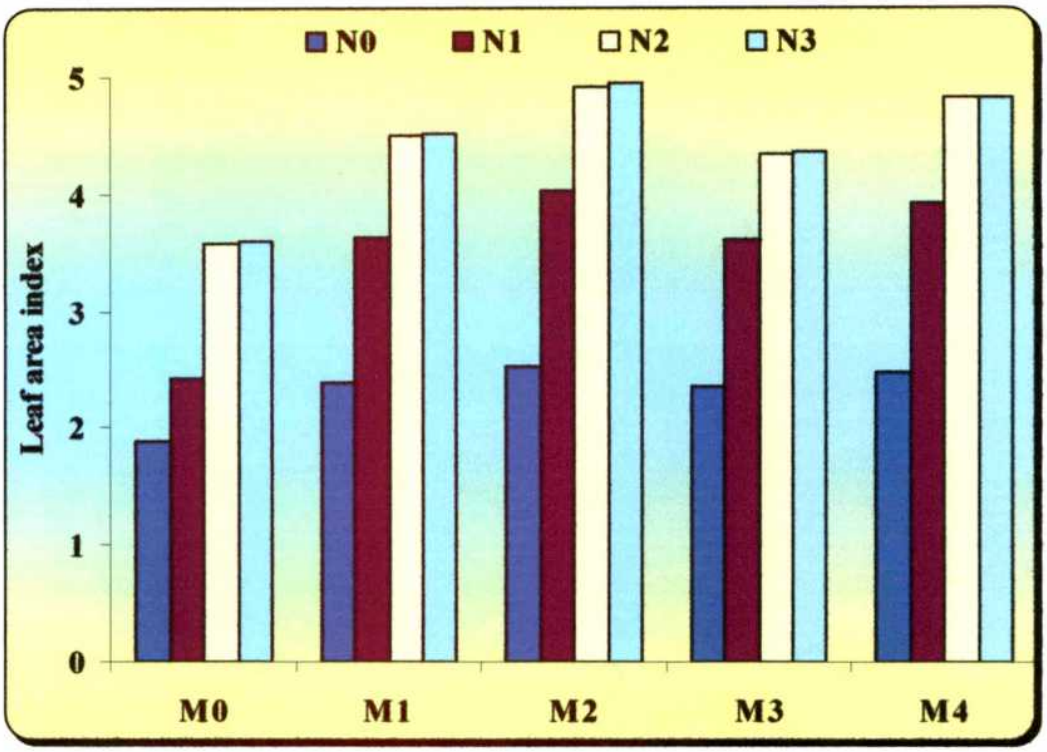


Figure 3. Effect of nutrient management on leaf area index of babycorn at 60 DAS

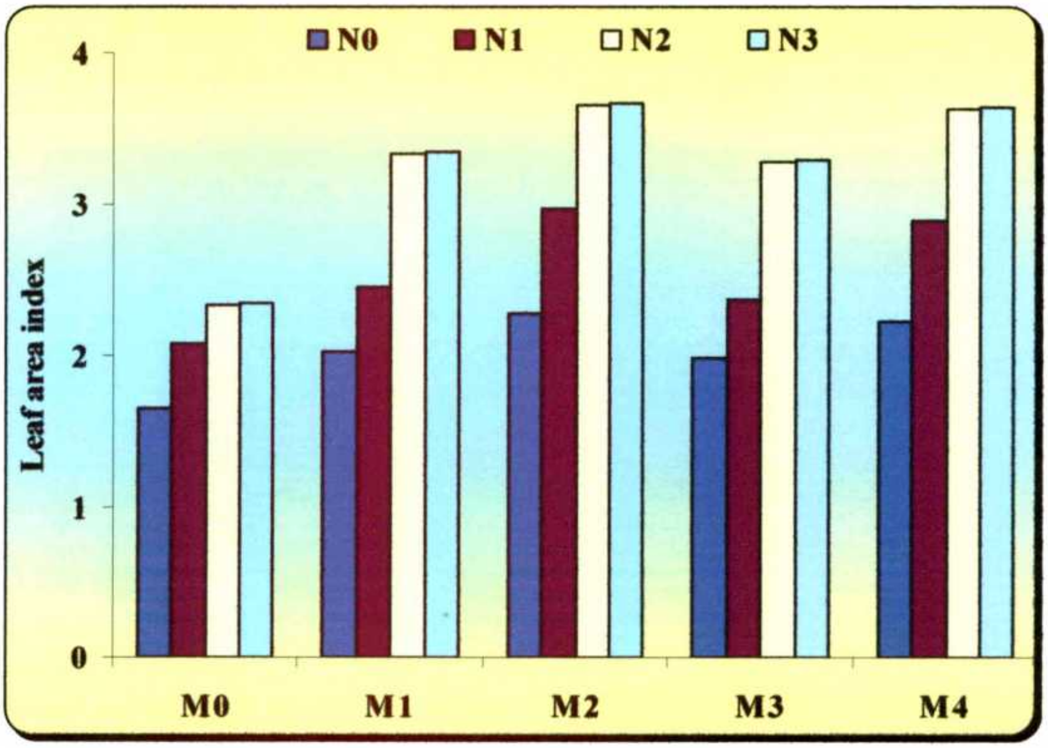


Figure 4. Effect of nutrient management on leaf area index of babycorn at harvest

The response of babycorn to N fertilizer was quite evident (Vadivel *et al.*, 2001; Singh *et al.*, 2003; Sofi *et al.*, 2005), however, there was no statistically significant difference in growth attributes between 180 and 120 kg N ha^{-1} (N_3 and N_2). Significant improvement in plant height, LAI, dry matter accumulation and CGR up to 120 kg N ha^{-1} (N_2) compared to other levels was due to easily available nutrient in adequate quantity by the treatment N_2 might have led to rapid meristemic activity in plants contributing to taller plant height as well as to increase cell enlargement and cell division leading to lager LAI. The results of this study were in agreement with Bindhani *et al.* (2007). The lower value of CGR with gradual reduction in nitrogen levels was due to corresponding lower LAI values and less production of dry matter during all the growth periods.

The interaction effect between organic manure and nitrogen fertilizer (Table 4.2, 4.4 and 4.8) showed that growth attributes of plant increased significantly with application of 4 t vermicompost in combination with 120 kg N ha-1 (M_2N_2). This was probably due to the balanced supply of plant nutrients and favourable effect of vermicompost on growth attributes of crop, resulted in taller plant, larger LAI, more dry matter production and maximum CGR. The less expression of growth attributes in the control plot (no manure and N fertilizer) might be starvation of plants due to inadequate supply of nutrients.

5.1.2 Yield attributes

Regarding yield attributes of the crop, the number cobs $plant^{-1}$, cob weight without husk, cob length with and without husk and cob diameter with husk were significantly higher with the application of vermicompost @ 4 t ha^{-1} (M_2) than other manurial treatments employed (Table 4.9 and 4.11). Further the husk: corn ratio was significantly lower in M_2 treatment. This indicated the superiority of vermicompost over FYM as organic manure. The

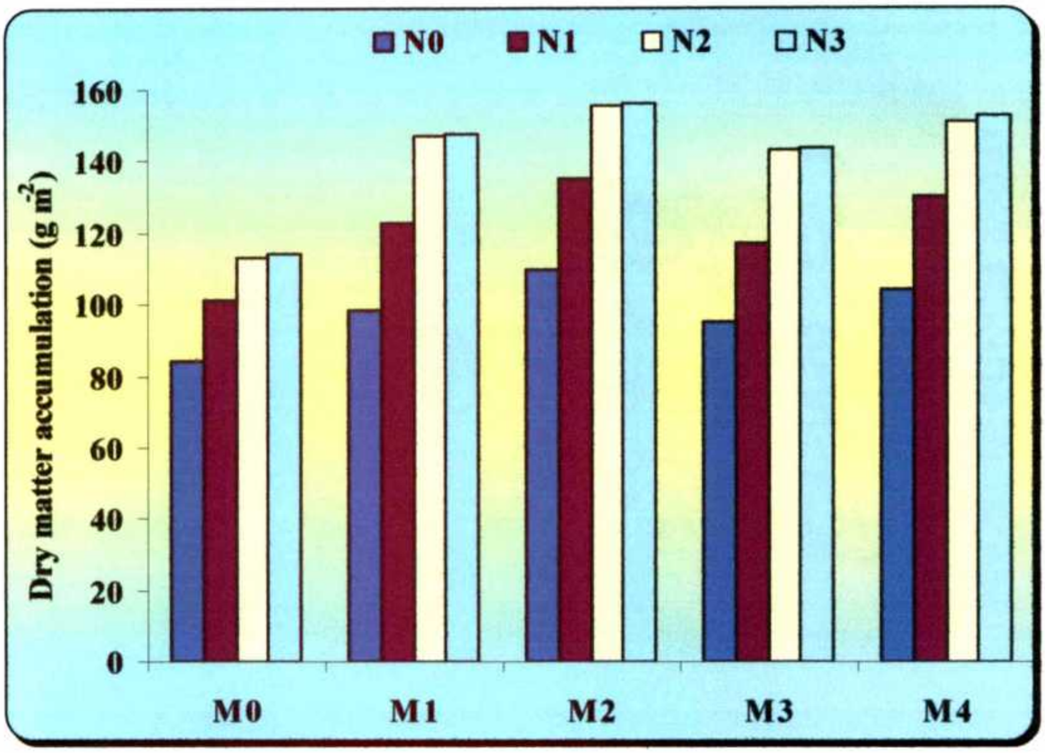


Figure 5. Effect of nutrient management on dry matter accumulation of babycorn at 20 DAS

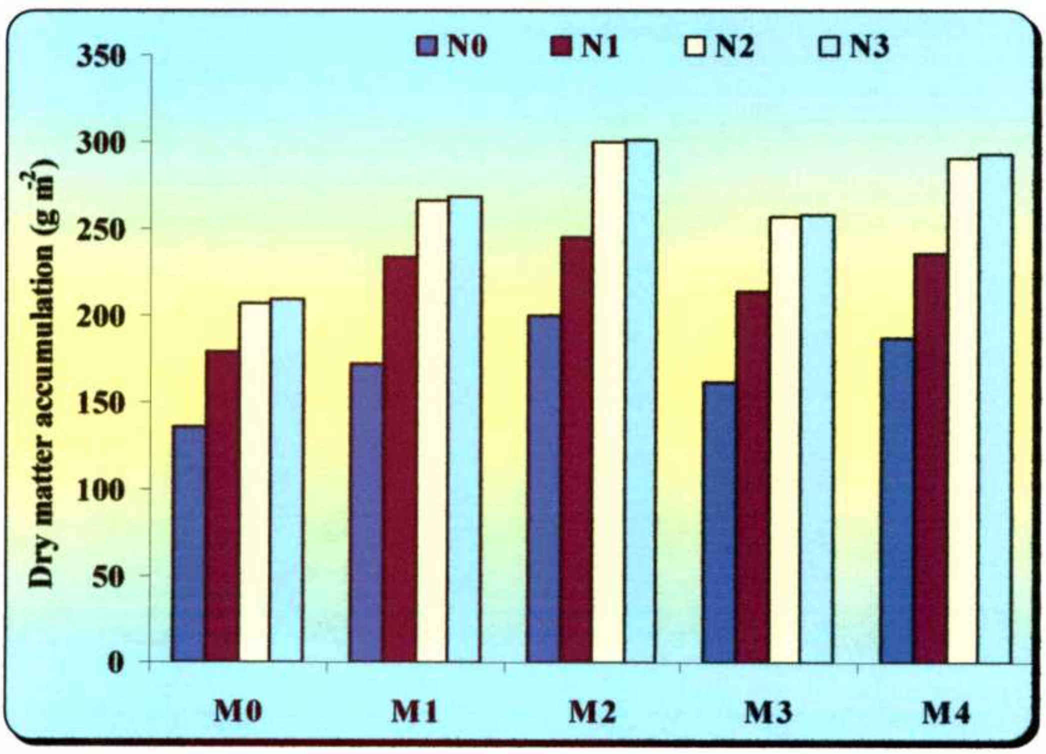


Figure 6. Effect of nutrient management on dry matter accumulation of babycorn at 40 DAS

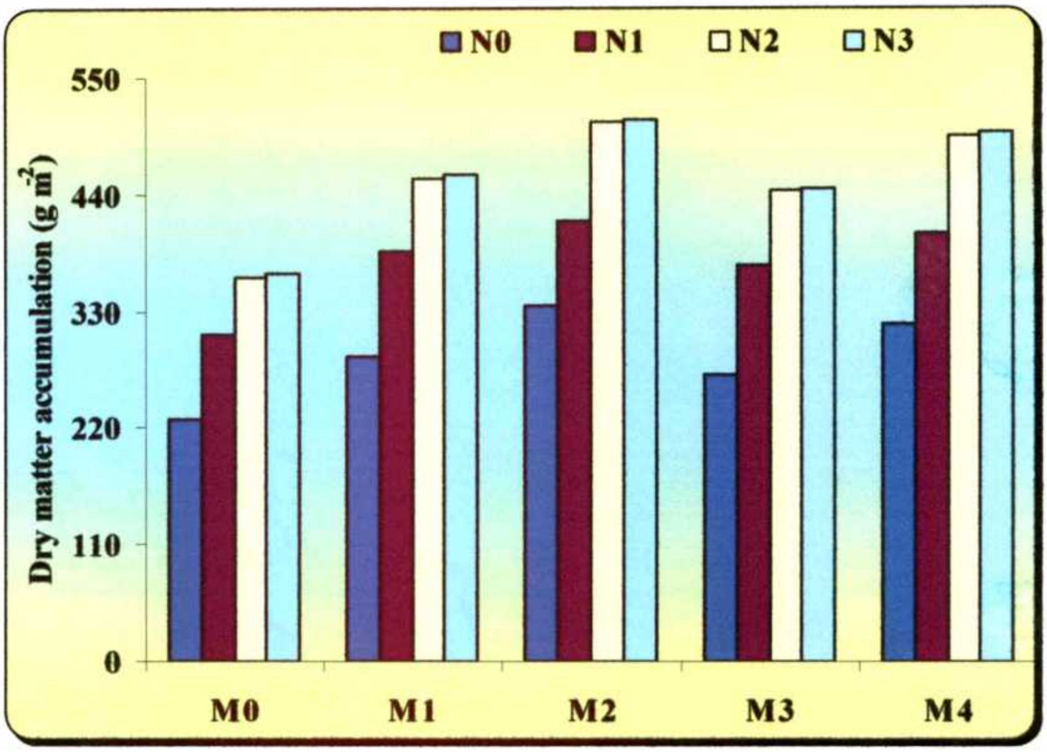


Figure 7. Effect of nutrient management on dry matter accumulation of babycorn at 60 DAS

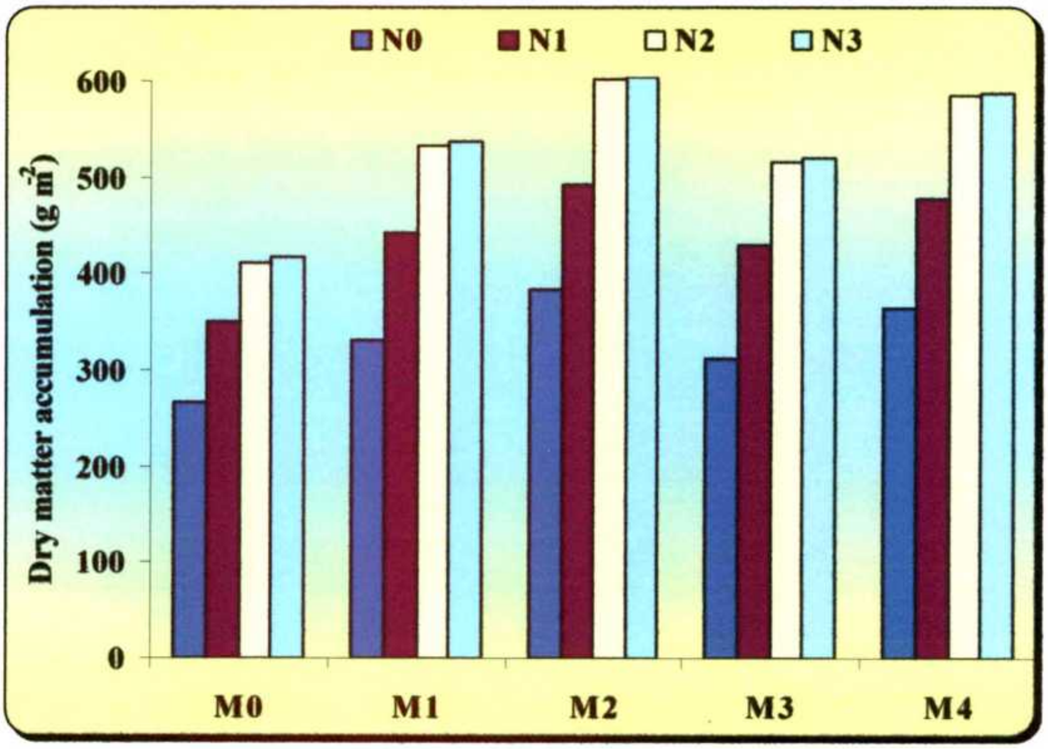


Figure 8. Effect of nutrient management on dry matter accumulation of babycorn at harvest

nutrient management through vermicomposting brought about a significant improvement in growth characters which encouraged the nourishment and development of reproductive organ which ultimately resulted in increased yield attributes. The M_2 treatment exhibited 44.23% higher cobs plant^{-1} than the M_0 treatment (control). In a similar way, the better performance of vermicompost in augmenting the yield attributing characters was reported by Khadtare *et al.* (2006) in sweetcorn.

Various treatments of inorganic nitrogen influenced the yield attributes of the crop. The yield attributes were recorded maximum with the highest dose of N i.e., 180 kg N ha^{-1} (N_3), however, significant improvement in yield attributes was observed with the application of 120 kg N ha^{-1} (N_2). The results indicated that the dose of N fertilizer (120 kg N ha^{-1}) was sufficient enough to supply the readily available plant nutrients which might have helped the plants to synthesize carbohydrates at a rapid rate encouraging the development of reproductive organs which ultimately resulted in increased yield attributes. The results corroborated in the findings of Meena *et al.* (2007).

Pooled data of interaction (Table 4.10 and 4.12) showed that application of 4 t vermicompost along with 180 kg N ha^{-1} (M_4N_3) improved the yield attributes at highest level, however, theses were significantly increased with 4 t vermicompost coupled with 120 kg N ha-1 (M_2N_2). Moreover, M_2 N_2 treatment was comparable with that of FYM @ 10 t + 180 kg N ha^{-1} (M_4N_3) in some characters. The combined use of organic manure and inorganic N fertilizer produced more leaf area, which contributed to higher rate of translocation of photosynthates from source to sink, resulting in higher expression of yield attributes. However, the control plot (no manure and N fertilizer) showed the poor results due to less improvement in growth characters.

5.1.3 Yield

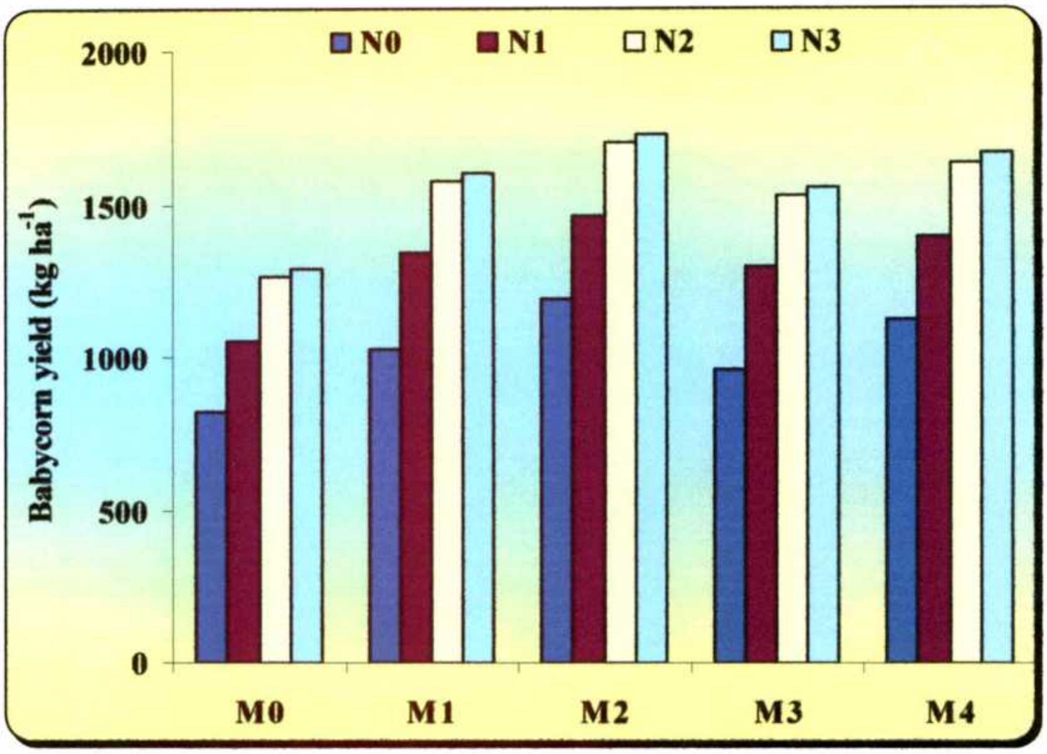


Figure 9. Effect of nutrient management on babycorn yield without husk

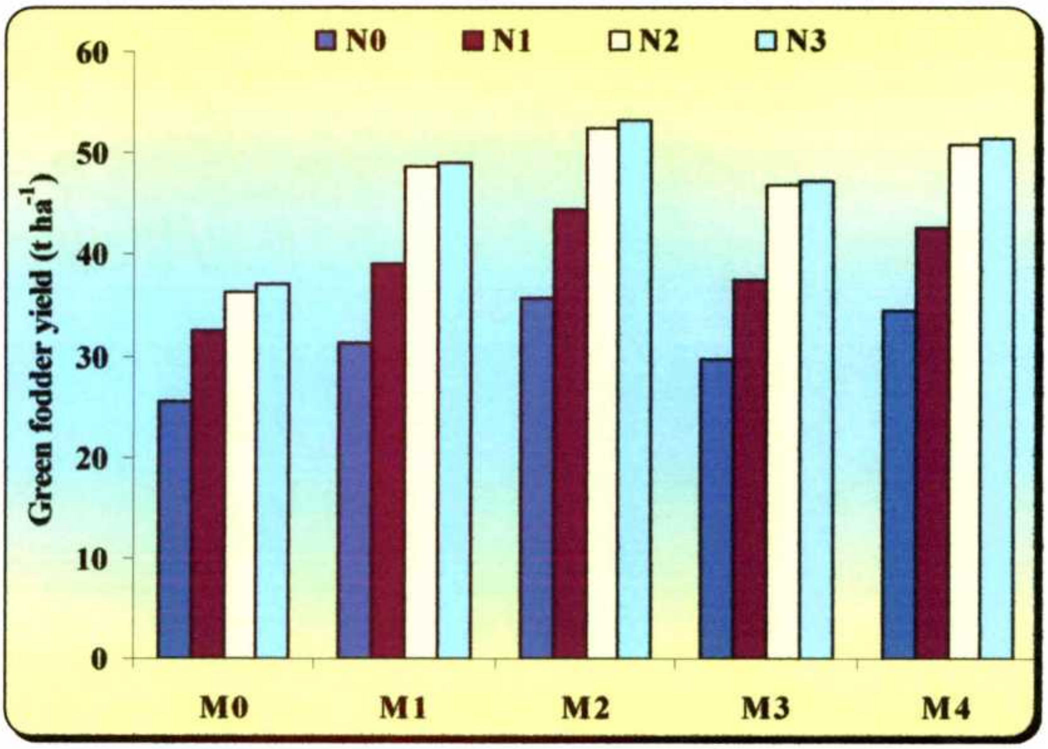


Figure 10. Effect of nutrient management on green fodder yield of babycorn

Results in the Table 4.13 revealed that vermicompost @ 4 t ha^{-1} (M_2) excelled other manurial treatments in respect of baycorn and green fodder yields. The M_2 treatment exhibited 37.27% higher babycorn and 41.49% higher green fodder yields than that of control plot (no manure). The significant effect of vermicompost over FYM could be attributed to the beneficial effect of vermicompost on growth and yield attributing parameters, which ultimately resulted in higher babycorn and green fodder yield. Kumar *et al.* (2007) reported that the positive effect vermicompost on yields might be due to that vermicompost as a source of macro and micronutrients, vitamin, and growth hormones like gibberellins which regulate the growth and yield attributes of plant, resulting in increased babycorn and green fodder yield.

Among the fertilizer treatments, 120 kg N ha^{-1} (N_2) showed significantly higher yields of babycorn and green fodder than other treatments. This indicated that beyond this level, the crop response to N fertilizer was insignificant. The similar results were reported by Parmar and Sharma (2001) and Meena *et al.* (2007). Application of N @ 120 kg ha^{-1} to the crop helped the plants to absorb more nutrients leading to more photosynthesis, resulting in development of reproductive organs which gave more yields.

The interaction Table 4.14 stated that neither the organic manure alone or nor the sole N fertilizer may be adequate for higher yield of babycorn and fodder. The conjunctive use of vermicompost @ 4 t and N fertilizer @ 180 kg ha^{-1} (M_2N_3) showed highest babycorn and green fodder yield, however, it was statistically at par with vermicompost @ 4 t and N fertilizer @ 120 kg ha^{-1} (M_2N_2). The results are in agreement with Chandrashekara *et al.* (2000).

5.1.4 Nutrient uptake

Regarding the uptake of nutrient by the crop (Table 4.15), the vermicompost @ 4 t ha^{-1} (M_2) showed its superiority over other treatments might be due to that earthworm castings are rich in available nutrients like ammonia, urea and nitrate (Lee, 1985), free amino acids and plant growth substances like cytokinins and auxins (Tomati *et al.*, 1988) which in turn increased the plant growth, yield and uptake of N. Again the microbial load of the ejected material from earthworm body also contains enzymes namely amylase, lipase, cellulose, protease, chitinase etc which increase the availability of nutrients (Manna and Biswas, 1996) and would have favoured the translocation of phosphorus. Mackay *et al.* (1962) observed that earthworm stimulate phosphorus uptake from the redistribution of organic matter and increasing enzymatic activities of phosphatase. The increase in K uptake in vermicompost treated plots compared to FYM was most probably due to the earthworm castings i.e., rich in exchangeable K (Edwards and Lofty, 1997) content helps to higher uptake rate of K.

Among the fertilizer treatments, 120 kg N ha^{-1} (N_2) showed significantly higher uptake of N, P and K as application of N at higher level helped the plants to produce more vegetative and reproductive yields and nutrient contents in corn and fodder. Paliwal *et al.* (1999) reported that the yields, values of yield components and N, P and K uptake increased with increasing N rates.

The interaction Table 4.16 stated that the combined use of vermicompost @ 4 t and N fertilizer @ 180 kg ha^{-1} (M_2N_3) showed highest uptake of N, P and K, however, it was statistically at par with vermicompost @ 4 t and N fertilizer @ 120 kg ha^{-1} (M_2N_2).

5.1.5 Soil fertility status

The total nitrogen, available phosphorus and potassium content of the soil after harvest of the babycorn increased significantly from its initial level due to application of organic manures in both the years (Table 4.17). The maximum value of these soil fertility parameters were recorded under the vermicompost @ 4 t ha^{-1} (M_2) treatment compared to all other treatments. The increasing levels of vermicompost significantly increased the soil N, P and K were reported by Srikanth *et al.* (2000) and Singh and Chauhan (2002). Blair *et al.* (1997) depicted the similar result that vermicompost increased soil mineral N concentrations as the concentrations of labile organic N was generally high with vermicompost treatments. Similarly, the presence of phosphorus solubilizing bacteria like *Bacillus* and *Aspergilus* in vermicompost was in higher proportion which increased the solubility of phosphorus (Vasanthi and Kumaraswamy, 1999). Lui Shuxin *et al.* (1992) reported that application of vermicompost to the soil increased the available phosphorus and potassium content in the soil. However, the availability of soil N, P and K was increased with application of 18o kg N ha^{-1} (N_3).

The interaction effect showed that the maximum residual effect of total N (0.085 %), available P (27.48 kg ha^{-1}) and K (145.79 kg ha^{-1}) remained in the treatment where crop received vermicompost @ 4 t + 180 N kg ha^{-1} (M_2N_3), which was followed by FYM @ 10 t + 180 kg N ha-1 (M_4N_3). Similar observation in the favourable effect of inorganic fertilizers coupled with organic manures on soil fertility status in pearl millet-pigeon pea cropping system was reported by Tolanur and Badanur (2003). This was might be due to the mixing of nitrogen fertilizers and vermicomost reduced the nutrient loss, increased mineralization and solubilization of nutrients, increased biological fixation of nitrogen and lengthened fertilizer efficiency (Zhao-Shi-Wei and Haung Fuzhen, 1992).

5.1.6 Quality parameters

The quality parameters of babycorn like reducing sugar, total sugar, protein and TSS were maximum under the vermicompost @ 4 t ha^{-1} (M_2) treatment (Table 4.19). This was might be due to greater availability of

Plate 1. Over view of experimental field

Plate 2. Baby corn plant with cob

nutrients, hormones and enzymes, leading to higher quality of babycorn as reported by Meena *et al.* (2007). On the other hand, an improvement in the quality of corn with increase in the N levels corroborated the findings of Banerjee *et al.* (2004) and Raja (2001). This was due the correlation of the level of reducing sugar, total sugar and protein content with N nutrition, which increased significantly with higher doses of 120 kg N ha^{-1}.

The interaction table 4.20 showed that the maximum value of reducing sugar, total sugar, protein and TSS under vermicompost @ 4 t along with 180 kg N ha^{-1}(M_2N_3) was might be due to favourable effect of organic compost and inorganic N fertilizers on quality parameters. Khadtare *et al.* (2006) also reported similar results on quality of sweet corn where N was applied both organic and inorganic forms.

5.1.7 Production economics

The cost of cultivation of babycorn was varied from Rs. 20,562 ha-1 under the control (M_0N_0) to Rs. 36,548 ha^{-1} under the application of vermicompost @ 4 t and N fertilizer @ 180 kg ha^{-1} (M_2N_3). With the increase in doses of organic manures along with N fertilizer the cost simultaneously increased (Table 4.21). However, the cost of cultivation was higher in vermicompost than FYM treatment at the same level of nitrogen. This was due to the higher price of vermicompost compared to FYM. The highest gross and net returns were recorded in M_2N_3 treatment. This was due to maximum increase in babycorn and green fodder yields with the integrated use of vermicompost and inorganic N fertilizer, which increased the returns. However, the benefit: cost ratio was the maximum in FYM @ 5 t + 120 kg N ha^{-1} (M_3N_2). This was due to the relative cost advantage in integration of FYM @ 5 t along with 120 kg N ha^{-1} than M_2N_3. Similar trend was reported by Kumar *et al.* (2002) and Tank *et al.* (2006).

5.2 Experiment 2. Weed management in babycorn

5.2.1 Weed

5.2.1.1 Weed density, dry weight and weed control efficiency

The results presented in Table 4.22 to 4.30 revealed that among the various weed management methods, hand weeding twice at 20 and 40 DAS (W_4) showed the best result in reducing weed density per unit area, weed dry weight and enhancing weed-control efficiency. This was due to the better eradication of all categories of weeds that emerged at early and later stage of crop growth and maintained almost weed free situation at all the time by two manual weedings. An initial mulching with paddy straw @ 10 t / ha (W_3) had also a smothering effect on weeds and thereby, exhibited lower emergence of weeds. Higher efficiency of weed-control under mulch might be due to its effectiveness to suppress the growth of existing as well as germinating weed flora during the crop period. The treatment W_3 for weed control was comparable with W_4. Wahab *et al.* (2000) opined that mulching had a significant effect on weed count and weed biomass in rainy and summer season maize. Increased the concentration of pre-emergence herbicides like atrazine (W_1) and metribuzin (W_2) applied @ 2 kg a.i. ha^{-1} each did not exhibit higher weed control efficiency, however, lower the concentration of these herbicides (atrazine or metribuzin applied @ 1 kg a.i. ha^{-1} each) coupled with one hand weeding at 30 DAS (W_5 or W_6) was more effective in controlling the weeds. The treatment W_1 or W_2 was not superior to that of respective integrated weed management (W_5 or W_6) because they might have reduced the population and dry matter accumulation of weeds at the early phase of crop growth, but at the later stage more weeds per unit area had emerged with the crop. This was probably due to volatile nature and low persistence of these herbicides in the soil that reduced their activity for longer period. However, the higher weed control efficacy and less

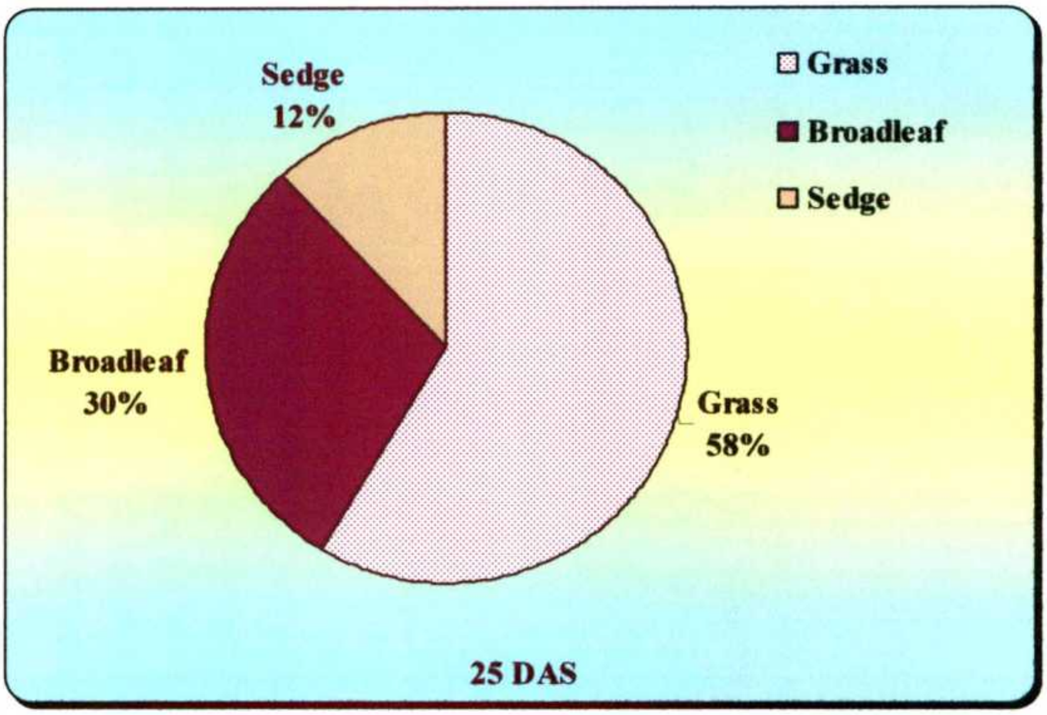


Figure 14. Effect of weed management on grass, broadleaf and sedge weed population at 25 DAS

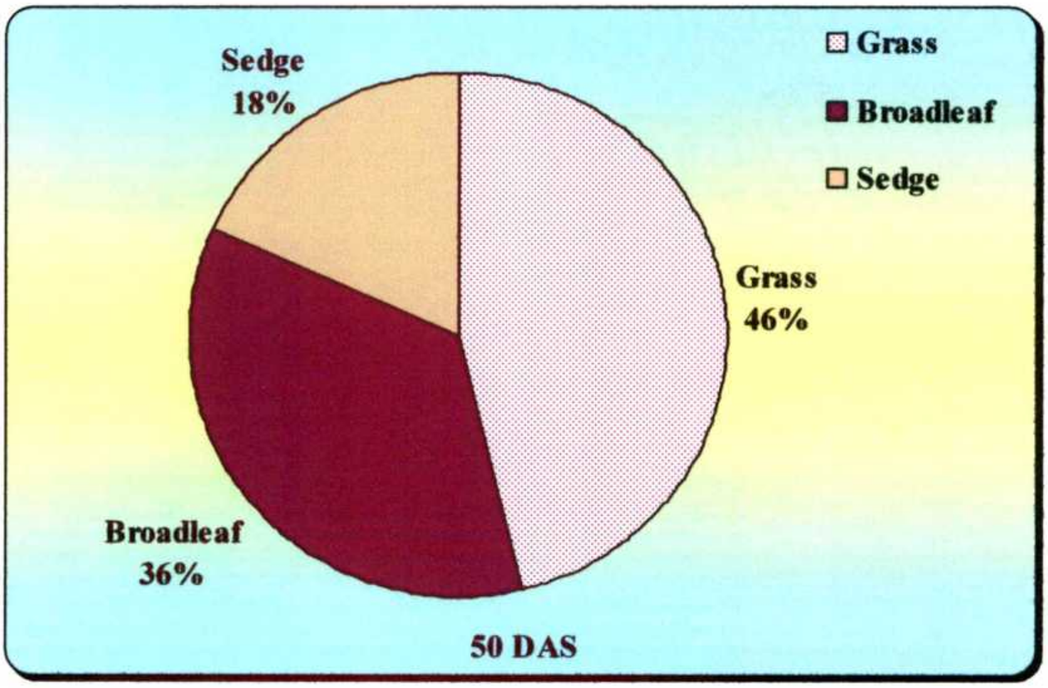


Figure 15. Effect of weed management on grass, broadleaf and sedge weed population at 50 DAS

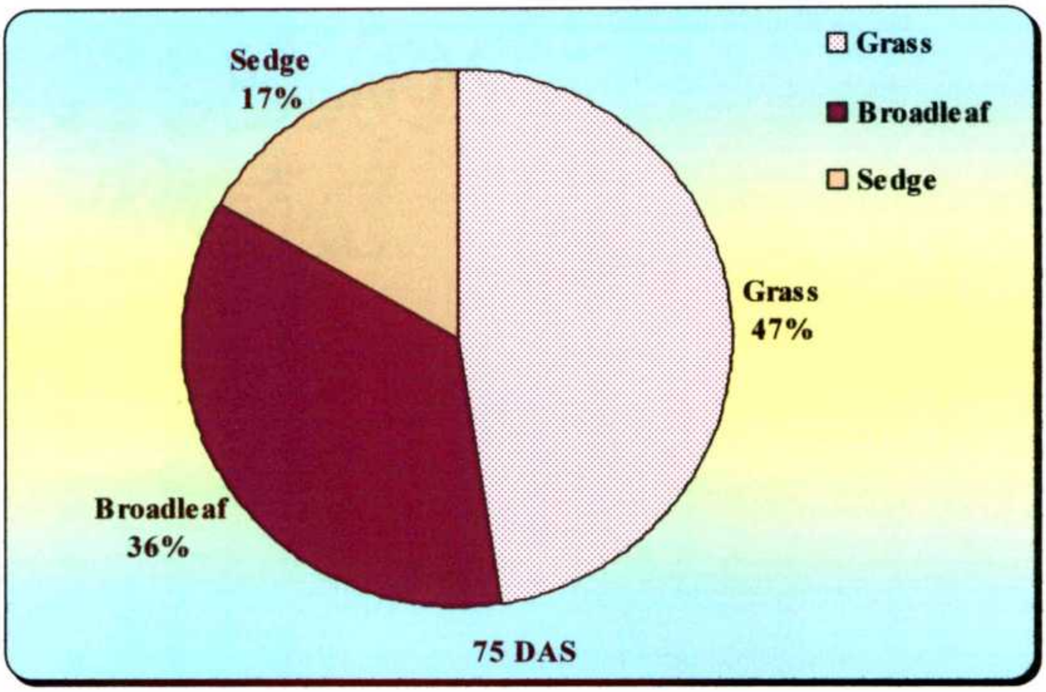


Figure 16. Effect of weed management on grass, broadleaf and sedge weed population at 75 DAS

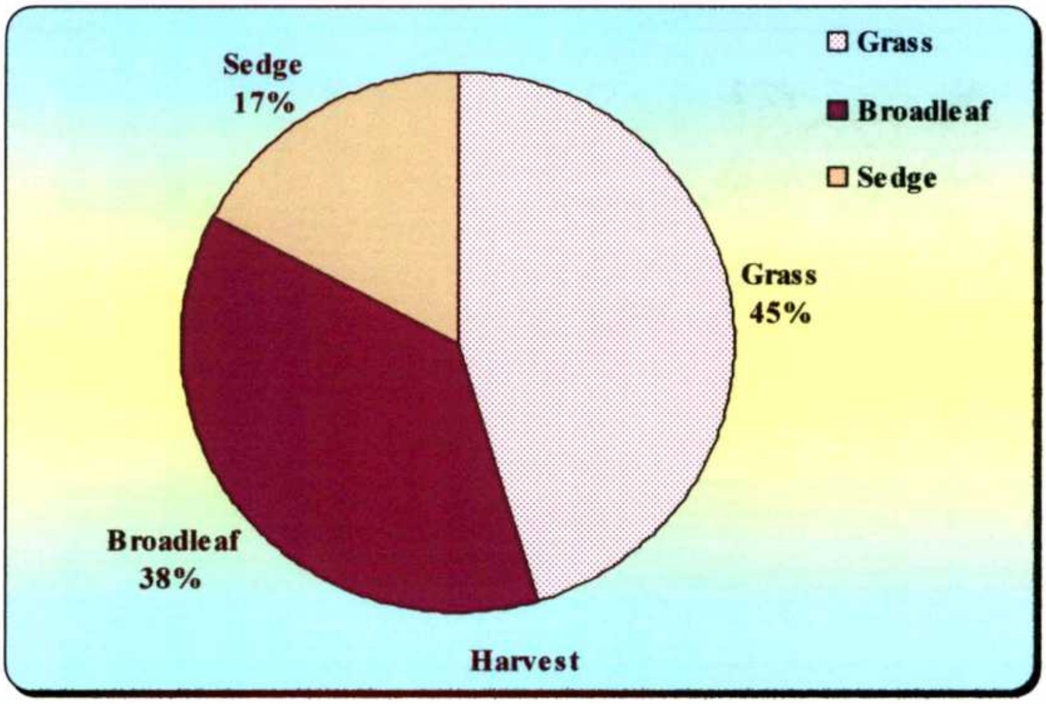


Figure 17. Effect of weed management on grass, broadleaf and sedge weed population at harvest

competition from weeds under W_5 and W_6 treatments might be due to the effectiveness of herbicide in killing the weeds initially followed by eradication of the second flash of weeds by one hand weeding at 30 DAS in a better way. Mundra *et al.* (2003) also reported the effectiveness of herbicides in integration with one manual weeding to check the weed growth. Among these herbicides, atrazine (alone or integrated) showed its superiority by lowering the density and dry weight of grass, sedge and broadleaf weeds as compared to that of metribuzin. The better ability of atrazine might have attributed to control of weeds effectively due to its effect on wide spectrum of weed species. On the contrary, the lower weed-control efficacy of metribuzin was due to the escape of some weed species. The ability of atrazine to control weeds of maize in an effective way was revealed by Fathi (2005) and Norsworthy & Frederick (2005). Because of having no weed control measure, the weedy check plots (W_7) were severely infested with weeds indicating the highest density and greater dry matter accumulation of weeds at all dates of observations.

5.2.2 Soil micro-flora

The experimental results revealed that herbicidal treatments exerted a significant detrimental effect on aerobic non-symbiotic N-fixing bacteria and P-solubilizing bacteria and reduced the microbial count in all soil samples collected at 25 DAS (Table 4.31 to 4.32). But the harmful effect of herbicides did not last long and that was reflected through the stimulation on microbial population in the rhizosphere soil thereafter (Barman *et al.*, 2002). Initial suppression of microbial population might be due to toxic effects of herbicides in soil environment. The effect was more pronounced in pre-emergent metribuzin (W_2) with higher dose compared to that of atrazine (W_1). Similar results were also observed by Ghosh *et al.* (2003). In case of both the bacteria, the pattern of decline in population and subsequent

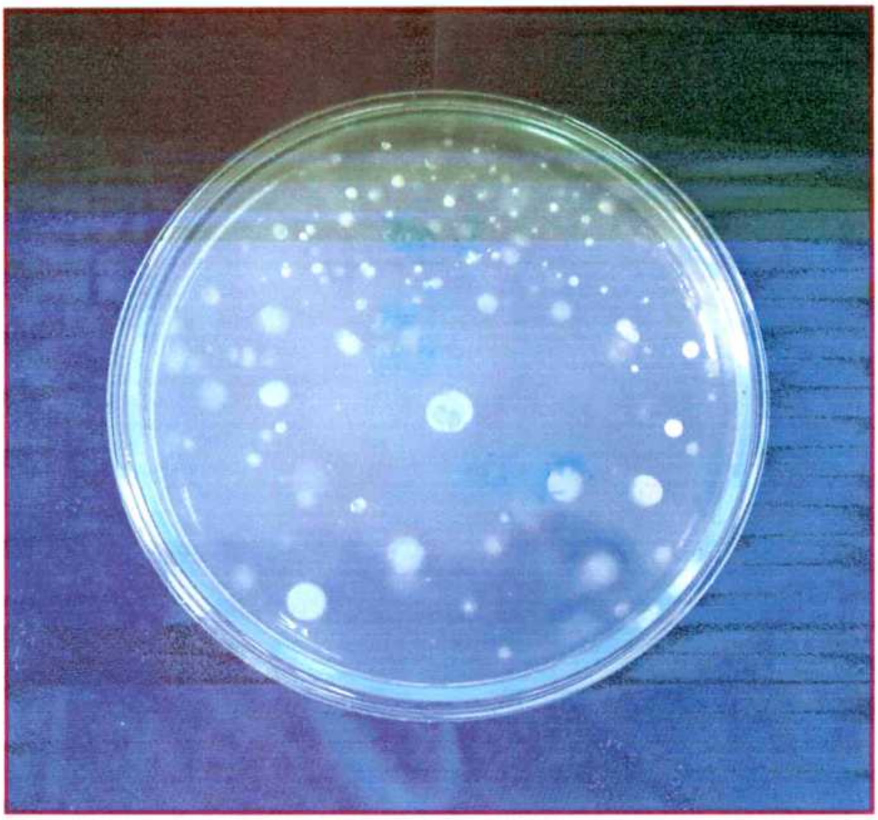


Plate 3. Phosphate solubilizing bacteria (W_3)

Plate 4. Nitrogen fixing bacteria (W_1)

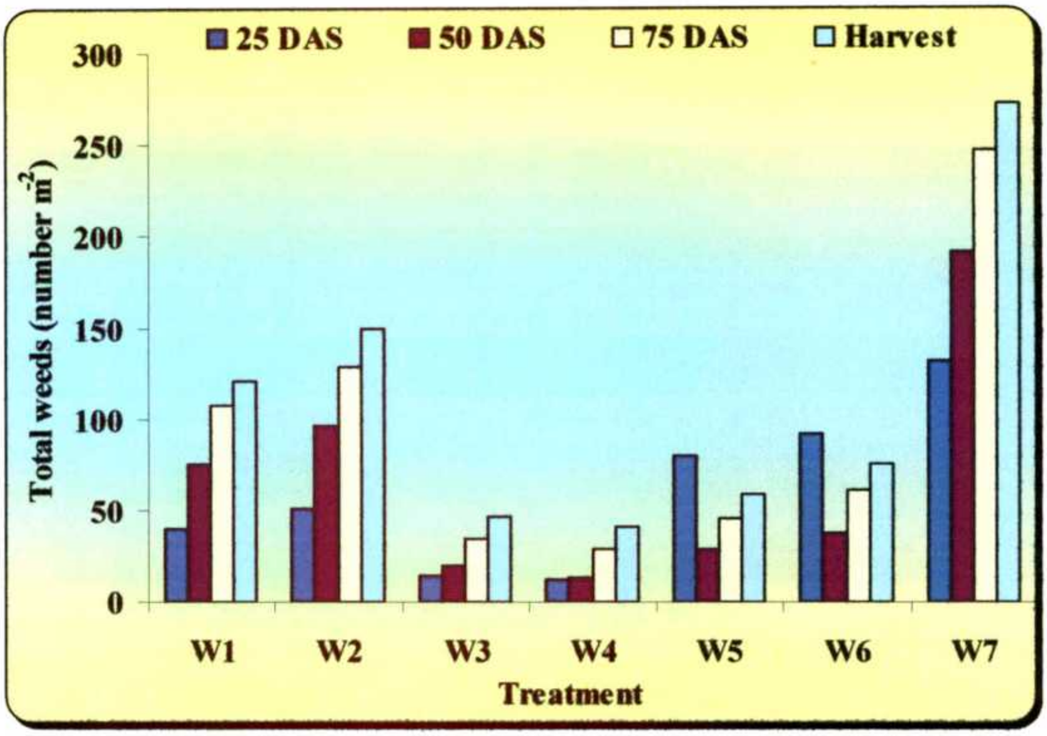


Figure 18. Effect of weed management on total weed population in babycorn

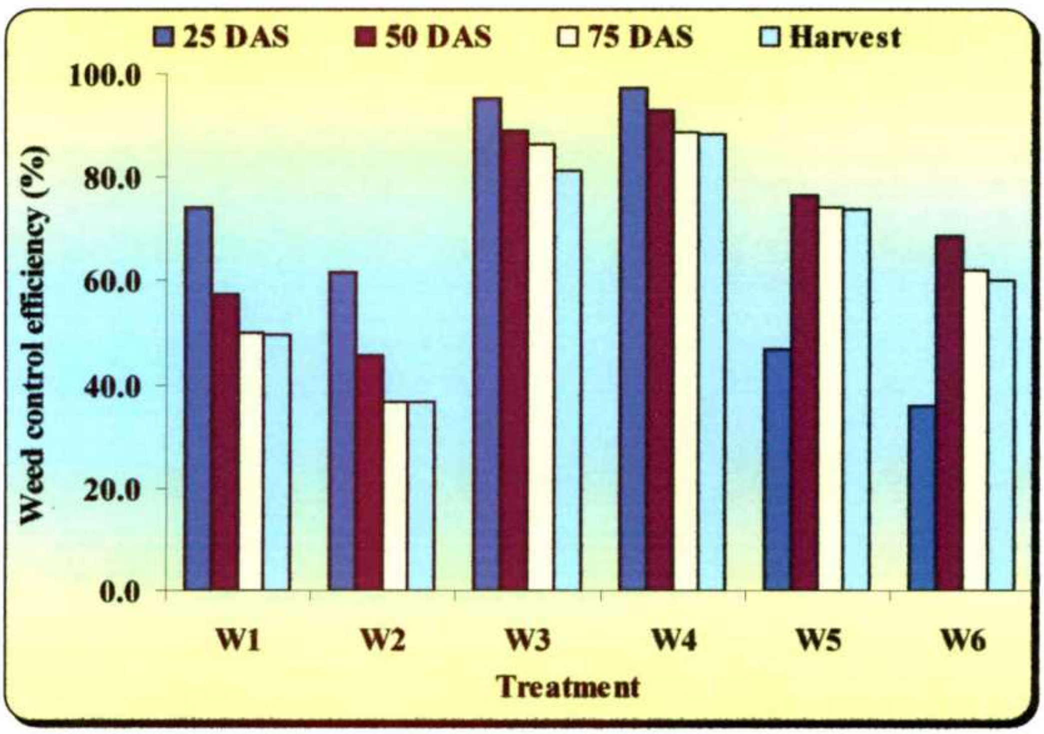


Figure 19. Effect of weed management on weed control efficiency of babycorn

recovery followed the similar fashion. Among the herbicides, the recovery rate was faster in atrazine than metribuzin with respect to bacterial population (Pandagare *et al.*, 2003). Under straw mulch (W_3), increase in the microbial population continued significantly up to highest level was due to the conservation of optimum moisture in addition to the greater availability of energy and nutrients (carbon and nitrogen) for higher rate of mineralization of organic substances in soil at an elevated temperature. The results were in agreement with Hundal *et al.* (2000) and Singh and Rana (2003). Similar trend of microbial proliferation was observed in hand-weedings at 20 and 40 DAS (W_4) plots due to conserve nutrients for the growth and multiplication of these microorganisms. However, the microbial population did not enhance profusely in weedy check plots (W_7), which might be due to the harmful effect of root-exudates secreted by the complex weed flora in the rhizosphere soil.

5.2.3 Babycorn

5.2.3.1 Growth attributes

The results as presented in Table 4.33 to 4.36 related to growth attributes of babycorn, revealed that among the different weed management treatments, the weedy check (W_7), as expected, showed the minimum plant height, LAI and dry matter accumulation due to severe competition of weeds with babycorn for growth resources such as plant nutrients, soil moisture etc. throughout the life span of the crop. The crop did not grow well as weeds robbed up the growth resources and thereby, less expression of growth attributes also reduced crop growth rate (CGR) drastically in W_7. However, the twice hand-weeding plots (W_4) recorded the maximum values of the above-mentioned growth attributes as the crop did not face much competition with weeds for growth resources at any time in its life, resulting in vigorous growth of the crop. Under W_4 treatment, the higher LAI might be

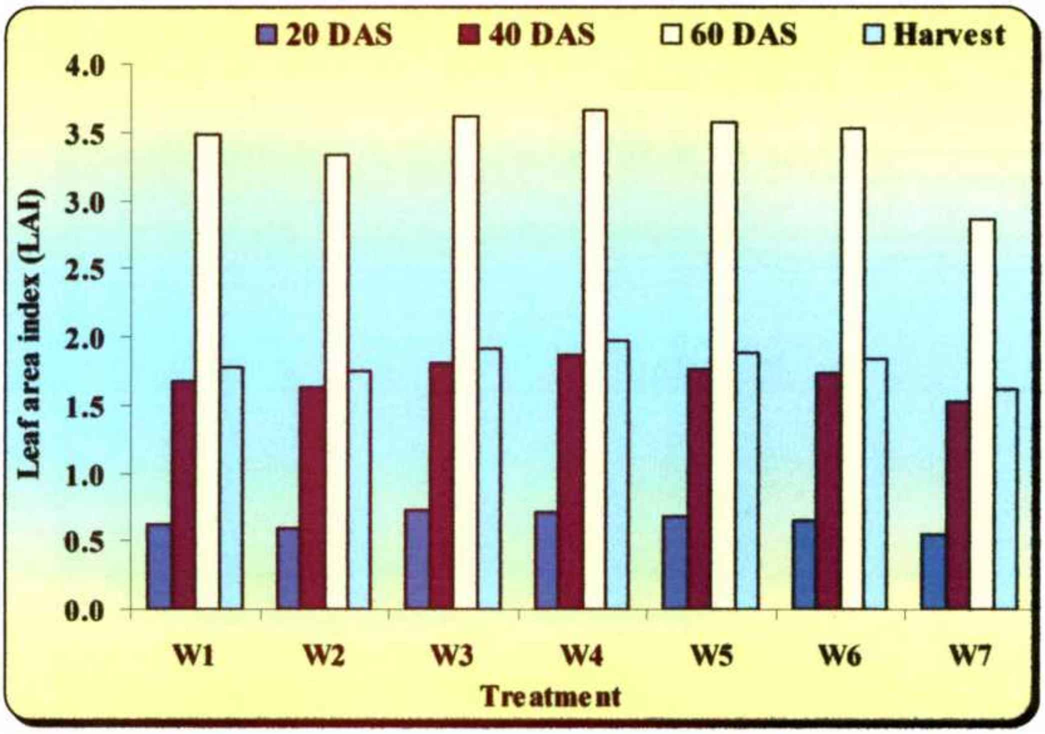


Figure 20. Effect of weed management on leaf area index of babycorn

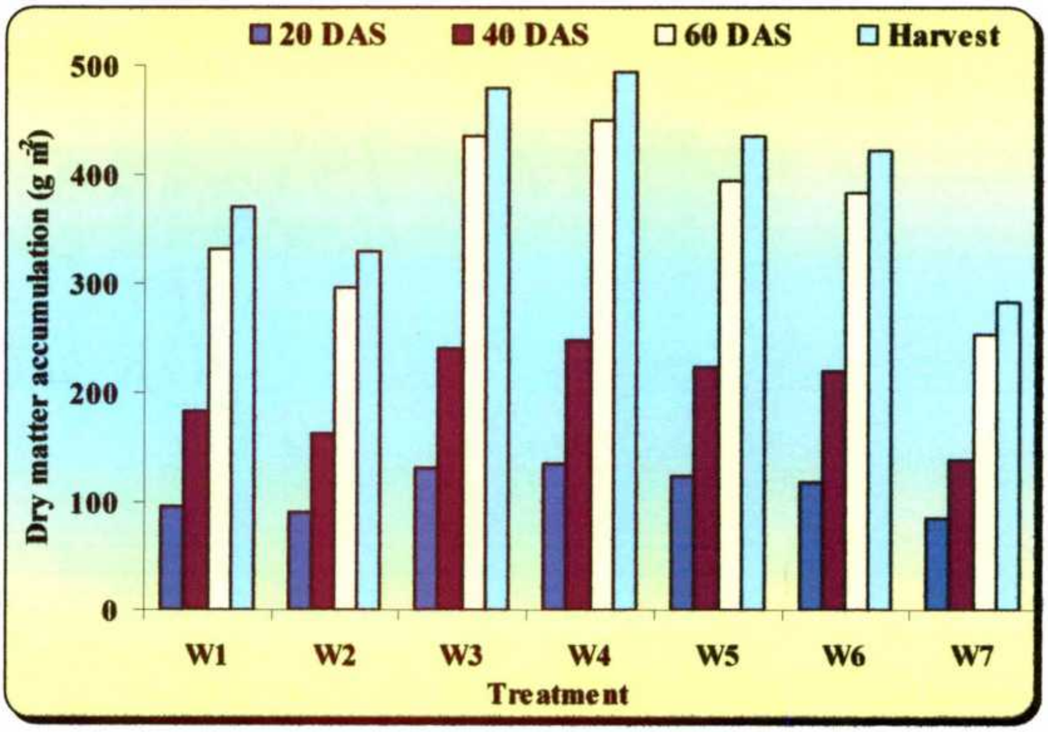


Figure 21. Effect of weed management on dry matter accumulation of babycorn

associated with greater photosynthetic ability of plants, which in turn increased dry matter accumulation and faster growth rate of the crop. The results supported the findings of Sinha *et al.*, (2001). Similarly, integrated weed management with pre-emergence application of atrazine or metribuzin coupled with one hand weeding at 30 DAS (W_5 or W_6) performed better than herbicide alone (W_1 or W_2) due to their higher weed control ability and thereby, rendering the crop to compete with weeds less for growth resources and producing better growth attributes. The results were similar to the reports of Pandey *et al.*, (2002).

5.2.3.2 Yield attributes

Among the weed management treatments, hand-weeding twice at 20 and 40 DAS (W_4) showed significantly highest yield attributes of babycorn viz. number of cobs plant^{-1}, cob length, cob diameter and cob weight as well as lower husk: babycorn ratio as compared to other treatments (Table 4.37 to 4.39). This could be attributed to less weed infestation, higher weed control efficiency and better utilization of growth resources by the crop which favoured to produce higher growth and yield attributes. Mandal *et al.*, (2004) had also obtained similar type of results. As a result of severe weed-crop competition throughout the life span of crop, the weedy check plots (W_7) recorded the lowest values of yield attributes. The treatment W_4 exhibited 64.75% higher number of cobs plant^{-1} than W_7. The straw mulch treatment (W_3) also showed higher yield attributes, next to hand-weeding twice (W_4), which might be due to its smothering effect on weeds and more availability of nutrients and moisture to crop that reflected on growth attributes. However, the integrated weed control either pre-emergent atrazine + one hand weeding at 30 DAS (W_5) or pre-emergent metribuzin + one hand weeding at 30 DAS (W_6) showed significantly higher yield attributes than pre-emergent atrazine (W_1) / metribuzin (W_2) alone. Such improvement of yield attributes under integrated weed management was reported earlier (Prasad *et al.*, 1990; Talatala Sinco and Ranchez, 1990; Pandey *et al.* 2002 and Mandal *et al.*, 2004).

5.2.3.3 Yield

It is superfluous that weeds take up the growth resources which otherwise would be utilized by the crop. Therefore, the longer the period weeds compete with the crop, the higher will be the loss of growth resources for the crop, resulting poor yield attributes and yield. Owing to high weed infestation as well as competition during the growth period of the crop in weedy check plots (W_7) hindered to produce optimum number of yield attributes, resulting in lowest yield of babycorn (Table 4.39). Weeds, when allowed to grow unchecked (W_7), caused 56.91% loss in babycorn yield compared to the highest level (W_4). However, the growth resources were more available to crop in hand-weeding twice (W_4) plots due to the less crop-weed competition, which in turned increased the growth and yield attributes that ultimately reflected in highest yields of babycorn and green fodder. The treatment W_4 produced 56.91% higher babycorn yield and 30.03% higher green fodder yield over weedy check. The results corroborated the findings of Sinha *et al.* (2001) in maize. Straw mulch treatment (W_3) also improved the yield of babycorn and found as the next best treatment due to its higher efficiency of weed suppression and more availability of moisture and nutrients to crop. The treatment W_3 showed 53.80% higher babycorn yield and 27.29% green fodder yield than W_7. Between the herbicidal treatments, the superiority of pre-emergent atrazine alone (W_1) over metribuzin (W_2) in respect of babycorn yield might be due to its better efficacy in controlling weeds and reducing the weed-crop competition. The important reason behind this was the effective and broad-spectrum weed controlling ability of atrazine (Norsworthy & Frederick, 2005) and at the same time the inability of metribuzin to control all categories of weed

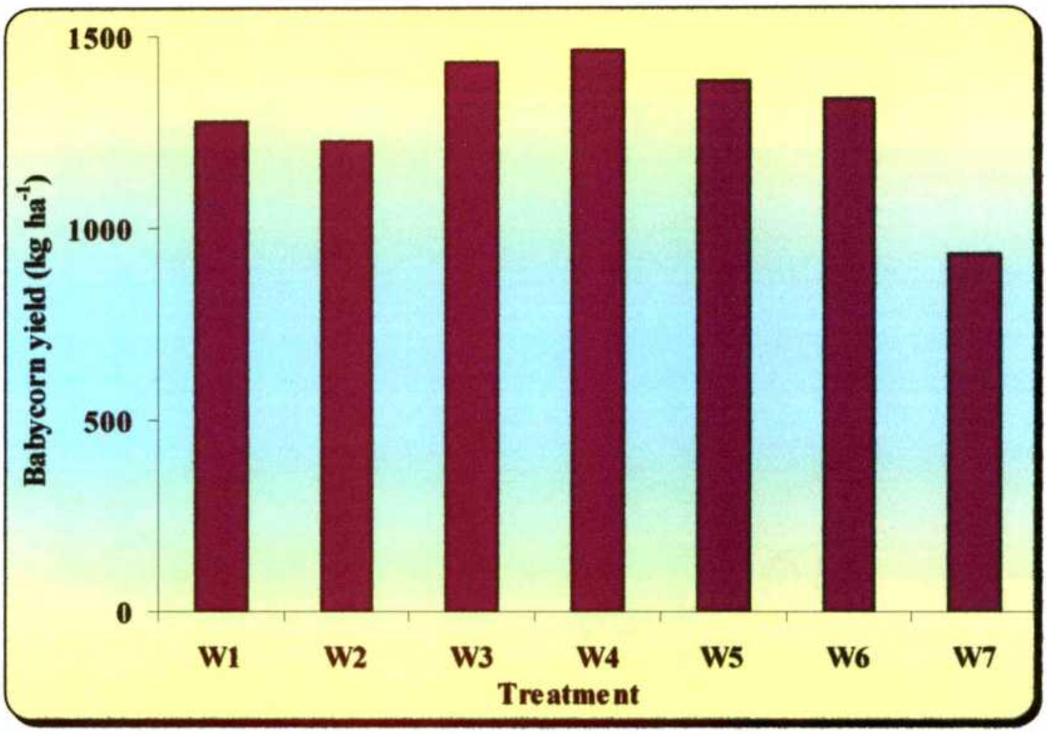


Figure 22. Effect of weed management on babycorn yield without husk

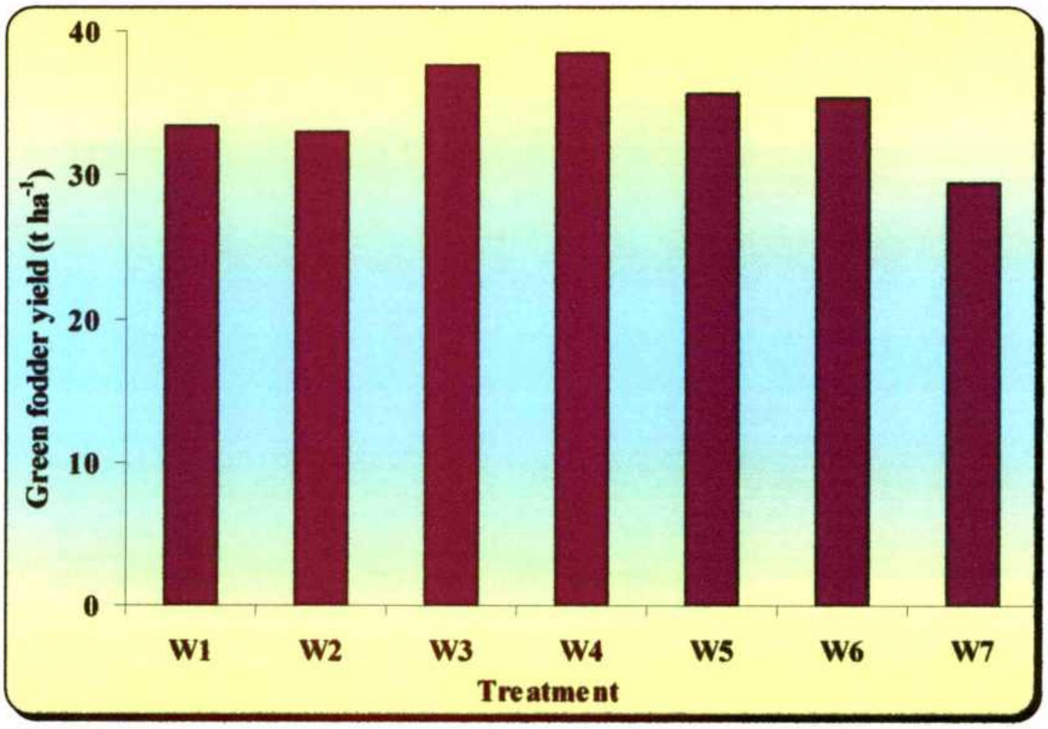


Figure 23. Effect of weed management on green fodder yield of babycorn

flora that established along with the crop. As a result, W_1 produced 4.15% higher babycorn yield than W_2. However, weeds did not reduce the yield drastically in pre-emergence application of atrazine or metribuzin followed by hand weeding at 30 DAS (W_5 or W_6) corresponding to pre-emergent herbicide alone (W_1 or W_2), as in the former case, the crop faced less competition imposed by all categories of newly emerged weed flora during the later stage of the growth as happened in later one. Similar trend of results were observed by Pandey *et al.*, (2002). Further, both the herbicides did not exhibit any phytotoxicity symptoms to plants even at higher concentration.

5.2.3.4 Production economics

All the weed control treatments recorded considerably higher returns over weedy check (Pandey *et al.*, 2002). In spite of higher gross return and net return, the benefit: cost ratio was lower in straw mulching @ 10 t ha^{-1} (W_3) compared to pre-emergence application of atrazine @ 1 kg. a.i. ha^{-1} along with one hand weeding at 30 DAS (W_5). This was mainly due to the higher cost of paddy straw (Table 4.40). However, the maximum gross return, net return and benefit: cost ratio were obtained with two hand weeding at 20 and 40 DAS (W_4), which showed an additional net return of Rs. 26,727 and 39.15% higher benefit: cost ratio than Weedy cheek (W_7). In W_7, though incurred the minimum cost, the benefit: cost ratio was lowest due to less return owing to severe weed infestation and heavy reduction in crop yield. However, the integrated weed-control methods (inclusion of one hand-weeding with pre-emergent atrazine @ 1 kg. a.i. ha^{-1}, W_5 or metribuzin @ 1 kg a.i. ha^{-1}, W_6) was superior to the respective herbicide alone (W_1 or W_2) while considering the benefit: cost ratio. W_5 treatment exhibited 8.71% higher benefit: cost ratio than straw mulch due to its lower total cost and provided additional net return of Rs. 4790 and 22803 ha^{-1} compared to W_1 and W_7 respectively. Similar type of result was reported by Mandal *et al.* (2004).

CHAPTER 6

Summary and Conclusion

Summary and Conclusion

Two field experiments on babycorn were conducted at the Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal during *rabi* season of 2005 – 2006 and 2006 – 2007 to study the nutrient and weed management in winter babycorn (Zea mays) cv. Early Composite under the Gangetic Alluvium of West Bengal.

In experiment I, the study on nutrient management in babycorn was undertaken in a split-plot design with five treatments (M_0 – No organic manure, M_1 – Vermicompost @ 2 t ha^{-1}, M_2 – Vermicompost @ 4 t ha^{-1}, M_3 – FYM @ 5 t ha^{-1} and M_4 – FYM @ 10 t ha^{-1}) in main plot and four treatments (N_0 – Without nitrogen application, N_1 – 60 kg N ha^{-1}, N_2 – 120 kg N ha^{-1} and N_3 – 180 kg N ha^{-1}) in sub-plot and three replications. Nitrogen fertilizer was applied in two splits – $^1/_2$ as basal and rest $^1/_2$ at 30 DAS.

In experiment II, the study on weed management in babycorn was undertaken in randomized block design with seven treatments [W_1 – Atrazine @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS), W_2-Metribuzin @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS), W_3-Paddy straw mulch @ 10 t ha^{-1}, W_4-Hand weeding (HW) twice at 20 DAS and 40 DAS, W_5-Atrazine @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS, W_6-Metribuzin @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS and W_7-Weedy cheek] and three replications.

The experimental soil was sandy-clay loam and having good irrigation cum drainage facility. All other recommended package of practices were followed uniformly except nutrient management in Experiment I and weed management in Experiment II.

The analysis of pooled data revealed that growth attributes, yield components, yields, uptake of nutrients, quality parameters, economics and soil fertility status were significantly influenced by the nutrient management practices. The increase in the levels of organic manure (FYM / Vermicompost) to babycorn significantly increased plant height, LAI, dry matter production and CGR. However, vermicompost treatment showed its superiority over FYM treatment. The maximum growth and yield attributes were observed with the application of 4 t vermicompost ha^{-1} to babycorn, followed by application of FYM @ 10 t ha^{-1}, whereas the minimum value was recorded with no manure treatment. Among the levels of N-fertilizer, the maximum plant height, dry matter accumulation, LAI, CGR and the yield attributing characters of babycorn were observed with 180 kg N ha^{-1}, which was statistically at par with 120 kg N ha^{-1}. However, integrated use of vermicompost @ 4 t along with 120 kg N ha^{-1} showed significantly higher growth and yield attributes compared to all other combinations. The similar trend was observed in case corn and green fodder yields of babycorn. The maxium babycorn and green fooder yields were recorded with vermicompost @ 4 t ha^{-1}, which produced 37.27% and 41.49% higher yields than control (no manure). The application of 120 kg N ha^{-1} showed significant superiority in babycorn (1542 kg ha^{-1} without husk) and green fodder (46.95 t ha^{-1}) yields over other doses of N fertilizer, however, the treatment was statistically at par with that of 180 kg N ha^{-1}. The combined application of vermicompost @ 4 t along with 180 kg N ha^{-1} recorded maximum cob yield with husk and without husk, however, there was no significant difference between vermicompost @ 4 t + 180 kg N ha^{-1} and vermicompost @ 4 t + 120 kg N ha^{-1}.

The maximum uptake of N, P and K by babycorn plants were recorded in vermicompost @ 4 t ha^{-1} though it was significantly superior to other treatments. The highest uptake of nutrients provided by 180 N kg ha^{-1} was statistically at par with 120 kg N ha^{-1}. However, the significantly higher uptake of N, P and K was obtained by the application vermicompost @ 4 t + 120 N kg ha^{-1} in case of interaction effect.

Moreover, the quality of babycorn including reducing sugar, total sugar, protein and TSS was found highest with vermicompost @ 4 t ha^{-1}, whereas the minimum was under without organic manure (control). The treatment vermicompost @ 4 t ha^{-1} showed significantly higher quality than FYM @ 10 t ha^{-1}. Application of 180 kg N ha^{-1} was recorded the highest values of quality parameters than other treatments, but statistically at par with 120 kg N ha^{-1}. The interaction effect between organic manure and inorganic nitrogen on quality parameters was significant which exhibited that the maximum value of reducing sugar (1.90%), total sugar (2.91%), protein (1.94%) and TSS (8.28 °Brix) under vermicompost @ 4 t along with 180 kg N ha^{-1}. The control plot showed the minimum value of these parameters.

The over all economics of the treatments revealed [illegible] the maximum cost and net return were obtained in vermicompost @ 4 t + 180 kg N ha^{-1} (Rs. 36,548 and 76,402 ha^{-1} respectively), followed by vermicompost @ 4 t + 120 kg N ha^{-1}. However, the benefit: cost ratio of was highest (2.58) in FYM @ 5 t + 120 kg N ha^{-1} (2.55) and lowest (1.24) in vermicompost @ 4 t ha^{-1} without inorganic N fertilizer.

Different treatments showed significant effect on residual fertility of soil after harvesting of babycorn. The residual soil nitrogen, available P and K was maximum under vermicompost @ 4 t ha^{-1} which was significantly higher than other treatments and closely followed by FYM @ 10 t ha^{-1}. Treatment received highest dose of nitrogen (180 N kg ha^{-1}) produced highest percentage of total N and available P and K, followed by 120 kg N ha^{-1} and N @ 60 kg ha^{-1}respectively. Similarly, in conjunctive use of nutrients, the maximum effect on soil fertility in the treatment of vermicompost @ 4 t + 180 N kg ha^{-1}.

In experiment II, the weed species, population and dry weight of weed flora, growth and yield attributes as well as yields were recorded and the production economics of the treatments, applied for weed management, were also calculated. The phytotoxicity of the chemicals was recorded through visual scoring scale. The effect of treatments on the population of micro-flora in the rhizosphere soil of babycorn was studied through serial dilution technique and pour plate method on agar plates containing appropriate media.

Results revealed that the most predominant weed species observed in the babycorn fields were *Amaranthus viridis, Chenopodium album, Commelina benghalensis, Cynodon dactylon, Cyperus rotundus, Digera arvensis, Digitaria sanguinalis, Echinochloa colona, Melilotus alba* and *Physalis minima.* Among the weed management treatments, as a result of most severe and least competition of weeds with the crop throughout the life span in weedy check control and hand-weeding twice at 20 and 40 DAS plots respectively, they provided the minimum and maximum growth and yield attributes of the crop, which ultimately reflected on its yield (1464 kg ha^{-1}). The two hand weeding showed 97.47% and 88.39% weed-control efficiency at early stage of growth and at harvest and also produced 23.61% higher plant height at harvest, 64.75% higher number of cobs $plant^{-1}$ and 56.91% more babycorn yield than weedy check. Straw mulching with 10 t ha^{-1} exhibited as the next best treatment which recoded 53.80% higher corn yield than weedy check. Due to the broad-spectrum weed control ability and reduced the weed-crop competition more effectively by sole atrazine @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS) than metribuzin @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS), the former one showed 4.15% higher babycorn yield over the later one. The ineffectiveness of metribuzin against all categories of weed led to profuse growth of weeds and lower weed-control efficiency.

However, the integrated weed management [atrazine @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS or metribuzin @ 1 kg a.i. ha^{-1} (pre-emergence at 3 DAS) + HW at 30 DAS] exhibited 49.16% and 63.92% higher weed control efficiency at harvest, higher growth and yield attributes and finally 8.21% and 8.88% higher corn yield than the respective sole atrazine @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS) or sole metribuzin @ 2 kg a.i. ha^{-1} (pre-emergence at 3 DAS). This was probably due to control of weeds growth initially by herbicide followed by eradication of emerging weeds after 30 DAS by hand-weeding.

The production economics showed that net return (Rs. 66,905ha^{-1}) and benefit: cost ratio (2.63) were maximum with two hand-weeding at 20 and 40 DAS. The net return was second highest in rice straw mulching @ 10 t ha^{-1} than pre-emergent atrazine @ 1 kg a.i. ha^{-1} + HW at 30 DAS, but the trend was reverse in benefit: cost ratio due to higher cost of straw mulch. However, the integrated weed-management (pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + hand-weeding at 30 DAS or metribuzin @ 1 kg a.i. ha^{-1} + hand-weeding at 30 DAS) was superior to the respective sole atrazine or metribuzin @ 2 kg a.i. ha-1 while considering the benefit: cost ratio. The lowest returns and benefit : cost ratio was obtained with weedy check treatment.

The toxic effect of herbicides reduced the bacterial population (aerobic non-symbiotic N-fixing bacteria and P-solubilizing bacteria) initially (up to 25 DAS), but thereafter, there was a steady growth of the population in the rhizosphere soil. The initial suppression of microbial population was more pronounced in metribuzin with higher dose compared to that of atrazine. Moreover, the optimum moisture, temperature and greater availability of nutrients under the straw mulch treatment favoured the maximum growth and multiplication of soil microbes continuously, followed by hand-weeding twice. Straw mulch enhanced population of aerobic non-symbiotic N-fixing bacteria and P-solubilizing bacteria by 157.96% and 178.11% respectively over weedy check, which showed an declining trend due to harmful effect of root-exudates secreted by complex weed flora. However, the herbicide atrazine and metribuzin applied at higher or lower concentration did not exhibit any phytotoxicity symptoms at any stage of crop growth.

From the results of the above two experiments, the followings are concluded –

a. The application of vermicompost @ 4 t + 120 kg N ha^{-1} to babycorn can be recommended for its significant superiority in growth, yield and quality of babycorn as well as augmenting the soil fertility status.

b. Application of FYM @ 5 t + 120 kg N ha^{-1} provided quite higher benefit-cost ratio.

c. Control of weeds by two-hand weedings at 20 and 40 DAS should be recommended for babaycorn as it effectively reduces the weed-crop competition and greatly increases the growth and yield attributes and babycorn and green fodder yields and becomes most remunerative in terms of net return and benefit : cost ratio.

d. For herbicidal control of weeds, integrated weed management with pre-emergent atrazine @ 1 kg. a.i. ha^{-1} + hand-weeding at 30 DAS should be considered as atrazine proves effective than metribuzin.

e. Straw mulch treatment maximum favoures the soil microbial growth. The toxic effect of herbicides on the bacterial population being recovered at later stage.

CHAPTER 7

Future Scope of Research

Future Scope of Research

Experiment – 1

Today, the challenge with the agricultural scientists is to achieve comprehensive and sustainable food and nutrition security despite burgeoning population, decline in per capita land holding (from 0.5ha in 1951 - 1952 to 0.12ha in 2000). Continuous cereal - cereal cropping system leads to destruction of several soil properties, resulting in a sizeable yield gap between the genetically achievable yield and actual farm yield. The even increasing population of India which will be 1.4 billion by 2.25 AD will exercise a demand of 301mt food grains, and in order o meet this need, production of crops must be on a sustainable basis. It is apparent that sustainability of crop production system in future will mainly depend to a large extent on the adequacy and balanced supply of nutrients through inorganic and organic sources. Present experiment generates abundant scope of research in future on the following aspects.

1. Further investigation can be undertaken with green leaf manure crops like *Sesbania rostrata, Sesbania Cannabina, Leucaena leuedcephala* (Su-babul) and also with non symbiotic nitrogen fixing free living bacteria like *Axotobacter, Azospirillum* etc.

2. Investigation can also be undertaken to study the effect of combined organic and inorganic sources of nitrogen on physical properties of soil like tilth water holding capacity, structure, porosity, infiltration rate and bulk density of the soil.

3. Besides physical, chemical and physico-chemical properties like pH, Eh, ion exchange capacity, specific conductance of the soil and nutrient

status of the soil, as influenced by the organic sources of nitrogen can also be conducted.

4. Not only on sustainable quantity but also further investigation on, insect and disease occurrence in crops as influenced by organic manuring are imperative.
5. Above all, to draw a sound and valid conclusions with regard to the present findings and above mentioned scope for future research towards the attainment on sustainable productivity, experiment should be continued on a long term basis for at least 5 - 6 years.

Experiment – 2

Through the present investigation on integrated weed management on babycorn has been conducted under this Viswavidyalaya at the New Alluvial Zone (NAZ) of West Bengal as carefully as possible. Some more investigations are required to be studied in future to interpret in a better way on this aspect. Due to the variation of weed flora in different agro-climatic situations, general recommendations of the herbicide cannot be advocated for all the agro-climatic situations. Therefore, the first and foremost thing should be to conduct this type of experiment under different agro-climatic zones. In addition to the above, further research work should be carried out on the following lines for the improvement of baby corn crop both qualitatively and quantitatively.

1. To express the dominance and ecological success of crop and weed species Importance Value Index (IVI) is essential and should be taken into consideration.
2. Weed biology of the dominant weed species should be studied to formulate their management methods effectively.

3. Critical period of crop-weed competition along with a detail study on resource competition separately among the component vegetation should be taken into consideration for a clear understanding on these processes.
4. Development of threshold level determination model for dominant weed species as well as weed category is needed.
5. Moisture extraction pattern along with the rooting depth of both crop and weed species at different soil depth should be evaluated.
6. Residual effect of these herbicides both in the soil and plant along with the edible parts may be investigated in addition to their effect on ground water and other components of the environment.

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APPENDICES

Appendix – I

Table I.1: Common cost incurred in all the treatments for cultivation of babycorn (Hectare basis) in experiment – 1

Particulars	Quantity required	Rate (Rs./Unit)	Cost (Rs./ha)
A. Labour and Machinery cost			
1. Land preparation	For 1 hectare area	Rs. 2250/ha	2,250.00
2. Sowing	30 m.u.	Rs. 71/m.u.	2,130.00
3. Irrigation	12 m.u.	Rs. 71/m.u.	852.00
4. Weed control (2 HW)	60 m.u.	Rs. 71/m.u.	4,260.00
5. Harvesting	25 m.u.	Rs. 71/m.u.	1,775.00
6. Processing	3 m.u.	Rs. 71/m.u.	213.00
B. Material inputs			
1. Seed	40 kg	Rs. 40/kg	1,600.00
2. Irrigation	For 1 hectare area	Rs. 3750/ha	3,750.00
3. Plant protection	Nil	–	–
4. Bags	60 ps.	Rs. 10-/ps.	600.00
C. Miscellaneous			1,488.00
D. Interest on working capital		8% per annum	1,644.00
Total cost			**20,562.00**

Table I.2: Treatment cost/ha

Treatments	Dose (kg/ha) N, P_2O_5 and K_2O	Amount of fertilizers and manures (kg/ha)	Price in Rs.	Cost of fertilizers and manures (Rs./ha)	Cost of application	Total cost (Rs./ha)
M_0N_0	0	0	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg	0	0	0
M_0N_1	60 : 60 : 40	130.43 : 375 : 67	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg	652 + 1425 + 321 = 2398	284.00	2,682.00
M_0N_2	120 : 60 : 40	260.87 : 375 : 67	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg	1304 + 1425 + 321 = 3050	284.00	3,334.00
M_0N_3	180 : 60 : 40	391.30 : 375 : 67	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg	1956 + 1425 + 321 = 3702	284.00	3,986.00
M_1N_0	0 : 60 : 40 + 2 t Vermicompost	0 : 375 : 67 + 2 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	6000 + 1425 + 321 = 7746	284.00	8,030.00
M_1N_1	60 : 60 : 40 + 2 t Vermicompost	130.43 : 375 : 67 + 2 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	652 + 1425 + 321 + 6000 = 8398	284.00	8,682.00
M_1N_2	120 : 60 : 40 + 2 t Vermicompost	260.87 : 375 : 67 + 2 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	1304 + 1425 + 321 + 6000 = 9050	284.00	9,334.00
M_1N_3	180 : 60 : 40 + 2 t Vermicompost	391.30 : 375 : 67 + 2 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	1956 + 1425 + 321 + 6000 = 9702	284.00	9,986.00
M_2N_0	0 : 60 : 40 + 4 t Vermicompost	0 : 375 : 67 + 4 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	1425 + 321 + 12000 = 13746	284.00	14,030.00
M_2N_1	60 : 60 : 40 + 4 t Vermicompost	130.43 : 375 : 67 + 4 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	652 + 1425 + 321 + 12000 = 14398	284.00	14,682.00
M_2N_2	120 : 60 : 40 + 4 t Vermicompost	260.87 : 375 : 67 + 4 t Vermicompost	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	1304 + 1425 + 321 + 12000 = 15050	284.00	15,334.00

Treatments	Dose (kg/ha) N, P_2O_5 and K_2O	Amount of fertilizers and manures (kg/ha)	Price in Rs.	Cost of fertilizers and manures (Rs./ha)	Cost of application	Total cost (Rs./ha)
M_2N_3	180 : 60 : 40 + 4 t Vermicompost	391.30 : 375 : 67	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + Vermicompost Rs. 3.00/kg	1956 + 1425 + 321 + 12000 = 15702	284.00	15,986.00
M_3N_0	0 : 60 : 40 + 5 t FYM	0 : 375 : 67 + 5 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1425 + 321 + 4000 = 5746	284.00	6,030.00
M_3N_1	60 : 60 : 40 + 5 t FYM	130.43 : 375 : 67 + 5 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	652 + 1425 + 321 + 4000 = 6398	284.00	6,682.00
M_3N_2	120 : 60 : 40 + 5 t FYM	260.87 : 375 : 67 + 5 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1304 + 1425 + 321 + 4000 = 7050	284.00	7,334.00
M_3N_3	180 : 60 : 40 + 5 t FYM	391.30 : 375 : 67 + 5 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1956 + 1425 + 321 + 4000 = 7702	284.00	7,986.00
M_4N_0	0 : 60 : 40 + 10 t FYM	0 : 375 : 67 + 10 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1425 + 321 + 8000 = 9746	284.00	10,030.00
M_4N_1	60 : 60 : 40 + 10 t FYM	130.43 : 375 : 67 + 10 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	652 + 1425 + 321 + 8000 = 10398	284.00	10,682.00
M_4N_2	120 : 60 : 40 + 10 t FYM	260.87 : 375 : 67 + 10 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1304 + 1425 + 321 + 8000 = 11050	284.00	11,334.00
M_4N_3	180 : 60 : 40 + 10 t FYM	391.30 : 375 : 67 + 10 t FYM	Urea – Rs. 5.00/kg SSP – Rs. 3.80/kg MOP – Rs. 4.80/kg + FYM Rs. 0.80/kg	1956 + 1425 + 321 + 8000 = 11702	284.00	11,986.00

Value of the produce:

Babycorn Rs. 50/kg

Green fodder Rs. 50/quintal

Appendix – II

Table II.1: Common cost incurred in all the treatments for cultivation of babycorn (Hectare basis) in experiment – 2

Particulars	Quantity required	Rate (Rs./Unit)	Cost (Rs./ha)
A. Labour and Machinery cost			
1. Land preparation	For 1 hectare area	Rs. 2250/ha	2,250.00
2. Sowing	30 m.u.	Rs. 71/m.u.	2,130.00
3. Irrigation	12 m.u.	Rs. 71/m.u.	852.00
4. Fertilizer application	4 m.u.	Rs. 71/m.u.	284.00
5. Harvesting	25 m.u.	Rs. 71/m.u.	1,775.00
6. Processing	3 m.u.	Rs. 71/m.u.	213.00
B. Materials input			
1. Seed	40 kg	Rs. 40/kg	1,600.00
2. Irrigation	For 1 hectare area	Rs. 3750/ha	3,750.00
3. Fertilizer			3,377.00
Nitrogen (through urea)	150 : 60 : 40 kg	Urea – Rs. 5.00/kg	
Phosphorus (through SSP)	N : P_2O_5 : K_2O/ha	SSP – Rs. 3.80/kg	
Potassium (through MOP)		MOP – Rs. 4.80/kg	
4. Plant protection	Nil	–	–
5. Bags	60 ps.	10/ps.	600.00
C. Miscellaneous			2,687.00
D. Interest on working capital			1,697.00
Total			**21,215.00**

Table II.2: Treatment cost/ha

Particulars	Quantity (per ha)	Application cost (labour per ha)	Rate (Rs./unit)	Cost (Rs./ha)
Atrazine	4 kg	2 @ Rs. 71.00	Rs. 270/kg	1222.00
Metribuzin	2.86 kg	2 @ Rs. 71.00	Rs. 1000/kg	3002.00
Paddy straw mulch	10 tonnes	5 @ Rs. 71.00	Rs. 50/quintal	5355.00
Hand weeding	2 HW	60 @ Rs. 71.00	Rs. 71.00/m.u	4260.00
Atrazine + hand weeding	2 kg + 1 HW	2 @ Rs. 71.00 + 30 @ Rs. 71.00		2812.00
Metribuzin + hand weeding	1.43 kg + 1 HW	2 @ Rs. 71.00 + 30 @ Rs. 71.00		3702.00