

MATERIAL AND METHODS

A field experiment entitled “Integrated Nutrient Management on Broccoli (*Brassica oleracea* L. var. *italica* Plenck.) under north central plateau zone of Orissa” was carried out for two consecutive cropping years (2008-09 and 2009-10). Different techniques of investigation followed during the trials have been described in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was conducted at Regional Research Transfer of Technology Station, Keonjhar during the year 2008-09 and 2009-10.

3.2 LOCATION OF THE EXPERIMENTAL SITE

The experimental site is located at an altitude of 463.3 m above the mean sea level at 20° 1' to 22° 10' N latitude and 85°11' to 86° 22' E longitude. It comes under North Central Plateau Zone. Keonjhar is around 232km away from Bay of Bengal towards the North site.

3.3 CLIMATE OF EXPERIMENTAL SITE

The location is characterized by hot and sub-humid. The hottest month is April-May and coldest month is December

3.4 WEATHER CONDITION DURING THE PERIOD OF THE EXPERIMENT

The weather data pertaining to the cropping seasons of 2008-09 and 2009-10 recorded at meteorological observatory, RRTTS, Keonjhar are presented year wise separately in Table 3.1 and illustrated in Fig (3.1 and 3.1b).

Table 3.1 Meteorological data from August 2008 to January 2009 and August 2009 to January 2010

Month	Temperature (°C)		RH (%)	Rainfall (mm)	No. of Rainy days
	Maximum	Minimum			
2008-09					
August	29.8	23.9	87.94	193.7	23
September	30.1	22.9	87.60	429.3	18
October	31.0	20.4	78.00	4.6	6
November	29.3	16.8	71.57	15.0	1
December	27.9	14.0	80.29	-	-
January	28.5	14.1	78.90	-	-
2009-10					
August	30.6	24.0	84.13	334.0	23
September	30.9	23.5	85.70	195.7	16
October	29.9	18.3	69.19	124.0	8
November	28.3	16.9	71.43	26.8	2
December	26.6	12.7	68.42	-	-
January	26.2	11.3	67.30	1.3	1

3.4.1 Rainfall

The precipitation during the cropping period was 642.6mm and 681.8mm which was received between September to January of the year 2008-09 and 2009-10.

3.4.2 Temperature

The maximum temperature during the cropping period 31⁰C to 27.9⁰C in 2008-09 and 30.9⁰C to 26.2⁰C in 2009-10. The meteorological data obtained from the two consecutive cropping period of the experimental site i.e., from August 2008 to January 2009 and August 2009 to January 2010 is presented in Table 3.1 and Fig (3.1a and 3.1b).

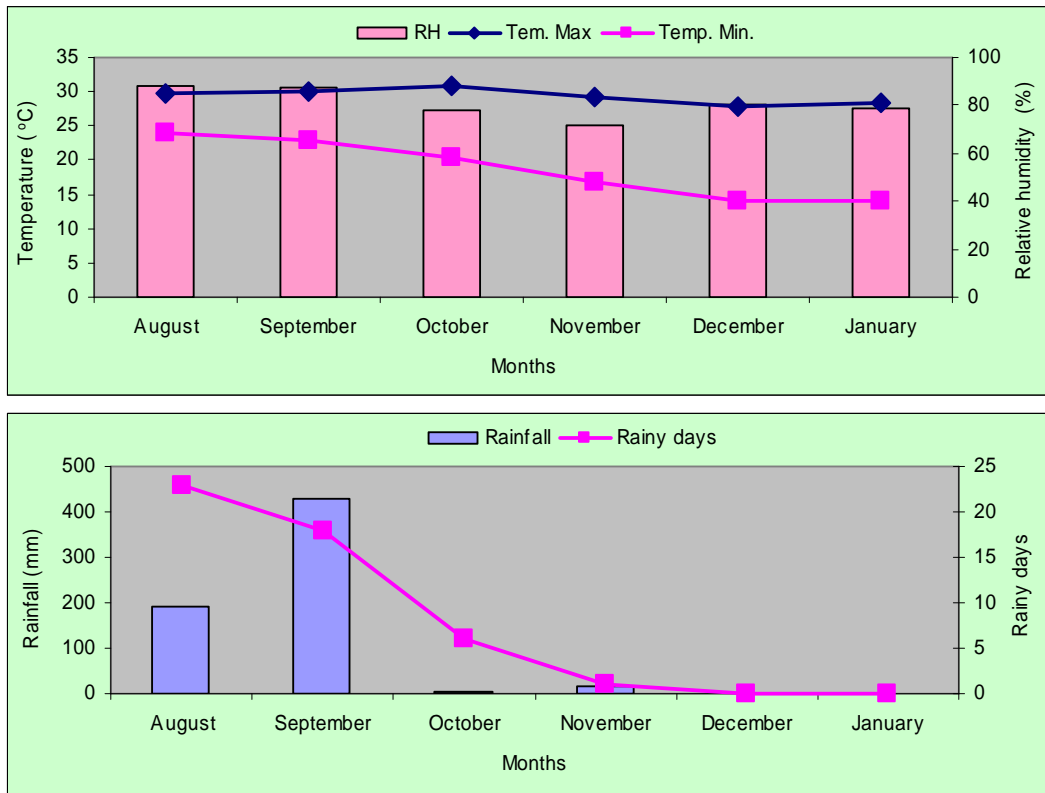


Fig. 3.1a Meteorological data during the cropping season 2008-09

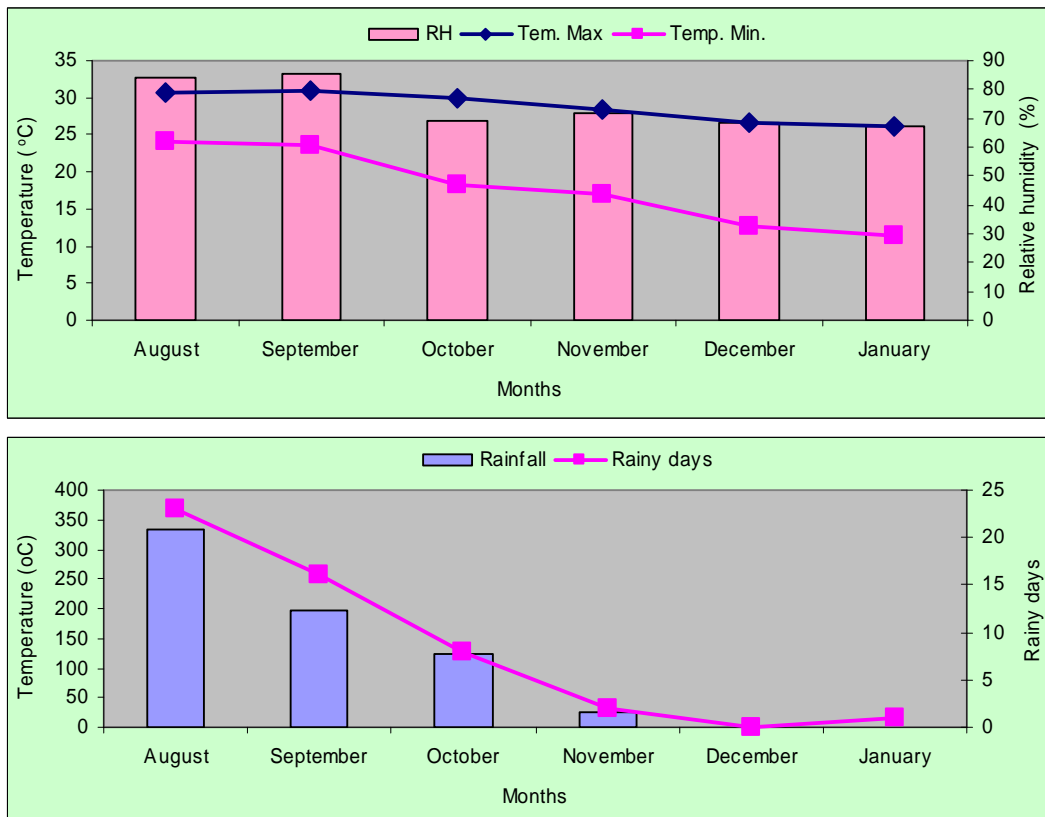


Fig. 3.1b Meteorological data during the cropping season 2009-10

3.5 CROPPING HISTORY OF EXPERIMENTAL SITE

Details of the cropping history of the experimental site during the preceding years are given below.

Table 3.2 Cropping history of the experimental site during the preceding years are given below

Year	Kharif	Rabi	Summer
2007-08	Okra	Tomato	Cucurbits
2008-09	Brinjal	Broccoli*	-
2009-10	Okra	Broccoli*	-

* Present experiment

3.6 SOIL OF THE EXPERIMENTAL SITE

A composite a soil sample was drawn from a depth of 25cm and was analysed to know the status of soil before the commencement of present investigation. The physico-chemical composition of the soil of the experimental field is given in Table 3.3.

Table 3.3 Physico- chemical properties of the soil of the experimental field.

Sl.No	Constituents	% Air dry basis	Method followed
A. Mechanical analysis			
1	Sand	68.74	Bouyoucos Hydrometer (Piper 1950)
2	Silt	16.1	
3	Clay	15.16	
B. Physical properties			
4	Textural class	Loamy	International triangle method Piper (1966)

C. Chemical composition of the soil

Sl. No	Constituents	Amount present (Air Dry basis)	Method followed
1	pH (1:2=soil: water)	6.06	pH meter (Jackson 1973)
2	OC (g/kg)	4.6	Walkley and black Wet Oxidation (Page <i>et al.</i> 1982)
3	EC (m mhos/cm)	0.06	Conduct metric (Jackson 1973)
4	Available N (kg/ha)	125.44	Alkaline permanganate method (Subbiah and Asija 1956)
5	P (kg/ha)	137.4	Bray/s Extract method (Page <i>et al.</i> 1982)
6	K (kg/ha)	212.1	Ammonium acetate extraction method (Jackson 1973)

3.7 EXPERIMENTAL DETAILS

The experiment was conducted in a randomized block design (factorial) having three replications in both the years. Twenty four different treatments were randomly allotted to the plots following random number table (Gomez and Gomez, 1976)

3.7.1 Treatment details

There were (24) treatmental combinations consisting of four sources of organic manures and six doses of inorganic fertilizers.

i) Sources of organic manures

M₀ – No manure (Control)

M₁ – Farm Yard Manure (FYM)

M₂ – Vermicompost (VC)

M₃ – Farm Yard Manure + Vermicompost

ii) Doses of inorganic fertilizers

F₀ – No fertilizers (control)

F₁ – Bio-fertilizer (BF)

F₂ – 75 % NPK of Recommended Dose of fertilizer

F₃ – 100% NPK of Recommended Dose of fertilizer

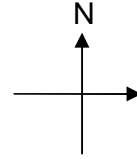
F₄ – 75% of Recommended Dose of fertilizer + Bio-fertilizers(BF)

F₅ – 100% of Recommended Dose of fertilizer + Bio-fertilizers(BF)

iii) Treatments**Table 3.4 Treatment details**

Sl. No.	Notations		Treatments
1	T1	M ₀ F ₀	No-manure + No-fertilizer
2	T2	M ₀ F ₁	No-manure + Bio-fertiliser(BF)
3	T3	M ₀ F ₂	No-manure + 75 % Recommended dose of fertilizer(RDF)
4	T4	M ₀ F ₃	No-manure + 100% RDF
5	T5	M ₀ F ₄	No-manure + 75% RDF + BF
6	T6	M ₀ F ₅	No-manure + 100% RDF + BF
7	T7	M ₁ F ₀	Farm Yard Manure(FYM)+ No-fertilizer
8	T8	M ₁ F ₁	FYM + Bio-fertilizer(BF)
9	T9	M ₁ F ₂	FYM + 75 % RDF
10	T10	M ₁ F ₃	FYM + 100% RDF
11	T11	M ₁ F ₄	FYM + 75% RDF + BF
12	T12	M ₁ F ₅	FYM + 100% RDF + BF
13	T13	M ₂ F ₀	Vermicompost (VC) + No-fertilizer
14	T14	M ₂ F ₁	VC + BF
15	T15	M ₂ F ₂	VC + 75 % RDF
16	T16	M ₂ F ₃	VC + 100% RDF
17	T17	M ₂ F ₄	VC + 75% RDF + BF
18	T18	M ₂ F ₅	VC + 100% RDF + BF
19	T19	M ₃ F ₀	FYM + VC + No-fertilizer
20	T20	M ₃ F ₁	FYM + VC + BF
21	T21	M ₃ F ₂	FYM + VC + 75 % RDF
22	T22	M ₃ F ₃	FYM + VC + 100% RDF
23	T23	M ₃ F ₄	FYM + VC + 75% RDF + BF
24	T24	M ₃ F ₅	FYM + VC + 100% RDF + BF

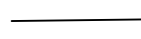
3.7.2 Plan of Layout



	R₁	R₂		R₃		
	M ₁ F ₀	M ₀ F ₅	M ₃ F ₃	M ₂ F ₅	M ₁ F ₃	M ₀ F ₅
	M ₁ F ₁	M ₀ F ₄	M ₃ F ₂	M ₂ F ₄	M ₁ F ₂	M ₀ F ₄
	M ₁ F ₂	M ₀ F ₃	M ₃ F ₀	M ₂ F ₂	M ₁ F ₀	M ₀ F ₂
	M ₁ F ₃	M ₀ F ₂	M ₃ F ₁	M ₂ F ₃	M ₁ F ₁	M ₀ F ₃
	M ₁ F ₄	M ₀ F ₁	M ₃ F ₄	M ₂ F ₁	M ₁ F ₄	M ₀ F ₁
	M ₁ F ₅	M ₀ F ₀	M ₃ F ₅	M ₂ F ₀	M ₁ F ₅	M ₀ F ₀
	M ₂ F ₀	M ₃ F ₅	M ₁ F ₃	M ₀ F ₅	M ₃ F ₃	M ₂ F ₅
	M ₂ F ₁	M ₃ F ₄	M ₁ F ₁	M ₀ F ₄	M ₃ F ₁	M ₂ F ₄
	M ₂ F ₂	M ₃ F ₃	M ₁ F ₀	M ₀ F ₁	M ₃ F ₀	M ₂ F ₁
	M ₂ F ₃	M ₃ F ₂	M ₁ F ₂	M ₀ F ₃	M ₃ F ₂	M ₂ F ₃
	M ₂ F ₄	M ₃ F ₁	M ₁ F ₄	M ₀ F ₂	M ₃ F ₄	M ₂ F ₂
	M ₂ F ₅	M ₃ F ₀	M ₁ F ₅	M ₀ F ₀	M ₃ F ₅	M ₂ F ₀

Fig. 3. 2 Plan of layout for experiments during 2008-09 and 2009-10

 Irrigation channel

 Bund

R₁ = Replication -1, R₂ = Replication 2, R₃ = Replication-3

3.7.3 Details of design and lay out

1. Design of layout	Randomized Block Design (Factorial)
2. Number of treatments	Twenty-four (24)
3. Number of replication	Three (3)
4. Plot size	4 x 2.4m
5. Spacing	
(a) Row to row	50 cm
(b) Plant to plant	40 cm
6. Number of rows per plot	Eight (8)
7. Number of plants per row	Six (6)
8. Width of the bed and separating the block	40 cm
9. Width of irrigation channel	1m
10. Length of the experimental field	65.1 m
11. Width of the experimental field	16m
12. Area of the experimental field	1041.6 sq.m
13. Variety	Puspa

Varietal characteristics

Plants are erect type with deep green foliage; heads are green, compact and medium size. Maturity period 70-75 days, average weight 300-350g.

3.7.4 Cultivation details

3.7.4.1 Preparatory cultivation

The experimental field was prepared for planting by ploughing twice with mould board plough. The land was finally leveled with a wooden plank. The plots were laid out as per the lay out plan (Fig.3.2) with proper attention to bunds and irrigation.

3.7.4.2 Source of planting materials

The planting material was hybrid seeds (F_1), Puspa collected from Seminis Vegetable Seeds Company (India) Ltd., Aurangabad. The seeds were sown in the nursery beds on 2.10.2008 during 2008-09 and on 6.10.2009 during 2009-10. The seedlings were ready for transplanting after 24 days of sowing and were uprooted after giving irrigation. The transplanting was completed on 26.10.2008 (2008-09) and on 30.10.2009 (2009-10).

3.7.4.3 Application of manures and fertilizers

a) Manures

Farm yard manure were procured from Government Dairy Farm, Keonjhar and vermicompost was collected from Department of Agriculture, Government of Orissa.

Farm yard manure @ 10 t/ha, Vermicompost @ 5 t/ha were incorporated in plots as per the layout for different treatments.

The manures were analyzed for their nutrient contents before use. Nutrient contents of two organic manures used in the study are presented below.

Nutrient content of organic manures

Organic manures	Nutrient content (%)					
	2008-09			2009-10		
	N	P	K	N	P	K
FYM	0.57	0.22	0.52	0.55	0.22	0.53
VC	0.95	0.31	0.60	1.00	0.32	0.60

b) Fertilizers

The recommended dose of N, P_2O_5 and K_2O @ 150:45:80 kg/ ha was applied through urea, single super phosphate and muriate of potash, respectively. Half of the quantity of nitrogen and potassium along with full dose of phosphorus were applied as basal in the light furrows by the trench hoe. The balance quantity of nitrogen and potash was top dressed after 30

days of planting. The fertilizer dose was fixed as per the soil testing. It was observed that the quantity of phosphorus was high 137.4 kg/ha in the soil. Therefore, the application of phosphatic fertilizer was reduced by 25% which was applied as per the treatments schedule for both the year.

C) Bio-fertilizers/Bio-inoculants

Bio-inoculants like *Azotobacter*, *Azospirillum* and *Phosphorus Solubilizing Bacteria* (PSB) were mixed in 1:1:1 ratio with well decomposed FYM in the ratio of 1:25 and incubated for seven days at 30% moisture level. Then the incubated FYM containing inoculants @6 kg/ ha were applied as per layout for different treatments to the rhizosphere of broccoli seedling at the time of planting.

3.7.4.4 Planting of seedlings

Broccoli seedlings were planted in the field at a spacing of 40cm after dipping the root portion of seedlings in 0.2% Bavistin solution.

3.7.4.5 Intercultural operations

Hoeing and weeding were done manually after 30 days of planting followed by top dressing with rest half of nitrogen, potash. The second hoeing, weeding and earthing up were carried out after one month of the first one in both the experiments conducted in 2008-09 and 2009-10.

3.7.4.6 Irrigation

Watering was given immediately after transplanting of seedlings by rose can. This process continued till the establishment of the seedlings. Gap filling was also done after 4th day of transplanting and irrigation was given with rose can.

3.7.4.7 Plant Protection measures

Chloropyriphous @10 kg/ha was applied as soil application just before transplanting of plants to control the termite attack. In subsequent stages,

cartap hydrochloride @ 2g/litter was applied once 45 days after transplanting to control Spodoptera. Neem oil @5ml/litter was sprayed 50 days after transplanting that is just before the initiation of curd to control the aphids in the crop broccoli.

Table 3.5 Calendar of cultural operations

Sl. No.	Cultural Operations	2008-09	2009-10	Remark
1	Land preparation	1.10.2008	4.10.2009	By mould board plough
2	Nursery bed preparation	1.10.2008	5.10.2009	By manual labour
3	Sowing of seeds	2.10.2008	6.10.2009	By manual labour
4	Ploughing and leveling	4.10.2008	7.10.2009	By manual labour
5	Layout of experimental field	7.10.2008	8.10.2009	By manual labour
6	Ridge and furrow making	11.10.2008	12.10.2009	By manual labour
7	Application of organic manures	20.10.2008	21.10.2009	By manual labour
8	Application of fertilizers	21.10.2008	22.10.2009	By manual labour
9	Application of BF and planting of seedlings	26.10.2008	30.10.2009	By manual labour
10	Post planting irrigation	27.10.2008	28.10.2009	By manual labour
11	Gapfilling of seedlings	29.10.08	30.10.2009	By manual labour
12	Fertilizer top dressing and earthing up	13.11.2008	14.11.2009	By manual labour
13	Spraying of pesticide			By manual labour
	1st	22.11.2008	23.11.2009	By manual labour
	2nd	5.12.2008	6.12.2009	By manual labour
14	Irrigation	12.11.2008 20.11.2008 30.11.2008	14.11.2009 22.11.2009 1.12.2009	By manual labour
15	Harvesting	1.1.2009	4.1.2010	By manual labour

3.7.4.8 Harvesting

Broccoli curds were harvested after they attain the marketable size stage. The harvesting of the curds started 65 days after transplanting which continued up to 75 days. The marketable matured curds were harvested by using a sharp knife to cut the terminal heads and entire plant was left on the field to develop the small sprouts in subsequent stages. The smaller curds were cut after its development and the plants were uprooted.

3.8 BIOMETRIC OBSERVATIONS

3.8.1 Sampling technique

The plants (10) were selected in each plot to record the biometric observations time to time on different growth parameters like curd yield including other yield attributing characters.

3.8.2 Growth parameters

Observation on the following characters were recorded on selected plants of each plot for both the trials carried out in 2008-09 and 2009-10.

3.8.2.1 Plant height (cm)

The height of plant was recorded in centimeter from the base up to the tip of the functional leaf close to the curd and the observation was recorded at the time of marketable maturity of the curd.

3.8.2.2 Number of leaves/plant

The total number of leaves per plant was counted in each sample plant just before the harvesting of the curd at marketable maturity stage.

3.8.2.3 Leaf area (cm²)

The fourth leaf from the top of each sample plants was collected and the leaf area was measured by using leaf area meter. The average was calculated and expressed in cm².

3.8.2.4 Girth of stem (cm)

The girth of stem of individual sample plants was recorded at the base of each individual plant and expressed in centimeter.

3.8.2.5 Days taken for initiation of curd

As per treatments the initiation of curd varied which was counted in days and expressed in total number of days taken after transplanting.

3.8.2.6 Days taken for maturity of curd

At the time of harvesting total number of days taken from transplanting was calculated and expressed in total number of days taken for harvesting of the curd at marketable maturity stage.

3.9 OBSERVATION AT HARVEST

3.9.1 Unit curd weight (g)

Measured as the mean weight of individual curd of each sample plant in (g) and the mean weights were tabulated.

3.9.2 Curd diameter (cm)

The curd diameter (cm) was measured with help of a scale on the top of individual curd having maximum length and expressed in centimeter for all the sample plants of each individual treatment.

3.9.3 Total curd yield (q/ha)

Measured as weight of total quantity of curds per plants for each treatment in the replication and then calculated and expressed in q/ha.

3.10 OBSERVATION ON QUALITY ATTRIBUTES

3.10.1 Dry matter content of plant (q/ha)

The plant of ten sampled plants from each net plots were chopped separately and composite of 100g was taken from each plot. Samples were

air dried for three days and then oven dried at 60°C till a constant weight was obtained. The weight of the dried materials was recorded and expressed in percentage.

The dry matter production per hectare was calculated by using the following formula.

Dry matter production of plant per hectare (q) =

$$\frac{\text{Plant yield per hectare (q)} \times \text{Dry matter percentage}}{100}$$

3.10.2 Dry matter of the curd (q/ha)

Five randomly selected curds from the ten sampled plants from each net plot were collected and chopped into small pieces and a composite sample of 100g was taken from each plot. The samples were air dried for three days and then oven dried at 60°C till a constant weight was obtained. The weight of the dried materials were recorded and expressed in percentage. The dry matter production per hectare was calculated by the following formula:

$$\frac{\text{Curd yield per hectare (q)} \times \text{Dry matter percentage}}{100}$$

3.11 BIOCHEMICAL ANALYSIS

3.11.1 Sampling technique

a) Plant sample

The plant samples were collected at the harvesting stage and washed thoroughly with deionised water. The samples were air dried for three days and finally dried in the oven at 60°C temperature till a constant weight was

recorded. The oven dried plant samples were ground manually and kept for analysis of plant dry weight, uptake of N, P and K as per standard methods.

b) Curd sample

The curd samples were collected at the harvesting stage and then washed thoroughly with deionized water. The curd samples were analyzed freshly. The results expressed on oven dry basis.

3.11.2 Quality attributes

3.11.2.1 Sugar content of curds

The reducing sugar and total sugar content were estimated by Anthrone Calorimetric method out of the composite samples of the curds from each net plot (Whistler and Wolfrom, 1962).

3.11.2.2 Vitamin C (Ascorbic acid) content of curd

Vitamin-C content of the composite sample of curds from each net plot was estimated by Xylene extraction method (Rangana, 1977)

3.12 CHEMICAL ANALYSIS

3.12.1 Plant analysis

The plant samples were collected after harvesting and then washed thoroughly with deionized water. Then the plants were sun dried and finally dried in oven at 70° C till constant weight was recorded. The oven dried samples were ground manually and kept for analysis for plant dry weight, uptake of N, P, K by following standard procedure.

Nitrogen was estimated by modified Micro-Kjeldahl method (Page *et al.* 1982), phosphorus by spectrophotometer at 470 nm wave length by Vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973) and potassium by Flame Photometric method (Jackson, 1973)

3.12.2 Uptake of nutrients

Nutrient uptake was calculated after multiplying the concentration of nutrients in the plant parts with the representative dry matter production.

3.12.3 Apparent Nutrient recovery

Recovery of applied nutrients was calculated as per the formula given by Moll *et al.* (1982)

Apparent Nutrient Recovery (%) =

$$\frac{\text{Uptake of nutrient due to the treatment (kg/ha)} - \text{Uptake due to control (kg/ha)}}{\text{Nutrient added (kg/ha)}} \times 100$$

3.13 ECONOMICS

The gross and the net returns (Rupees per hectare) were computed considering the prevailing market price of input and produce. Benefit-cost ratio, which presents the return per rupee invested, was worked out for different treatments by dividing the gross return with corresponding cost of cultivation.

3.14 STATISTICALLY ANALYSIS

The experimental design followed for this research work was randomized block design (factorial) as outlined by Panse and Sukhatme (1985). The analysis of variance for each of the character was carried out with the mean value of data collected from the sample plants from each plot and the plot means used for partitioning the total variance ascribable to replication, treatment and error.

The test of significance of difference among treatments for the character was done by 'F' test. The significance difference between the

means of two treatments was tested by 't' test and critical difference (CD) was calculated as follows.

Particulars of treatment	SE(d)	CD (0.05)
M	$\sqrt{\frac{2 \times EMS}{r \times N}}$	SE(d) X t at e.d.f
N	$\sqrt{\frac{2 \times EMS}{r \times M}}$	SE(d) X t at e.d.f
M x N	$\sqrt{\frac{2 \times EMS}{r}}$	SE (d) x t at e.d.f

where r = Number of replications

N = Levels of nutrients with chemical fertilizers

M = Levels of amendments i.e. organic manures.

e.d.f = Error degree of freedom

SE(d) = Standard error of difference

EMS = Error mean square

T = Value of 't' at chosen level of significance

The results have been summarized in tables and illustrated by suitable figures.

The observation on the morphological characters at successive stages of growth have been presented by curves reference to the tables and figures have been made at appropriate places in the text.

