

**EFFECT OF DISTILLERY YEAST SLUDGE AS A SOURCE  
OF NITROGEN ON GROWTH AND YIELD OF CABBAGE  
AND SOIL PROPERTIES**

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OF NITROGEN ON GROWTH AND YIELD OF CABBAGE  
AND SOIL PROPERTIES**

*Thesis submitted to the  
University of Agricultural Sciences, Dharwad  
in partial fulfilment of the requirements for the*

*degree of*

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**in**

**SOIL SCIENCE AND AGRICULTURAL CHEMISTRY**

*By*

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C E R T I F I C A T E


This is to certify that the thesis entitled "EFFECT OF DISTILLERY YEAST SLUDGE AS A SOURCE OF NITROGEN ON GROWTH AND YIELD OF CABBAGE AND SOIL PROPERTIES " submitted by Mr. SATEESHA PATIL for the degree of MASTER OF SCIENCE (AGRICULTURE) in SOIL SCIENCE AND AGRICULTURAL CHEMISTRY to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any other degree, diploma, associateship, fellowship or other similar titles.

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# *Introduction*

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## I. INTRODUCTION

Urbanization and industrialization have led to the generation of large volumes of wastes in the form of solids, liquids and gases. Depending upon the nature of wastes generated, they can be grouped as either organic or inorganic. Solid organic wastes include sewage sludge, distillery yeast sludge, brewer's spent grain, dairy plant sludge, paper mill sludge, spent mushroom substrate etc. Solid inorganic wastes include sludges from mining industries. Though industrialization is believed to be the index of modernization, it has unavoidable effects on pollution of air, water and soil. The nature of pollution depends upon the type of industry, nature of raw material used and the manufacturing process involved (Hodges, 1973). Since the industrialization and pollution are complementary to each other, necessary steps need to be taken for disposal of the pollutants. Usually the wastes produced are dumped near the place of their production or factory premises as much is not known about their re-use in industries or in agriculture.

In India sugar industry is the second largest agro-based industry producing enormous quantities of molasses as a by-product. Presently there are 285 distilleries in India (AIDA, 1995) which produce alcohol and rectified spirit by using molasses as a raw material. Sugarcane molasses is fermented using yeast *Saccharomyces cerevisiae*. At the end of fermentation and distillation large quantities of effluent (spent wash) is generated. The quantity of waste generated is estimated to be 12 to 15 times that of alcohol produced. Yeast cells are separated from the spent wash and dried to get yeast sludge.

The sludge so produced does not have any further industrial use and hence its disposal is a problem. One of the approaches to alleviate this problem would be using the sludge in agriculture. The sludge is reported to contain good amount of protein, major and micronutrients. The high protein content of the sludge makes its potential for use as poultry feed. However,

the higher content of total ash and lead along with the difficulties involved in collection and drying could be limiting factors in its utilization (Senthilkumar *et al.*, 1996).

In the current days, crop production is over dependent on the chemical fertilizers. Increased prices of fertilizers make difficult to meet the nutrient requirement of crops through fertilizers. Acute shortages of FYM necessitates to identify the alternate sources of plant nutrients without compromising the yields. Use of industrial wastes, which have an inherent problem of safe disposal need examination in this regard. Thus, the disposal problem of yeast sludge can be solved by utilizing it as source of organic matter and plant nutrients.

Yeast sludge contains autolysed spent yeast cells useful as a source of nitrogen (Weathers, 1996). The preliminary analysis of sludge showed that this microbial biomass has good amount of organic matter, nitrogen, potassium and other plant nutrients with a narrow C:N ratio (11:1). Cabbage is an important vegetable crop of India. Nitrogen is one of major nutrients required by cabbage crop for its high productivity. The amount of N removed by cabbage with an yield level of 700 q ha<sup>-1</sup> was 370 kg according to Tandon (1987).

In the light of the above facts, a field experiment was conducted using the distillery yeast sludge generated at Shri. Laxmi Narasimha Distilleries, located at Garag village of Dharwad district, Karnataka, as a source of N and its effect on growth, yield and quality parameters of cabbage and soil properties with the following objectives.

1. To study the effect of yeast sludge on growth, yield and certain quality parameters of cabbage.
2. To know the effect of yeast sludge on the uptake of major and micronutrients by cabbage, and
3. To study the effect of yeast sludge on soil properties.

*Review of Literature*

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## II. REVIEW OF LITERATURE

In an effort to know the "Effect of distillery yeast sludge as a source of nitrogen on growth and yield of cabbage and soil properties" relevant literature pertaining to several aspects of distillery by-products and their use in agriculture is reviewed here under the following headings.

- 2.1 Composition of distillery by-products.
- 2.2 Distillery by-products as source of nutrients.
- 2.3 Effect of distillery by-products on growth, yield and quality of crops.
- 2.4 Effect of distillery by-products on soil physico-chemical properties.
- 2.5 Effect of distillery by-products on soil biological properties.
- 2.6 Effect of distillery by-products on nutrient availability and uptake by crops.
- 2.7 Effect of different sludges on crops and soil properties.
- 2.8 Effect of FYM on crops and soil properties.

### 2.1 COMPOSITION OF DISTILLERY BY-PRODUCTS

The by-products of distillery industry are spent wash and yeast sludge. Spent wash is also referred to as potale, stillage, vinasse, detritus and dunder. After distillation the solids that are separated from spent wash and dried are obtained as yeast sludge. Yeast sludge is also referred to as molasses soluble, molasses sludge, molasses stillage and slop and rum distiller's stillage. The chemical composition of yeast sludge varies widely depending upon the nature of molasses and chemicals used in manufacturing rectified spirit.

On an average spent wash, which was evaporated, reported to contain dry matter of about 30.5 per cent while, major plant nutrients N, P and K

were 3.68, 1.1 and 1.1 per cent, respectively. The Ca, Mg and Na contents were 0.45, 0.5 and 0.35 per cent, respectively (Miller, 1973).

Deshmane (1975) stated that spent wash solids contained relatively more quantities of arabinose, galactose, glucose and xylose. The spent wash solids contained more inorganic nitrogen and less unhydrolysable nitrogen than FYM.

Jadhav and Sawant (1975) while studying the effect of spent wash on soil physico-chemical properties analyzed the spent wash for its chemical composition. The values for different constituents were; pH : 8.0, EC (dS/m) : 31.0, total N : 1,400 ppm, total K : 13,600 ppm total Ca : 100 ppm, total Mg : 1,700 ppm and chemical oxygen demand (COD) : 1,300 ppm.

Bucknall *et al.* (1979) reported that the potale had a pH of 3.3 and other constituents were; N: 2,080ppm, P: 700 ppm, K: 100 ppm, Mg: 200 ppm and Na: 2,080 ppm on fresh weight basis.

Savant *et al.* (1982) evaluated the chemical nature of spent wash solids (SWS) and FYM. They reported that SWS contained more ether soluble, alcohol soluble and hot water soluble fractions and further it also contained appreciable amounts of inorganic nitrogen and less undrolysable nitrogen than FYM. While it was poor source of total as well as organic and inorganic phosphorus as compared with FYM. However, the total potassium content of SWS (9.96%) was about 12 times more than FYM. They reported that SWS has a total N, P and K of about 2, 0.28 and 9.98 per cent, respectively.

Brewery sludge is the waste obtained from brewerage industry. The chemical composition of brewery sludge was total N: 2.59 per cent, total P: 0.64 per cent, total K: 0.11 per cent, Ca: 16.8 per cent, Mg: 0.37 per cent, Na: 0.20 per cent and pH: 11.3 (Naylor and Severson, 1984).

Kulkarni *et al.* (1987) stated that spent wash was major pollutant because of its high organic content. They opined that spent wash as dilute

liquid organic fertilizer with high K content and further reported that it contained about 90 to 93 per cent water and 7 to 9 per cent solids. The seventy five per cent solids were organic and remaining 25 per cent inorganic. Its N content was mostly in the colloidal form, which behaved as a slow release fertilizer, and it was better than other inorganic N source. Two thirds of P was in organic form and the metabolic availability of which was more than any important inorganic nutrients. Moreover it also contained large amounts of important secondary and micronutrients such as Ca, S and Mg as well as Cu, Mn and Zn. Besides nutrients it also contained 29.06 per cent reducing sugar, 9.0 per cent protein, 1.5 per cent volatile solids, 21.0 per cent gums, 4.5 per cent combined lactic acid, 1.5 per cent combined organic acids, 5.5 per cent glycerol and 15.0 per cent wax and phenolic bodies.

Cerri *et al.* (1988) reported that vinasse had the highest content of organic N, nutrients and ash. While, bagasse contained the least. Organic compounds extracted by alkaline reagents were of humic nature and were similar to those in soil except that fulvic acid predominated over humic acid.

Mbagwu and Ekwealor (1990) while studying the agronomic potential of brewers' spent grain analyzed it for chemical characteristics, *viz.*, pH: 4.4, organic carbon: 21 per cent, total N: 5.1 per cent, total P: 0.4 per cent, K: 3.4 per cent, Ca: 0.4 per cent, Mg: 0.48 per cent.

Senthilkumar *et al.* (1996) analyzed the nutritive composition of dried yeast sludge. They analyzed sludges of four different distilleries and the range of values for different constituents were; protein 4.1 to 24.6 per cent, ash: 29.16 to 62.50 per cent, phosphorus: 0.34 to 0.87 per cent, potassium: 6.24 to 11.70 per cent, calcium: 4.44 to 7.62 per cent, magnesium: 0.39 to 0.77 per cent, sodium: 1.38 to 2.12 per cent and trace elements Zn: 37.5 to 106.8 ppm, Mn: 36.8 to 101.7 ppm, Co: 26.6 to 29.0 ppm, Cu: 70.9 to 505.2 ppm, Fe: 1043.0 to 2481.3 ppm and Pb: 30.0 to 71.0 ppm.

Srikant *et al.* (1999) reported chemical composition of yeast sludge while, studying the preparation of composts of farm, city and industrial wastes. The value for different constituents were pH (1:5): 7.30, organic carbon: 9.30 per cent, total N: 1.00 per cent, C : N ratio 9.30, total P: 0.56 per cent, total K: 0.48 per cent, Ca: 12.95 per cent, Mg: 2.85 per cent, S: 1.12 per cent, Fe: 0.28 per cent Mn: 0.02 per cent, Cu: 0.01 per cent and Zn: 1.17 per cent.

From the literature given above it can be inferred that the distillery by-products (spent wash and yeast sludge) can be used as sources of plant nutrients.

## **2.2 USE OF DISTILLERY BY-PRODUCTS AS SOURCE OF PLANT NUTRIENTS**

Bajpai and Dua (1972) suggested the use of distillery effluent as a nitrogen source by obtaining a significantly higher yield of sugarcane with the application of 200 kg N through spent wash. The manurial value of distillery effluent can profitably be used to supplement the fertilizer when used along with irrigation water. The use of effluent indicated that 25 per cent of the recommended dose of fertilizer nutrients could be saved besides solving the problem of disposal (Jadhav and Savant, 1975).

Dongale and Savant (1978) opined that spent wash was as good as potassium chloride (KCl) as a source of potassium for sorghum. Evaluation of stillage as a source of K for maize (*Zea mays* L) in comparison with potassium chloride (KCl) and potassium sulphate ( $K_2SO_4$ ) was done by Berton *et al.* (1983). They found that availability of K with respect to different concentration (0,75,15,225 and 300 mg/dm<sup>2</sup> soil) was similar to that of KCl and  $K_2SO_4$ .

Distillery waste could safely be used as fertilizer along with irrigation water (Goel and Mandavekar, 1983). *Cymopsis tetragonolaba* (cluster bean)

irrigated with 10 per cent distillery waste showed more nodulation. But higher concentration suppressed the nodulation and growth.

Brewery sludge residuals are approximately equivalent to fertilizers on a dry basis with an analysis of 3:1:0 (N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O). It is estimated that a single application of 5 to 20 tons of dry sludge residues per acre increased overall hay yields by at least five times as compared to untreated hay fields (Naylor and Severson, 1984).

Chares (1985) reported that the distillery effluent could be used as a compliment to mineral fertilizer to sugarcane in Brazil. The distillery effluent contained N, P, K, Ca, Mg and S and it was thus valued as a fertilizer when applied to soil through irrigation water (Samuel, 1986).

Kulkarni *et al.* (1987) classified spent wash as dilute organic fertilizer with a high potassium content and its nitrogen was mostly in colloidal form behaving as a slow release fertilizer better than most chemical nitrogenous fertilizers. Further, they stated that the availability of phosphorus was more than any other chemical source besides containing large amounts of important secondary plant nutrients such as Ca, S and Mg as well as micronutrients such as Cu, Mn and Zn.

The spent wash treated by aerobic composting technology could be used as manure (Khambe *et al.*, 1992). The maximum manuring rate 60 t ha<sup>-1</sup> was found to be optimum, above which earthworms found to be affected. It was also observed that the introduction of spent wash compost leachate in water streams enhanced the growth of algae and did not cause any toxic effects on the aquatic ferns. The distillery effluent can be considered as liquid manure and controlled application of the treated effluent increased the productivity of sugarcane and sugar beet (Devarajan *et al.*, 1993).

Zalwadia and Raman (1994) reported that 25 per cent of recommended fertilizers could be saved in onion by irrigating with distillery wastewater. The total dry matter and yield obtained was on par with 100 per cent

recommended dose of fertilizer application and normal water irrigation. Further, percentage utilization of applied N, P and K through fertilizer were more in distillery wastewater with 75 per cent fertilizer dose.

Benke *et al.* (1998) made carbon-13 CP/MAS nuclear magnetic resonance spectroscopy (<sup>13</sup>CP/MAS NMR) and diffuse reflectance fourier-transfer infrared spectroscopy (DR-FIR) study on sugarcane distillery waste (vinasse). They found that dissolved organic carbon (DOC) and particulate organic carbon (POC) fractions to be the main forms in vinasse. The POC fraction corresponds to 8 to 21 per cent only of the total unfractionated vinasse dry matter. They also opined that the POC fraction seemed to be an important source of nitrogen (21 to 58 g/kg) with a C/N mole ratio of 9 to 24.

The distillery effluent could be used as soil amendment as it increased the yield of wheat and rice grown in sequence and further improved the soil physico-chemical properties (Pathak *et al.*, 1999).

From the review mentioned above it can be inferred that the distillery by-products (effluent and sludge) could be used as source of nutrients for crops.

## **2.3 EFFECT OF DISTILLERY BY-PRODUCTS ON GROWTH YIELD AND QUALITY OF CROPS**

### **2.3.1 Effect on cereals**

Bucknall *et al.* (1979) reported that total annual application of potale (waste product of malt whisky distillery) @ 100 m<sup>3</sup> ha<sup>-1</sup> or more increased the dry matter yield of low land grass and grain yield of barley. Application of 220 m<sup>3</sup> ha<sup>-1</sup> potale gave higher grain yield (5000 kg/ha) over control (2900 kg/ha). Number of ears m<sup>-2</sup> area and 100 grain weight also increased due to the application 554 and 42.9 g, respectively of potale over control 445 and 39.0 g, respectively.

Mbagwu and Ekwealor (1990) observed increased plant height and dry matter of maize due to brewer's spent grain application. The plant height and dry matter yields were increased from 45.1 cm and 1.77 g pot<sup>-1</sup> in the treatment receiving complete fertilizer (N: 60 ppm, P: 15 ppm, K: 60 ppm and Mg: 20 ppm applied as solutions of NH<sub>4</sub>Cl, NaH<sub>2</sub>PO<sub>4</sub>. H<sub>2</sub>O, KCl and MgSO<sub>4</sub>, respectively) to 68.3 cm and 51.2 g pot<sup>-1</sup> in the treatment receiving 2.5 per cent brewer's spent grains.

Shankarappa (1993) observed significantly higher plant height (83.00 cm), dry matter (26.00 g/hill) and grain yield (3346 kg/ha) of finger millet by applying a combination of distillery sludge (10 t/ha) along with half recommended dose of fertilizer.

Pujar (1995) recorded the highest grain yield of wheat and maize with 50 and 10 times dilution of effluent irrigation, respectively. Twelve pre sowing irrigation with distillery effluent had no adverse effect on the germination, instead improved the growth and yield of maize (Singh and Bahadur, 1998).

### **2.3.2 Effect on pulses**

Rani and Srivastav (1990) while studying the impact of various concentrations of distillery effluent (10, 25, 50, 75, 100% v/v) on growth of peas, recorded 25 per cent increase in shoot length number of leaves per plant, leaf area and chlorophyll content. However, the effluent at all concentrations inhibited root growth. The number of pods per plant, seeds per pod and seeds per plant increased upto 25 per cent dilution, but seed chlorophyll content was the highest (15.73%) with 10 per cent dilution.

Goyal and Kapoor (1995) reported that application of distillery wastewater upto 160 m<sup>3</sup> ha<sup>-1</sup> led to an increase in dry matter production of mungbean. Further, with an increase in level of distillery wastewater also led to increased dry matter production. However, application @ 640 m<sup>3</sup> ha<sup>-1</sup>, declined the dry matter drastically and was even less than the control.

Babu *et al.* (1996) found that application of spent wash without dilution did not result in growth deformities or any alteration in plant metabolism. A significant increase in all the plant growth attributes were observed. Further, they noticed increased total chlorophyll, phenol, pigments, proteins, aminoacids, starch and nitrogen contents in leaves in treated plants.

### 2.3.3 Effect on cash crops

In a sand culture study, the growth and chemical composition of sugarcane were not affected by spent wash applied @ 250 ppm (Jagadale and Sawant, 1979). But higher rates of application were found detrimental. An increase in ash and K content of raw and clean juice of sugarcane and molasses by the application of vinasse was observed by Rodella and Ferrari (1977).

Silva *et al.* (1980) reported that application of 80 m<sup>3</sup> ha<sup>-1</sup> vinasse alone considerably improved the yield of cane and sugar per hectare.

Madrod *et al.* (1986) observed that levels of vinasse increased the cane and sugar yield, but reduced apparent purity, brix and sugar yield.

Barrocal (1988) observed delayed cane ripening and increased cane and sugar yield ha<sup>-1</sup> due to vinasse application @ 120 m<sup>3</sup> ha<sup>-1</sup>. The increase in sugar yield was 2.07 t ha<sup>-1</sup> over control.

Mohan Singh *et al.* (1993) observed juice quality parameters such as pol per cent and purity coefficient, which remained unaffected with the application of 500 m<sup>3</sup> ha<sup>-1</sup> distillery effluent. However, cane yield and juice quality decreased with increasing concentrations of the effluent in irrigation water. The best results were obtained (Ghugare and Magar, 1995) when 50 times diluted vinasse was applied @ 16,000 litre ha<sup>-1</sup>, the cane yield (188.1 t/ha) and commercial cane sugar yield (25.96 t/ha) were 20 per cent higher than control values (155.9 and 20.94 t/ha).

Pujar (1995) recorded the highest sugar cane yield with 10 times dilution when effluent amended with pressmud. But the quality parameters of sugar cane were not influenced by diluted effluent irrigation. Zalwadia *et al.* (1997) found that the application of spent wash diluted at any level increased sugarcane yield. Less diluted spent wash gave a greater yield of biomass than the more diluted ones.

## **2.4 EFFECT OF DISTILLERY BY-PRODUCTS ON SOIL PHYSICO-CHEMICAL PROPERTIES**

### **2.4.1 Physical properties**

Escolar (1963) observed changes in hydraulic conductivity, aggregate stability and improvement in infiltration rate by the addition of distillery slops and molasses to a column of saline sodic soil.

Jadhav and Savant (1975) reported that the physical properties of soil like water retention hydraulic conductivity and water stable aggregates decreased due to irrigation with distillery effluent. Vinten *et al.* (1983) opined that the reduction in hydraulic conductivity was due to accumulation of solids at the surface.

Mbagwu and Ekwealor (1990) observed that the increased levels (2.5 to 10%) of brewer's spent grain increased the mean weight diameter of water stable aggregates from 1.62 mm to 2.20 mm, moisture retention from 17.17 per cent to 20.25 per cent and available water holding capacity from 14.7 per cent to 18.3 per cent of soil.

Rachhapal *et al.* (1980) concluded that the addition of spent wash without dilution was very effective in increasing the water intake rate of sodic calcareous soil. Application of spent wash followed by irrigation was very effective than dilution of spent wash at the time of its application in reclaiming a sodic soil. Shinde *et al.* (1993) have also noticed improvement in

stability of aggregates and porosity due to application of spent wash solids and spent wash pressmud compost.

Singh and Bahadur (1997) stated that effluent irrigation decreased the infiltration rate and bulk density of soil, which are favourable traits for sandy soils. Whereas, saturated hydraulic conductivity, bulk density and volumetric water content of soils improved with effluent application (Pathak *et al.*, 1999).

#### **2.4.2 Chemical properties**

Incubation studies conducted by Jadhav and Savant (1975) indicated that application of spent wash increased the pH, EC, cations, anions, sodium adsorption ratio (SAR), potassium adsorption ratio (PAR), exchangeable Na and K but decreased exchangeable Ca and Mg. Dongale and Savant (1979) also noticed increased potassium content in soil when treated with spent wash. Parer and Ortiz (1979), Vicent Chandler *et al.* (1984) and Shankarappa (1993) also noticed similar observations in their studies.

Nunes *et al.* (1981) observed at increased levels of spent wash that total N, C levels, exchangeable Na were not increased on the other hand, exchangeable K Ca, Mg and pH were increased. While, exchangeable Al, available P and NO<sub>3</sub> decreased. Mineralization of organic materials as well as nutrients in effluents were responsible for increased availability of plant nutrients (Somashekhar *et al.*, 1984).

Orland *et al.* (1985) applied vinasse for 20 years and observed beneficial effects on soil in terms of increase in pH, K, Ca and Mg contents and greater CEC. Guruswamy (1986) noticed that discharge of untreated spent wash on land lowered soil pH and waste water produced in the distillery carried a high organic load. Which caused severe fouling atmosphere.

Taluk and Medeiror (1989) also observed increased soil pH, available N, P, K, Ca and Mg by the application of vinasse @ 80 m<sup>3</sup> ha<sup>-1</sup>. Irrigation to cane field with distillery effluent increased exchangeable Ca in soil.

Shinde *et al.* (1993) observed increased EC and available K in soil and saturation paste extract when applied with spent wash solids. Further, increased available N, P and DTPA extractable Fe, Mn and Zn in the soil at harvest of sorghum were also noticed.

Zalwadia and Raman (1994) recorded higher values of EC, organic carbon, available N, P and K with usage of effluent water irrigation than with normal water at the same level of fertilizer application. Soil fertility was built up by the effluent application particularly soil organic carbon and potassium status (Singh and Bahadur, 1997). Further, with increased application of effluent increased soil pH, EC, available N, P and potassium.

Singh and Bahadur (1998) recorded that a slight increases in pH and EC of the soil. Whereas, the soil organic carbon, nitrogen phosphorus and potassium contents increased significantly with increase in number of pre-sowing effluent irrigation.

## **2.5 EFFECT OF DISTILLERY BY-PRODUCTS ON SOIL BIOLOGICAL PROPERTIES**

### **2.5.1 Effect of distillery by-products on soil microorganisms**

According to the incubation studies conducted by Neves *et al.* (1983), the application of various rates of stillage resulted in substantial but temporary increase in the population of bacteria and fungi. But, actinomycetes were inhibited until population of other microorganism decreased. Application of stillage contributed to soluble nitrogen, which stimulated non-fixing bacteria but inhibited temporary nitrogen fixing *Beijerinckia*. The population of *Beijerinckia* increased rapidly following the decline of the non-fixing bacteria.

*Azospirillum* spp and nitrogenase activities were also stimulated by stillage application but effect was only in the presence of applied molybdenum.

Filip and Muller (1984) reported that application of fermentation residues @ 200 t ha<sup>-1</sup> positively influenced the biological activity of soil. Bacteria, actinomycetes and microscopic fungi in amended soil sample showed significantly higher colony counts than in the unamended soils.

The abundant growth of *Calothrix maxchica* var. intermedia was noticed in soil, which received the effluent of molasses distillery. The effluent particularly at low concentrations (1-10% v/v) and neutral pH increased the growth of organism. The *Cyanobacterium* grew photoheterotrophically and chemoheterotrophically in the medium supplemented with sucrose and lower concentrations (10% v/v) of neutralized distillery effluent (Adhikary, 1989).

### **2.5.2 Effect of distillery by-products on soil enzymes**

Enzymes are the indicators of microbial activity and may provide an index of total microbial activity in soil (Smith, 1991). The soil enzymes show an immediate response to any deviation in soil health (Brookes, 1995).

Palm *et al.* (1988) reported a partial inhibition of acid phosphatase activity in red yellow latosol irrigated with cumulative dose of distillery effluent. However, Tauk *et al.* (1990) found that annual application of vinasse increased the amylase and cellulase activity but the urease activity was unaffected in the red yellow latosol of Cerroda area in Brazil.

Lal (1990) compared the effect of distillery spent wash and sewage effluent on enzyme activities in different soils concluded that the cellulase, dehydrogenase and phosphatase activities were increased in soil irrigated with distillery effluent than sewage effluent. He also reported that increase in enzyme activity was more marked in Palampur acid soil than in neutral soil of IARI, New Delhi.

Goyal *et al.* (1995) also observed microbial biomass and dehydrogenase activity due to application of distillery effluent and established a close relationship between the number of micro-organisms and enzyme activity in the soil.

## 2.6 EFFECT OF DISTILLERY BY-PRODUCTS ON NUTRIENT AVAILABILITY AND UPTAKE BY CROPS

Escolar (1966) observed increased yield and uptake of P, K and Ca by snap bean due to spent wash application. A significantly higher yield of sugarcane and increased availability of N in soil was recorded with 200 kg N applied through spent wash application (Agarwal and Dua, 1976; Bajpai and Dua, 1972). Further, decrease in sugarcane yield and available N with 300 kg N ha<sup>-1</sup> through spent wash application was observed.

In a laboratory incubation study, Dongale and Savant (1978) applied K at 1000 ppm through spent wash. They noticed that at the end of 60 days, the ammonium acetate extractable K was higher in spent wash applied soil (320 ppm) than in control (160 ppm). The uptake of K by jowar was also higher in treated soil (21 mg/40 plants) than in control (9 mg/40 plants).

Chatterjee *et al.* (1979) reported that FYM or decomposed straw applied at the time of planting did not release as much available N as green leaf manures (*Sesbania bispinosa* and *Ipomea crassicaulis*) or spent hop (waste from brewage industry) applied at 10 t ha<sup>-1</sup> to four to five weeks before planting of rice in submerged soil. The waste (spent hop) released more N (65 ppm) than other bulky organic manure (64 ppm). Application of spent hop resulted in increased organic carbon (1.0%), CEC (15.15 me/100g), P (8.7 kg/ha) and K (196 kg/ha) than control (0.87% organic carbon, (13.89 me/100g) CEC, (7.1 kg/ha) P and (193 kg/ha) K.

Parer and Ortiz (1979) found that application of rum distillery waste @ 6.2 cm, 18.6 cm and 31.0 cm slops ha<sup>-1</sup> contributed to higher K content of 1.89, 5.66 and 9.44 me 100<sup>-1</sup> g soil, respectively. The initial salt content

was increased to about 23 per cent. After application of 6.1 cm of water, salt content was reduced to two thirds of the total salt content from top 60 cm soil in all treatments.

Velloso *et al.* (1982) reported that the application of distillery residues to the soil decreased the nitrate loss from soil. The soil treated with 400 m<sup>3</sup> ha<sup>-1</sup> of residues with addition of N and P the leaching of nitrate was about 30 ppm lower and the leaching of ammonium about 4 ppm more than in no residue treated soil.

Vicente–Chandler *et al.* (1984) studied the effect of distillery slops on rice and rice soils. Exchangeable and HNO<sub>3</sub> extractable K increased with increasing levels of slops upto a total of 313 kg ha<sup>-1</sup> when no slops were applied to 699 kg ha<sup>-1</sup> when 20 hectare litre of slops were applied per ha weekly 12 weeks to 4 successive crops. Exchangeable NH<sub>4</sub> content in the soil and leaf contents of N, P, K, Ca and Mg were not affected by the levels of distillery slops.

Paula *et al.* (1989) has found an increase in the K concentration of soil with increased rate of stillage application in potato field. There was also increase in soil Ca and pH with the application of stillage upto 100 m<sup>3</sup> ha<sup>-1</sup>.

Shinde *et al.* (1993) observed that spent wash solids, farmyard manure and spent wash pressmud compost were equal in their effect. Also found that pressmud compost was superior to other sources in respect of N, P, K, Fe and Zn uptake by sugarcane.

Zalawadia *et al.* (1997) showed that application of spent wash diluted to any levels increased cane yield and nutrient uptake significantly over irrigation with tube well water. They also observed considerable increased availability of P, K and S nutrients indicating the signs of improvement in soil suitability and physical properties. Similarly increased soil available N, P and K contents by pre-sowing irrigation with distillery waste were also recorded by Singh and Bhahadur (1998).

## 2.7 EFFECT OF DIFFERENT SLUDGES ON CROPS AND SOIL PROPERTIES AND CROPS

Larry (1984) studied the amount of nitrogen mineralized from organic wastes amended soil to supply 500 mg total N kg<sup>-1</sup> soil. He observed highest mineralized nitrogen (258 g/kg) in soil amended with waste-activated sludge from poultry processing unit, followed by (232 g/kg) in sludge from brewery wastewater treatment plant (Fermentation waste) and the least in wood processing waste (-81 to - 88 g/kg) indicating the immobilization of soil N.

Sherry *et al.* (1984) reported that addition of spent mushroom substrate (SMS) @ 0 to 20 kg m<sup>-2</sup> resulted in decreased bulk density, increased per cent small pores, pH and EC. The yields of onions decreased to 5.09 kg m<sup>-2</sup> when 20 t ha<sup>-1</sup> SMS applied over 7.80 kg m<sup>-2</sup> when no SMS applied, while the yields of cabbage, cucumber, radish, spinach and mustard were not affected.

Atalay and Blanchar (1988) studied the urease activity in soils amended with methane generator sludge charged with fescue hays in an incubation study. The urease activity increased with increasing levels of sludge. Ureae activity increased to 55  $\mu\text{g N g}^{-1} \text{h}^{-1}$  (80 g/kg sludge amended soil) compared to 10  $\mu\text{g N g}^{-1} \text{h}^{-1}$  in control at 106 days after incubation. The peak urease activity reached to 75  $\mu\text{g N g}^{-1} \text{h}^{-1}$  at 42 days after incubation.

Ranganna *et al.*, (1991) conducted an experiment to compare untreated FYM and biogas spent sludge (BGSS) as sources of nutrients. They studied the influence of FYM (10 t/ha) and BGSS (10 t/ha) on ragi, sugarcane, cabbage, tomato, chilli, french bean and garlic. In general the plots receiving BGSS recorded higher average yields than FYM. They reported that the increased yield was to the tune of 44.99 per cent in ragi and 24.65 per cent in garlic. The higher yields were because of the higher contents of organic carbon, N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O in BGSS than FYM.

Smith and Hadley (1992) conducted a pot culture experiment to know the response of cabbage on a sandy soil fertilized with protox (activated

sewage sludge derived protein), dried blood,  $\text{NH}_4\text{NO}_3$ ,  $(\text{NH}_4)_2\text{SO}_4$ ,  $\text{NaNO}_3$  and urea. Yield response to organic N was marginally lesser compared to mineral fertilizers. Also they reported that the protein-based fertilizers increased the rate of soil microbial activity and protox seemed an effective alternative to mineral fertilizers in reducing the stress of a soil environment which would occur following the application of inorganic N.

Vogtmann *et al.* (1993) observed the effect of kitchen and yard waste compost, FYM and mineral fertilizers on yield and quality of vegetables like tomato, cabbage, potato and carrots. As a general trend composts positively affected the food quality, improved storage. Composts significantly reduced nitrates and improved nitrates to vitamin C ratio in vegetable whereas, the yields of vegetables in compost treated plots were lower during the first two years but did not differ significantly after the third application.

Smith and Hadley (1998) conducted an experiment to compare the response of summer cabbage to inorganic and organic N fertilizers (Sludge and feather meal). They reported that crop response to ammonium nitrate was greater than to organic materials below an application rate of  $250 \text{ kg N ha}^{-1}$ . However, at higher rates of application ( $375$  and  $500 \text{ kg N/ha}$ ) gave higher yields.

Stewart *et al.* (1998a) reported an improvement in physical conditions of soils due to spent mushroom substrate application @  $80 \text{ t ha}^{-1}$  in four applications. The bulk density decreased by  $0.05$  to  $0.25 \text{ g cm}^{-3}$  at  $10 \text{ cm}$  depth, aggregate stability increased by  $13-16$  per cent, clod and crust formation reduced by  $16-31$  and  $18-94$  per cent, respectively. Infiltration rate was also increased by  $130-207 \text{ mm h}^{-1}$ , water content of soil increased by  $0-7$  per cent (w/w) and reduced the fluctuations in diurnal temperatures of a fine sandy loam soil.

Stewart *et al.* (1998b) observed the increase in sweet corn, cabbage and potato tuber yields with increase in spent mushroom substrate (SMS)

from 0-80 t ha<sup>-1</sup>. The increase in yield was to the tune of 38 per cent, 82-96 per cent and 26-46 per cent, for sweet corn, cabbage and potato, respectively. However, they also reported that the considerable increase in yield due to combined application of SMS and inorganic fertilizers. Maximum yield 128.6 t ha<sup>-1</sup> obtained when SMS @ 80 t ha<sup>-1</sup> along with inorganic fertilizers (338: 100: 100: N, P, K kg/ha) applied as compared to 102.3 t ha<sup>-1</sup> when only SMS @ 80 t ha<sup>-1</sup> applied in cabbage.

Zibilske *et al.* (2000) observed the improvement in physical properties due to paper mill sludge (PMS) application. When PMS applied at 90 t ha<sup>-1</sup> and above rates upto 225 t ha<sup>-1</sup> annually, increase in soil organic carbon, soil moisture, soil aggregates and decrease in bulk density as compared to biennial and single application in a five year experiment on a peru fine sandy loam soil.

Simard (2001) tested combined primary/secondary paper mill sludge (PS) as a source of N in cabbage-sweet corn cropping sequence in a silty clay soil. Both cabbage and sweet corn yields increased with increasing PS levels. When PS was supplemented with ammonium nitrate (AN) yields increased further. The apparent total N recovery by the two crops was similar for PS and AN (34% vs 38%). They also reported that the apparent recovery of organic N from PS decreased with increasing rates of application from 46 to 25 per cent. Based on these results they suggested that PS could be an effective source of N for crops and its residual N effects should be considered while estimating N needs of subsequent crops.

Bhattacharya *et al.* (2000) observed addition of municipal solid waste compost @ 20 t ha<sup>-1</sup> increased the microbial biomass in the initial 30 days after incubation and declined then onwards to reach lowest value at 120 days after incubation. Urease enzyme activity reached its maximum at 45 days after incubation.

## 2.8 EFFECT OF FYM ON CROPS AND SOIL PROPERTIES

The FYM supplies both macronutrients and micronutrients, which improves the physical condition of the soil and encourages the soil microbial activity. Several studies have indicated the favourable effect of FYM on various crops.

### 2.8.1 Effect of FYM on crops

In an experiment conducted over three seasons on a sandy loam soil at the Division of Agronomy, IARI, it was evident that application of FYM along with inorganic nitrogen increased the yield of cabbage heads than application of inorganic nitrogen alone. A basal application of 12.5 t ha<sup>-1</sup> FYM appeared to be necessary for obtaining high yields of marketable cabbage heads (Khokar *et al.*, 1970).

Singh (1977) reported significant increase in tuber yield, dry matter and protein production per ha in potato with an increase in the FYM levels. FYM when applied in combination with inorganic nitrogen increased the tuber yields significantly than application of inorganic N alone.

Subbaiah *et al.* (1983) studied the effect of varying levels of organic fertilizers on brinjal in a sandy loam soil with low available N. It was found that levels of FYM had profound influence on the yield, dry matter and uptake of N, P, K and Ca, while the levels of inorganic fertilizers had no marked effect on the above parameters. Application of 12.5 t ha<sup>-1</sup> of FYM along with 50 per cent of RDF proved beneficial.

Meena and Peter (1990) opined that combination of FYM 15 t ha<sup>-1</sup> + 175:40:25 N, P, K kg ha<sup>-1</sup> registered the highest yield of red chilli compared to organic fertilizers and inorganic fertilizers alone at Vellanikkara, Kerala.

Kropiszcz (1992) studied the effect of application of different composts and FYM @ 25 t ha<sup>-1</sup> in three years field trials with cabbage, onion, and carrot.

The combination of FYM+NPK registered highest yield of all the three crops as compared to the application of either FYM or inorganic fertilizers individually.

Chavan *et al.* (1997) recorded the highest ascorbic acid content (241.2 mg/100 g) of green chillies when N was supplied at 75 kg ha<sup>-1</sup> through FYM and 75 kg ha<sup>-1</sup> through urea.

### **2.8.2 Effect of FYM on soil properties**

Dehydrogenase enzyme activity indicates the total microbial count in the soil. They play an essential role in the process of organic matter oxidation particularly in the electron transfer reaction (McLaren and Paterson, 1967).

Baravah and Mishra (1984) observed that dehydrogenase activity was higher at grand growth period of rice than early or harvest stages of the crop.

Singaram and Kamalkumari (1999) in a long term experiments related the activity of soil enzymes to carbon, nitrogen and phosphorus cycling. The higher enzymes activity of dehydrogenase, urease and phosphatase was recorded in FYM treatment than inorganic treatment alone.

Chavan *et al.* (1997) showed that application of 75 kg N ha<sup>-1</sup> through FYM + 75 kg N ha<sup>-1</sup> through urea recorded highest available nitrogen (366.45 kg ha<sup>-1</sup>) over other treatments after harvest of the chilli crop at Parabhani.

Balasubramanian *et al.* (1998) observed the post harvest soil fertility level was improved by the application of both organic and inorganic nutrients to tomato crop at Paiyur. The N, P and K levels of post harvest soil increased by the application of soil test based NPK + ZnSO<sub>4</sub> + borax coupled with either composted coir pith or tank silt over control.

# *Material and Methods*

### **III. MATERIAL AND METHODS**

A field experiment was conducted at Garag village of Dharwad district during *rabi* season of 2001-02 under irrigated condition, to study the effect of distillery yeast sludge as a source of nitrogen on growth and yield of cabbage and soil properties. The details of material used and techniques adopted during the course of investigation are explained in this chapter.

#### **3.1 EXPERIMENTAL SITE**

The experiment was conducted on a black clay soil in farmer's field at Garag village of Dharwad district.

#### **3.2 DISTILLERY YEAST SLUDGE**

Distillery yeast sludge (DYS) was collected from Shri. Laxmi Narasimha Distilleries, Garag. The sludge was analysed with respect to its chemical composition and nutrients by adopting standard procedures (Table 1).

#### **3.3 SOIL AND ITS CHARACTERISTICS**

The soil of the experimental site was black clay soil. A composite soil sample to a depth of 30 cm was collected from the experimental site before imposing treatments. Further, the soil was analyzed for physico-chemical properties. The results of analysis are furnished in Table 2.

#### **3.4 MATERIAL**

##### **3.4.1 Experimental details**

Crop	:	Cabbage cv. Pride of India
Season	:	<i>Rabi</i> 2001-02
Soil type	:	Black clay
Design	:	Randomised Complete Block Design

**Table 1. Chemical properties of distillery yeast sludge**

Characteristic	Value
pH (1:2.5)	6.10
EC (1:2.5) dS m <sup>-1</sup>	16.25
Organic carbon (%)	45.00
Total Nitrogen (%)	3.85
Total Phosphorus (%)	0.23
Potassium (%)	1.20
Calcium (%)	4.62
Magnesium (%)	0.55
Sodium (%)	0.82
Sulphur (%)	0.85
Iron (ppm)	265.20
Copper (ppm)	46.20
Zinc (ppm)	135.20
Manganese (ppm)	84.60

Table 2. Physico-chemical properties of the experimental site

Particulars	Value
<b>I. Physical properties</b>	
Particle size analyses	
Coarse sand (%)	9.10
Fine sand (%)	14.40
Silt (%)	18.20
Clay (%)	58.30
Textural class	Clay
Bulk density ( $Mg/m^3$ )	1.38
Infiltration rate (cm/h)	0.63
<b>II. Chemical properties</b>	
pH (1:2.5)	7.86
EC (1:2.5) $dSm^{-1}$	0.24
CEC ( c mol (p+) $kg^{-1}$ )	51.20
Organic carbon (g/kg)	6.20
Available Nitrogen (kg/ha)	312.8
Available Phosphorus (kg/ha)	23.8
Available Potassium (kg/ha)	396.4
Available Micronutrients (ppm)	
DTPA – Fe	8.20
DTPA – Zn	1.80
DTPA – Cu	1.30
DTPA - Mn	4.30

Replications : Three  
Plot size : Gross - 4.5 m x 4.5 m, Net – 3.6 m x 2.7 m  
Spacing : 45 cm x 30 cm  
RDF : 150 : 100 : 125 N : P<sub>2</sub>O<sub>5</sub> : K<sub>2</sub>O kg ha<sup>-1</sup>

### 3.4.2 Treatment details

T<sub>1</sub> 100% RDN (Urea)  
T<sub>2</sub> 100% RDN (DYS)  
T<sub>3</sub> 75% RDN (DYS) + 25% RDN (Urea)  
T<sub>4</sub> 50% RDN (DYS) + 50% RDN (Urea)  
T<sub>5</sub> 100% RDN (FYM)  
T<sub>6</sub> 75% RDN (FYM) + 25% RDN (Urea)  
T<sub>7</sub> 50% RDN (FYM) + 50% RDN (Urea)  
T<sub>8</sub> 75% RDN (DYS) + 25% RDN (FYM)  
T<sub>9</sub> 50% RDN (DYS) + 50% RDN (FYM)  
T<sub>10</sub> 25% RDN (DYS) + 75% RDN (FYM)

Recommended dose of P and K were applied to all the treatments.

## 3.5 CULTURAL OPERATIONS

### 3.5.1 Nursery preparation

A nursery bed of size 7.5 m x 1.2 m x 0.1 m was prepared. The nursery field was ploughed, harrowed and the soil was brought to fine tilth. Thirty kg of well decomposed FYM, 0.5 kg urea, 1.0 kg single superphosphate and 0.5 kg muriate of potash were applied and mixed well with the soil. Care was taken to protect the seedlings against damping-off by drenching the seed bed with 0.3 per cent captan solution. Then, captan (0.2%) treated cabbage seeds were sown in rows spaced 10 cm apart and covered with a thin layer of soil. Watering was done regularly to maintain optimum moisture in the seedbed. Seedlings were sprayed with Rogor (0.15%) and dithane M-45

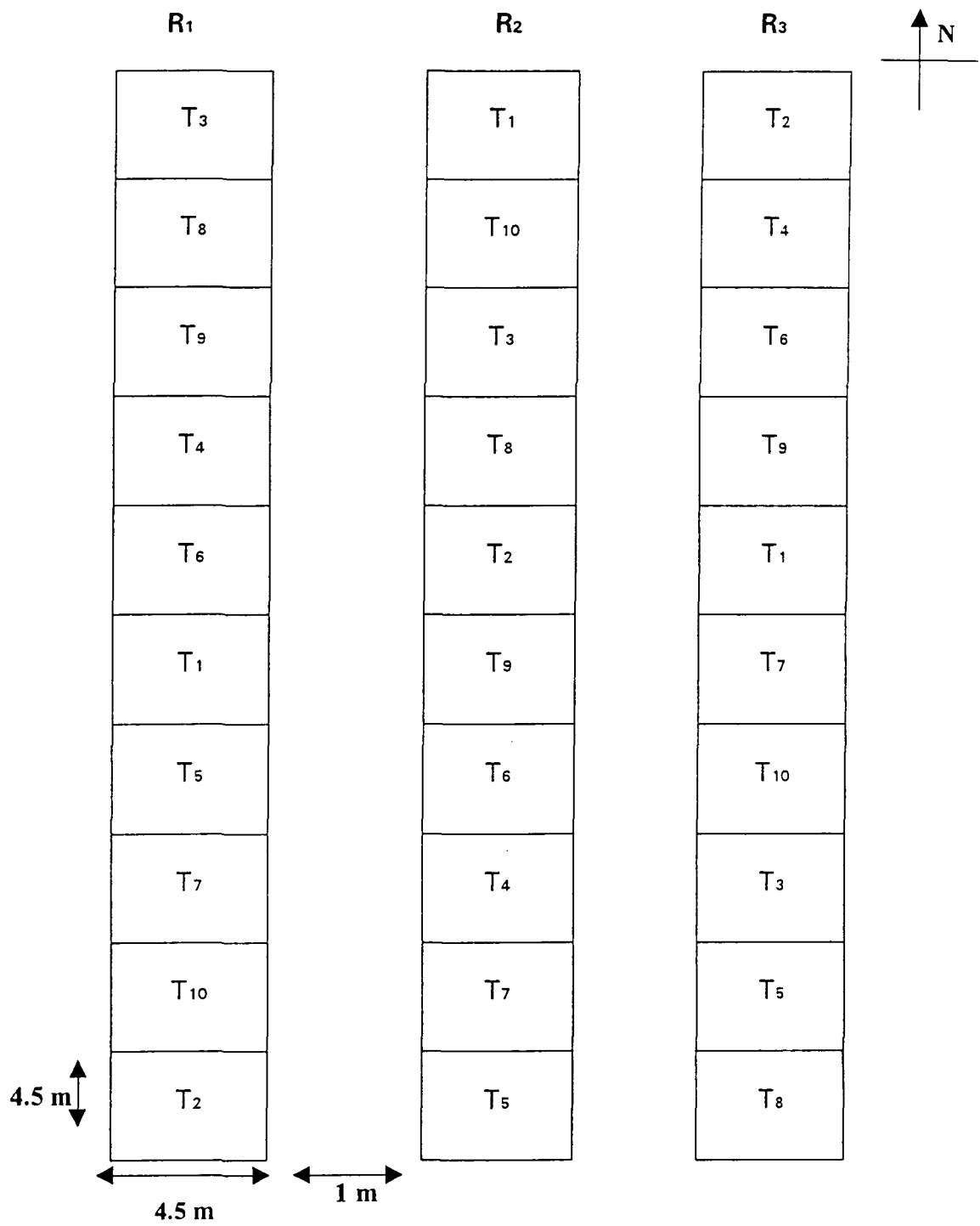


Fig. 1: Plan of layout of the experiment

(0.22%) three weeks after sowing. Seedlings were transplanted after four weeks of sowing.

### **3.5.2 Preparation of land**

The experimental field was ploughed once with wooden plough and harrowed twice. Stubbles and weeds were removed from the experimental area. Plots were laid out as per the plan and field channels were made well in advance to facilitate irrigation. Then the treatments were imposed. Required quantities of FYM and sludge were applied and incorporated. The optimum soil moisture was maintained through irrigation.

### **3.5.3 Imposition of treatments and fertilizer application**

The treatment containing only inorganic source of N (Urea) applied in two splits i.e., 50 per cent as basal and remaining 50 per cent as top dressed at 26<sup>th</sup> day after transplanting.

As per treatments, calculated quantities of organics and inorganics were applied. Organics were applied three weeks prior to transplanting. Recommended dose of P and K fertilizers applied at the time of transplanting. Substituted quantities of N fertilizer was applied as top dressing after 26<sup>th</sup> day after transplanting.

### **3.5.4 Transplanting of seedlings**

Light irrigation was given to the plots so as to provide optimum moisture in the soil before planting. Four week old uniform healthy seedlings were selected and planted on the slopes of the ridges at a distance of 30 cm apart accommodating 150 plants plot<sup>-1</sup>. Gap filling was done five days after planting.

### **3.5.5 Weeding and irrigation**

The experimental plots were kept weed free by regular hand weeding and earthing up was done each time. The individual plots were irrigated frequently (for every 8-10 days) depending upon the soil moisture.

### **3.5.6 Plant protection measures**

In order to control insect pests and disease, the crop was sprayed with quinalphos (2ml/l) nuvacron (2ml/l), endosulphon (2ml/l), curacron (2ml/l), and dithane M-45 (2g/l) at every fortnight.

### **3.5.7 Harvesting**

Harvesting of crop was done after complete maturity when the heads were firm and compact.

## **3.6 OBSERVATIONS RECORDED**

Five randomly selected plants were tagged in each plot for recording the observations on growth, yield and quality parameters. For observations like dry weight of plant, nutrient concentration and uptake of major and micronutrients, three plants from each treatment were carefully uprooted and used for further analysis.

### **3.6.1 Growth parameters**

#### **3.6.1.1 Plant spread**

The maximum growth of the plant in either direction (north-south and east-west) was measured and the average was recorded as the plant spread in cm at 25, 50 DAT and at harvest.

### 3.6.1.2 Number of leaves

The total number of leaves per plant was counted at 25, 50 DAT and at harvest. Then the average number of leaves per plant was worked out.

### 3.6.1.3 Number of days required for the initiation of head

The number of days required from planting to visible initiation of head formation of each plant was recorded and the average days taken for the initiation of head formation was later calculated.

## 3.6.2 Yield parameters

### 3.6.2.1 Yield

The yield per hectare was calculated and expressed in tones per hectare on the basis of the total weight of the head per net plot (kg/ha).

### 3.6.2.2 Weight of head

The fresh weight of the head (g) was recorded and the average weight of head per plant was calculated.

### 3.6.2.3 Diameter of head

The circumference of each head was measured with a thread and later diameter was calculated by using the following formula at harvest and the average diameter of head was worked out later.

$$C = 2 \pi r.$$

$$C = \pi \cdot D \text{ since } D = r \times 2$$

$$D = C/\pi$$

Where  $C$  = circumference of head (cm)

$r$  = radius of head (cm)

$\pi$  = 3.14159

$D$  = diameter of head (cm)

### **3.6.3 Dry matter production**

Three plants from each plot were selected at random. Selected plants were uprooted carefully and thoroughly washed. Then the plants were chopped into small pieces to enable complete drying and then were oven dried at 65-70°C to a constant weight. The oven dry weight of the whole plant was also recorded. Oven dry weight of head and plant recorded separately and expressed in gram per head and gram per plant, respectively.

### **3.6.4 Quality parameters**

#### **3.6.4.1 Protein content in head**

The protein content in oven dried head was estimated by indirect method. The oven dried head sample was finely ground and used to estimate the protein content in heads. First the nitrogen content of the sample was estimated by micro Kjeldhal's method (Jackson, 1967). Then, the per cent nitrogen value was multiplied by a factor 6.25 to get the per cent protein content of the sample.

#### **3.6.4.2 Ascorbic acid content in head**

Five gram of fresh sample of cabbage head was taken from a section transversely to the longitudinal axis of head situated just above the stalk (Sorenson, 1983). The sample was crushed with four per cent oxalic acid and filtered through muslin cloth to get a clear solution. Ascorbic acid content was estimated titrimetrically using 2, 6 dichlorophenol indophenol dye as per the modified procedure of AOAC (Anon, 1984). The content of ascorbic acid was expressed on fresh weight basis in milli gram per 100 g.

### **3.7 SOIL ANALYSIS**

Preparation of soil samples: The soil samples were dried in shade, powdered using a pestle and mortar and passed through a 2 mm sieve. The sieved samples were preserved in plastic bottles for further analysis.

### **3.7.1 Physical properties**

#### **3.7.1.1 Particle size analysis**

Soil samples were analyzed for their mechanical composition; coarse sand, fine sand, silt and clay by International pipette method (Piper, 1966).

#### **3.7.1.2 Bulk density**

Bulk density was determined by core method as described by Black (1965).

#### **3.7.1.3 Infiltration rate**

Infiltration rate was measured by using double ring infiltrometer having a height of 30 cm for both the rings and diameter of 40 cm and 20 cm for the outer and inner rings, respectively, as described by Marshall and Strik (1950).

### **3.7.2 Chemical properties**

#### **3.7.2.1 Soil pH**

The soil pH was determined in 1:2.5 soil to water suspension by using glass electrode pH meter (Model : systronics 331).

#### **3.7.2.2 Electrical conductivity**

Electrical conductivity in 1:2.5 soil to water extract using conductivity bridge (Model : systronics – 304).

#### **3.7.2.3 Organic carbon**

The organic carbon content was determined by taking finely ground sample using Walkely and Balck's wet oxidation method as described by Jackson (1967).

#### **3.7.2.4 Cation exchange capacity (CEC)**

The cation exchange capacity (CEC) of the soil samples was determined by sodium saturation method (Jackson, 1967).

#### **3.7.2.5 Available nitrogen**

Available nitrogen was determined by alkaline potassium permanganate method as outlined by Subbaiah and Asija (1959).

#### **3.7.2.6 Available phosphorus**

Available P was determined by Olsen's method using 0.5 M NaHCO<sub>3</sub> having pH 8.5 as an extractant. The extracted P was determined by chlorostannous reduced molybdophosphoric blue colour method in HCl system using spectrophotometer at 660 nm (Jackson, 1967).

#### **3.7.2.7 Available potassium**

Available K was extracted with neutral normal ammonium acetate and the content of K in the solution was estimated by flame photometer (Model : systronics FPM – 125) as explained by Jackson, 1967.

#### **3.7.2.8 DTPA extractable micronutrients**

Micronutrients in the soil samples were extracted by using DTPA extractant (Lindsay and Norvell, 1978) and the content of Fe, Mn, Cu and Zn were measured by atomic absorption spectrophotometer (Model: GBC 932 AA).

### **3.7.3 Biological properties**

#### **3.7.3.1 Total microbial count**

Pour plate method was followed for enumeration of total bacterial, fungal and actinomycetes content in the soil. Ten gram of soil was added to 90 ml sterile water blank and serial dilutions were made. One ml of serially

diluted solution was pipetted out into sterilized petriplates and suitable molten agar medium cooled to 50°C was poured into the respective plates (soil extract agar for bacteria, Martin's Rose Bengal agar for fungi and Kuster's agar for actinomycetes). Then plates were gently rotated in clockwise and anticlockwise direction for uniform distribution of the soil suspension. The medium was allowed to solidify and incubated in inverse position at 30°C in an incubation for 3-7 days and number of colonies formed were recorded. The population counts were expressed per gram of oven dry soil.

### **3.7.3.2 Soil enzyme activity**

#### **3.7.3.2.1 Dehydrogenase activity**

Dehydrogenase activity in the soil sample was determined by following the procedure as described by Casida *et al.*, (1964). Ten gram soil and 0.2 gram of CaCO<sub>3</sub> were thoroughly mixed and dispensed in test tubes. Each tube was added with one ml of 1.5 per cent aqueous solution of 2,3,5 – triphenyl tetrazolium chloride (TTC), one ml of one per cent glucose solution and eight ml of distilled water which was sufficient to leave a thin film of water above the soil layer. The tubes were stoppered with rubber bungs and incubated at 30°C for 24 hours. At the end of incubation, the contents of the tube were rinsed down into a small beaker and slurry was made by adding 10 ml methanol. The slurry was filtered through Whatman no. 50 filter paper. Repeated rinsing of soil with methanol was continued till the filtrate ran free of red colour. The filtrate was made upto 50 ml with methanol in a volumetric flask. The intensity of red colour was measured at 485 nm, against a methanol blank using spectrophotometer. The concentration of formazon formed in the soil sample was determined by using graded concentrations of formazon. The results were expressed as milli gram of triphenyl formazon (TPF) formed per gram of soil per day.

### 3.7.3.2.2 Urease activity

The procedure adopted to determine the urease activity of soil was essentially the same as adopted by Pancholy and Rice (1973), except that the ammonia liberated due to hydrolysis of urea in the reaction mixture was determined by Nesslerization as described by Jackson (1973).

Ten gram of each freshly collected soil sample was placed in 100 ml capacity conical flask to which one ml of toluene was added and allowed to stand for 15 minutes to permit complete penetration into soil. To each of these flasks were added 20 ml of phosphate buffer (pH 6.7) and 10 ml of 10 per cent urea solution. For control flask, urea solution was replaced with equal quantity of distilled water. The contents of the flasks were well shaken for five minutes and incubated at 30°C for 24 hours. After incubation, the contents of the flasks were added with 15 ml of 1N KCl solution containing 150 ppm HgCl<sub>2</sub>, shaken for five minutes and filtered. The volume of the total filtrate was made upto 100 ml in a volumetric flask using distilled water.

The amount of ammonia present in the filtrate was determined by Nesslerization. Two ml of filtrate of each sample was filtered to a 50 ml volumetric flask to which five ml of 10 per cent sodium tartarate solution and 1.5 ml of Nessler's reagent were added. The volume was made upto 50 ml with distilled water. The yellow colour developed after 30 minutes was measured at 410 nm using spectrophotometer against the reagent blank.

The results obtained were expressed as  $\mu\text{g}$  of ammonia liberated per gram soil (oven dry basis) per day with reference to a standard curve obtained by using graded concentration (0-100  $\mu\text{g/ml}$ ) of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> solution.

## 3.8 PLANT ANALYSIS

Plant and heads were separated dried and powdered. The powdered samples were stored in plastic bottles for further analysis.

### 3.8.1 Digestion of plant samples

Powdered plant and head samples pre-digested separately in  $\text{HNO}_3$ . The pre-digested samples were digested with diacid ( $\text{HNO}_3:\text{HClO}_4$ ) mixture (9:4) till clear solution was obtained. Then the residue cooled and dissolved in 1:6 dilute HCl. The content was made up to 50 ml using double distilled water.

A known quantity of extract was used for further analysis.

#### 3.8.1.1 Phosphorus

Phosphorus in plant and head was estimated by Vanadomolybdo phosphoric yellow colour method (Jackson, 1967) by using spectrophotometer at 420 nm.

#### 3.8.1.2 Potassium

Potassium in plant and head was estimated using flame photometer (Jackson, 1967).

#### 3.8.1.3 Micronutrients (Cu, Zn, Fe and Mn)

Cu, Zn, Fe and Mn in the plant digest were determined by using AAS (Model GBC – 923 B) as suggested by Jackson (1967).

#### 3.8.1.4 Nitrogen

The 0.5 gram powdered sample was digested with concentrated  $\text{H}_2\text{SO}_4$  in presence of digestion mixture ( $\text{CuSO}_4 + \text{K}_2\text{SO}_4 + \text{Selenium powder}$ ) till digest turned colourless. The digested sample was further diluted carefully with distilled water to a known volume. Then, a known amount of aliquot was transferred to distillation unit (micro-Kjeldhal apparatus) and liberated ammonia was trapped in boric acid containing mixed indicator. Later, it was titrated against standard  $\text{H}_2\text{SO}_4$  acid and the amount of nitrogen liberated was estimated (Black, 1965).

### 3.9 COST OF CULTIVATION, NET RETURN AND BENEFIT COST RATIO

The cost of cultivation was calculated based on the market prices of inputs that were prevailing at the time of their use. The selling price for the produce was obtained from vegetable market Hubli.

The net return per hectare was calculated by deducting the cost of cultivation from the gross income and expressed in rupees per hectare (Rs/ha).

*Benefit : Cost ratio worked out as below.*

$$\text{Benefit : Cost ratio} = \frac{\text{Gross return (Rs/ha)}}{\text{Total cost of cultivation (Rs/ha)}}$$

### 3.10 STATISTICAL ANALYSIS OF THE DATA

Fisher's method of analysis of variance was applied for analysis and interpretation of results as outlined by Panse and Sukhatame (1961). The level of significance used in 'F' and 't' tests at  $p=0.05$ . Critical differences (CD) were worked out whenever 'F' test was significant.

# Experimental Results

## IV. EXPERIMENTAL RESULTS

The results of the field experiment conducted during *rabi* 2001-02 to study the effect of distillery yeast sludge as a source of nitrogen on growth and yield of cabbage and soil properties are presented in this chapter.

### 4.1 GROWTH PARAMETERS

Data on effect of various treatments on number of leaves per plant, plant spread, dry matter production and number of days required for initiation of head are presented in Table 3 and 4.

#### 4.1.1 Number of leaves per plant (c.f. Table 3)

At 25 DAT significantly higher number of leaves per plant (8.13) was recorded in the treatment 100 per cent N (Urea) and it was on par with 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) with the average values of 7.94, 7.62 and 7.28, respectively. The lowest number of leaves (6.10) was recorded in the treatment receiving 100 per cent N (FYM) and was on par with rest of treatments receiving nitrogen as FYM + Urea and DYS + FYM combinations.

At 50 DAT significantly higher number of leaves (18.43) was recorded in the treatment 50 per cent N (DYS) + 50 per cent N (Urea), and was on par with the treatment 100 per cent N (Urea) which registered 8.67 leaves per plant. The treatments next in the order to increase number of leaves were 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (FYM) + 50 per cent N (Urea) that recorded 16.67 and 16.43 leaves per plant, respectively, which were on par with each other. The lowest number of leaves (12.32) was recorded in the treatment 100 per cent N (FYM) and was on par with the treatments involving combination of FYM + DYS.

**Table 3. Effect of distillery yeast sludge on number of leaves per plant and plant spread at different growth stages of cabbage**

Treatments	No. of leaves per plant			Plant spread (cm)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
100% RDN (Urea)	8.13	18.67	24.27	19.84	27.67	33.31
100% RDN (DYS)	7.94	14.40	18.64	18.97	21.33	26.02
75% RDN (DYS) + 25% RDN (Urea)	7.62	16.67	21.50	18.52	24.84	29.93
50% RDN (DYS) + 50% RDN (Urea)	7.28	18.43	24.03	18.25	27.40	33.17
100% RDN (FYM)	6.10	12.32	15.93	15.45	18.20	22.26
75% RDN (FYM) + 25% RDN (Urea)	6.20	14.67	18.82	15.83	21.90	26.20
50% RDN (FYM) + 50% RDN (Urea)	6.22	16.43	21.20	16.10	24.62	29.50
25% RDN (DYS) + 75% RDN (FYM)	6.46	12.40	16.00	16.41	18.42	22.56
50% RDN (DYS) + 50% RDN (FYM)	6.53	12.43	16.10	16.82	18.50	22.62
75% RDN (DYS) + 25% RDN (FYM)	6.82	12.57	16.23	16.94	18.64	22.75
S.Em±	0.316	0.568	0.756	0.503	0.846	1.042
CD (0.05)	0.96	1.69	2.25	1.65	2.51	3.09

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure

Similarly at harvest significantly higher number of leaves (24.03) was recorded in the treatment 50 per cent N (DYS) + 50 per cent N (urea), and was on par with the treatment 100 per cent N (Urea) which registered highest (24.27) number of leaves per plant. The lowest number of leaves (15.93) was recorded in the treatment 100 per cent N (FYM) and was on par with the treatments involving the combinations of DYS + FYM.

#### **4.1.2 Plant spread (c.f. Table 3)**

At 25 DAT significantly highest plant spread (19.84 cm) was recorded in the treatment 100 per cent N (Urea) and was on par with the treatments 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) that registered 18.97, 18.52 and 18.25 cm, respectively. The lowest plant spread (15.45 cm) was recorded in the treatment 100 per cent N (FYM) and found on par with rest of the treatments.

A significantly higher plant spread (27.40 cm) was recorded in the treatment 50 per cent N (DYS) + 50 per cent N (Urea) at 50 DAT which was on par (27.67 cm) with the treatment 100 per cent N (Urea). The treatments that followed the order of increase in plant spread were 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (FYM) + 50 per cent N (Urea) recorded 24.84 and 24.62 cm, respectively. The lowest plant spread (18.20 cm) was recorded in the treatment 100 per cent N (FYM) and was found on par with the treatments receiving nitrogen through DYS + FYM combinations.

At harvest significantly highest plant spread (33.31 cm) was recorded in the treatment 100 per cent N (Urea) and was found on par (33.17 cm) with the treatment 50 per cent N (DYS) + 50 per cent N (Urea). The lowest plant

spread (22.26 cm) was recorded in the treatment 100 per cent N (FYM) and was found on par with the treatments involving combinations of DYS + FYM.

#### **4.1.3 Dry matter production (c.f. Table 4)**

At 25 DAT, the highest dry matter (8.99 g/plant) was produced in the treatment 100 per cent N (Urea) and followed by 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) which recorded 8.64, 8.48 and 7.86 g plant<sup>-1</sup> of dry matter, respectively. The lowest dry matter (5.34 g/ plant) was produced in the treatment 100 per cent N (FYM) and found on par with rest of the treatments.

At 50 DAT significantly higher dry matter (36.86 g/plant) was recorded in the treatment 50 per cent N (DYS) + 50 per cent N (Urea) and was on par was (37.12 g/plant) with the treatment 100 per cent N (Urea). The treatments that followed the order of increase in dry matter production were 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (FYM) + 50 per cent N (Urea) that recorded 33.20 and 33.09 g plant<sup>-1</sup>, respectively. The lowest dry matter (23.85 g/plant) was produced in the treatment 100 per cent N (FYM) and found on par with the treatments involving combinations of DYS + FYM.

Similarly at harvest significantly highest dry matter (48.94 g/plant and 96.58 g/head) was produced in the treatment 100 per cent N (Urea) and was on par (48.65 g/plant and 95.86 g/head) with the treatment 50 per cent N (DYS) + 50 per cent N (Urea). The lowest dry matter (32.18 g/plant and 64.20 g/head) was produced in the treatment 100 per cent N (FYM) and found on par with the treatments involving combinations of DYS + FYM.

**Table 4. Effect of distillery yeast sludge on dry matter production per plant at different growth stages of cabbage and number of days required for initiation of head**

Treatments	Dry matter production (g)					No. of days required for initiation of head
	25 DAT		50 DAT		Harvest	
	S+L	S+L+H	S+L+H	S+L		
100% RDN (Urea)	8.99	37.12	48.94	96.58	41.33	
100% RDN (DYS)	8.64	29.01	38.04	75.95	42.00	
75% RDN (DYS) + 25% RDN (Urea)	8.48	33.20	43.71	86.91	42.00	
50% RDN (DYS) + 50% RDN (Urea)	7.86	36.86	48.65	95.86	41.33	
100% RDN (FYM)	5.34	23.85	32.18	64.20	42.67	
75% RDN (FYM) + 25% RDN (Urea)	5.66	29.39	38.25	76.59	42.05	
50% RDN (FYM) + 50% RDN (Urea)	5.82	33.09	42.85	85.87	41.67	
25% RDN (DYS) + 75% RDN (FYM)	5.94	23.96	32.45	64.96	42.00	
50% RDN (DYS) + 50% RDN (FYM)	6.13	24.13	32.91	65.76	42.33	
75% RDN (DYS) + 25% RDN (FYM)	6.22	24.83	33.34	66.18	42.33	
S.Em±	0.557	1.160	1.520	2.879	0.475	
CD (0.05)	1.68	3.44	4.52	8.55	NS	

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 S : Stem L : Leaves H : Head  
 NS : Non significant

#### **4.1.4 Number of days required for initiation of head (c.f. Table 4)**

The number of days required for initiation of head was not significantly influenced by different sources of nitrogen. However, head initiation was found earlier in the treatment 100 per cent N (Urea) and 50 percent N (DYS) + 50 per cent N (Urea) both requiring 41.33 days after planting.

## **4.2 YIELD AND YIELD ATTRIBUTES**

The data on yield (t/ha) and yield attributes of cabbage viz., number of inner leaves per head, fresh weight of head (g) and diameter of head (cm) are presented in Table 5.

### **4.2.1 Yield (c.f. Table 5)**

Significantly higher yield (37.34 t/ha) was observed in the treatment 50 per cent N (DYS) + 50 per cent N (Urea) which was on par with treatment 100 per cent N (Urea) that produced the highest yield (38.67 t/ha). The treatments that followed the order of increase were 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (FYM) + 50 per cent N (Urea) that produced 33.45 and 33.27 t ha<sup>-1</sup>, respectively, which were on par with each other. The lowest yield (24.12 t/ha) was recorded in treatment 100 per cent N (FYM) which was found on par with the treatments involving the combinations of DYS + FYM.

### **4.2.2 Number of inner leaves per head (c.f. Table 5)**

Significantly highest number of inner leaves per head (34.40) was recorded in the treatment 100 per cent N (Urea) and found on par with the treatment 50 per cent N (DYS) + 50 per cent N (Urea) and 75 per cent N (DYS) + 25 per cent N (Urea), which had 33.00 and 32.36 leaves,

Table 5. Effect of distillery yeast sludge on cabbage yield and yield attributes

Treatments	Yield (t/ha)	No. of inner leaves per head	Fresh weight of head (g)	Diameter of heads (cm)
100% RDN (Urea)	38.67	34.40	540.80	13.13
100% RDN (DYS)	29.28	27.98	425.27	11.10
75% RDN (DYS) + 25% RDN (Urea)	33.45	32.36	482.60	12.57
50% RDN (DYS) + 50% RDN (Urea)	37.34	33.00	536.93	12.86
100% RDN (FYM)	24.12	24.00	365.07	9.46
75% RDN (FYM) + 25% RDN (Urea)	29.56	28.40	428.87	11.18
50% RDN (FYM) + 50% RDN (Urea)	33.27	29.00	480.80	11.26
25% RDN (DYS) + 75% RDN (FYM)	24.48	24.20	363.73	9.78
50% RDN (DYS) + 50% RDN (FYM)	24.82	24.37	368.20	9.60
75% RDN (DYS) + 25% RDN (FYM)	25.12	24.50	370.53	9.52
S.Em±	1.176	1.036	16.118	0.402
CD (0.05)	3.49	3.08	47.87	1.19

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure

respectively. The lowest average number of inner leaves per head (24.00) was recorded in the treatment 100 per cent N (FYM) and found on par with the treatments involving the combinations of DYS + FYM.

#### **4.2.3 Fresh weight of head (c.f. Table 5)**

Significantly higher weight of head (536.93 g) was obtained in the treatment 50 per cent N (DYS) + 50 per cent N (Urea) and was found on par with treatment 100 per cent N (Urea) which recorded highest weight (540.80 g/head). The lowest weight (365.07 g) was obtained in the treatment 100 per cent N (FYM) and was found on par with the treatments having combinations of DYS + FYM.

#### **4.2.4 Diameter of head (c.f. Table 5)**

Significantly highest diameter (13.13 cm) was observed in the treatment 100 per cent N (Urea) and was found on par with treatments 50 per cent N (DYS) + 50 per cent N (Urea) and 75 per cent N (DYS) + 25 per cent N (Urea) that had diameter of 12.86 and 12.57 cm diameter, respectively. The lowest diameter (9.46 cm) was recorded in the treatment 100 per cent N (FYM) and found on par with the treatments having the combinations of DYS + FYM.

### **4.3 QUALITY PARAMETERS**

The data pertaining to quality parameters of cabbage *viz.*, protein content (%) and ascorbic acid content (mg/100 g) as influenced by different sources of nitrogen are depicted in Table 6.

**Table 6. Effect of distillery yeast sludge on quality parameters of cabbage at harvest**

Sl. No.	Treatments	Protein (%)	Ascorbic acid (mg/100 g)
1	100% RDN (Urea)	6.88	41.70
2	100% RDN (DYS)	6.85	42.25
3	75% RDN (DYS) + 25% RDN (Urea)	6.83	42.00
4	50% RDN (DYS) + 50% RDN (Urea)	6.87	42.46
5	100% RD (FYM)	6.81	41.93
6	75% RDN (FYM) + 25% RDN (Urea)	6.83	42.13
7	50% RDN (FYM) + 50% RDN (Urea)	6.83	42.50
8	25% RDN (DYS) + 75% RDN (FYM)	6.85	42.28
9	50% RDN (DYS) + 50% RDN (FYM)	6.83	42.31
10	75% RDN (DYS) + 25% RDN (FYM)	6.87	42.46
	S.Em±	0.005	0.412
	CD (0.05)	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

#### 4.3.1 Protein content (c.f. Table 6)

Protein content in head did not differ significantly due to sources of nitrogen. However, highest protein content (6.88%) was recorded in the treatment receiving 100 per cent N (Urea) and lowest protein content (6.81%) was recorded in the treatment 100 per cent N (FYM).

#### 4.3.2 Ascorbic acid content (c.f. Table 6)

Ascorbic acid content in head also not differed significantly due to various treatments. However, highest ascorbic acid content (42.50 mg/100 g) was recorded in the treatment 50 per cent N (FYM) + 50 per cent N (Urea), followed by the treatment 50 per cent N (DYS) + 50 per cent N (Urea) which recorded 42.46 mg 100 g<sup>-1</sup> of ascorbic acid content. The lowest (41.70 mg/100 g) ascorbic acid content was recorded in the treatment 100 per cent N (Urea).

### 4.4 PHYSICO-CHEMICAL PROPERTIES OF THE SOIL

The data pertaining to the physico-chemical properties of the soil *viz.*, bulk density, infiltration rate, organic carbon and cation exchange capacity are presented in Table 7.

The sources of nitrogen did not influenced significant changes in the physico-chemical properties of the soil. However, lowest bulk density (1.37 Mg/m<sup>3</sup>), highest IR (0.66 cm/h), the highest OC (0.73%) and highest CEC (52.93 cmol (p<sup>+</sup>) kg<sup>-1</sup>) were recorded in the treatment 100 per cent N (FYM). The lowest values were recorded in the treatment 100 per cent N (Urea) with respect to infiltration rate, OC and CEC.

**Table 7. Effect of distillery yeast sludge on bulk density of soil, infiltration rate, organic carbon and cation exchange capacity of soil after harvest of cabbage**

Treatments	BD (Mg/m <sup>3</sup> )	IR (cm/h)	OC (%)	CEC (c mol (p+) kg <sup>-1</sup> )
100% RDN (Urea)	1.38	0.63	0.60	49.77
100% RDN (DYS)	1.38	0.64	0.64	51.30
75% RDN (DYS) + 25% RDN (Urea)	1.38	0.64	0.63	50.77
50% RDN (DYS) + 50% RDN (Urea)	1.38	0.64	0.63	50.27
100% RD (FYM)	1.37	0.66	0.73	52.93
75% RDN (FYM) + 25% RDN (Urea)	1.38	0.65	0.71	52.47
50% RDN (FYM) + 50% RDN (Urea)	1.38	0.64	0.67	51.53
25% RDN (DYS) + 75% RDN (FYM)	1.38	0.65	0.72	52.70
50% RDN (DYS) + 50% RDN (FYM)	1.37	0.64	0.69	52.00
75% RDN (DYS) + 25% RDN (FYM)	1.38	0.64	0.65	50.77
S.Em±	0.01	0.004	0.03	1.891
CD (0.05)	NS	NS	NS	NS

DYS : Distillery Yeast Sludge

FYM : Farmyard Manure

NS : Non significant

## **4.5 SOIL REACTION (pH) AND ELECTRICAL CONDUCTIVITY (EC)**

### **4.5.1 pH (c.f. Table 8)**

The sources of nitrogen did not influence significant changes in pH of the soil at all the stages of the crop growth. However, lower soil pH was observed at 25 DAT compared to 50 DAT and at harvest. Among all the treatments 25 per cent N (DYS) + 75 per cent N (FYM) recorded lowest pH compared to other treatments at all the stages of the crop growth.

### **4.5.2 EC (c.f. Table 8)**

The sources of nitrogen did not influence significant changes in EC of the soil at all the stages of crop growth. However, higher EC was observed at early stage of crop growth (25 DAT) compared to later stages. Among all the treatments 100 per cent N (DYS) recorded higher EC (0.27 dS/m) at 25 DAT. Then the EC of the soil decreased gradually as the age of the crop increased.

## **4.6 AVAILABLE MAJOR NUTRIENTS IN SOIL**

The data on available nitrogen, phosphorus and potassium content in the soil as influenced by different sources of nitrogen is depicted in Table 9.

### **4.6.1 Available nitrogen (c.f. Table 9)**

The available nitrogen content in soil was higher at 50 DAI and decreased at harvest. At 25 DAT the highest available nitrogen (394.7 kg/ha) in soil was recorded in the treatment 100 per cent N (DYS) and was found on par with the treatments 75 per cent (DYS) + 25 per cent N (Urea), 75 per cent N (DYS) + 25 per cent N (FYM) that recorded 374.2 and 368.3 kg ha<sup>-1</sup>, respectively. The lowest available nitrogen (339.6 kg/ha) was recorded in the treatment 100 per cent N (FYM).

**Table 8. Effect of distillery yeast sludge on soil reaction (pH) and electrical conductivity (EC) at different growth stages of cabbage**

Treatments	pH			EC (dS/m)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
	100% RDN (Urea)	7.83	7.84	7.85	0.26	0.25
100% RDN (DYS)	7.83	7.84	7.85	0.27	0.26	0.25
75% RDN (DYS) + 25% RDN (Urea)	7.84	7.85	7.86	0.26	0.25	0.24
50% RDN (DYS) + 50% RDN (Urea)	7.83	7.84	7.85	0.25	0.24	0.25
100% RDN (FYM)	7.83	7.83	7.85	0.25	0.25	0.25
75% RDN (FYM) + 25% RDN (Urea)	7.83	7.83	7.85	0.26	0.25	0.24
50% RDN (FYM) + 50% RDN (Urea)	7.83	7.84	7.86	0.26	0.25	0.25
25% RDN (DYS) + 75% RDN (FYM)	7.82	7.83	7.84	0.25	0.25	0.25
50% RDN (DYS) + 50% RDN (FYM)	7.85	7.85	7.86	0.26	0.24	0.25
75% RDN (DYS) + 25% RDN (FYM)	7.84	7.85	7.86	0.26	0.25	0.25
S.Em±	0.008	0.005	0.004	0.003	0.003	0.002
CD (0.05)	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

At 50 DAT, the available nitrogen content in soil was not affected significantly due to the sources of nitrogen. However, highest available nitrogen (395.7 kg/ha) was recorded in the treatment 50 per cent N (DYS) + 50 per cent N (Urea) and the lowest (334.5 kg/ha) was recorded in the 100 per cent N (FYM).

At harvest significantly highest available nitrogen (341.14 kg/ha) recorded in the treatment 100 per cent N (DYS) and was found on par with the treatments 75 per cent N (DYS) + 25 per cent N (Urea) 50 per cent N (DYS) + 50 per cent N (Urea), 75 per cent N (DYS) + 25 per cent N (FYM), 50 per cent N (DYS) + 50 per cent N (FYM), 75 per cent N (DYS) + 25 N (FYM) with the values of 339.6, 332.1, 338.5, 336.5 and 325.4 kg ha<sup>-1</sup> nitrogen, respectively.

#### **4.6.2 Available phosphorus in soil (c.f. Table 9)**

The available phosphorus content in soil decreased with increase in the age of crop. However, available phosphorus content showed significant differences at all the growth stages of crop.

At 25 DAT significantly highest available phosphorus (57.7 kg/ha) in soil was recorded in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with the treatments 50 per cent N (DYS) + 50 per cent N (FYM) (57.2 kg/ha), 100 per cent N (FYM) (55.7 kg/ha), 75 per cent N (FYM) + 25 per cent N (Urea) (55.3 kg/ha) and 75 per cent N (DYS) + 25 per cent N (FYM) (54.4 kg/ha). Lowest available phosphorus (48.8 kg/ha) content in soil was found in the treatment 100 per cent N (Urea) and found on par with 50 per cent N (DYS) + 50 per cent N (Urea) (50.9 kg/ha), 50 per cent N (FYM) + 50 per cent N (Urea) (52.4 kg/ha), 100 per cent N (DYS) (52.6 kg/ha) and 75 per cent N (DYS) + 25 per cent N (Urea) (52.8 kg/ha).

Table 9. Effect of distillery yeast sludge on soil available nitrogen, phosphorus and potassium at different growth stages of cabbage

Treatments	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
100% RDN (Urea)	365.6	390.6	302.2	48.8	37.9	25.6	466.3	431.6	408.6
100% RDN (DYS)	394.7	385.2	341.4	52.6	41.9	29.9	477.3	444.7	426.7
75% RDN (DYS) + 25% RDN (Urea)	374.2	387.9	339.6	52.8	42.4	31.3	475.1	438.3	422.6
50% RDN (DYS) + 50% RDN (Urea)	367.6	395.7	332.1	50.9	39.7	28.6	476.5	439.6	423.5
100% RDN (FYM)	339.6	334.5	321.2	55.7	47.7	36.7	484.2	452.3	433.7
75% RDN (FYM) + 25% RDN (Urea)	341.2	352.3	319.3	55.3	44.4	33.2	489.9	458.7	439.9
50% RDN (FYM) + 50% RDN (Urea)	347.1	374.2	316.4	52.4	42.5	30.4	485.2	446.7	429.6
25% RDN (DYS) + 75% RDN (FYM)	344.4	337.8	325.4	57.7	47.4	36.8	496.8	462.7	446.7
50% RDN (DYS) + 50% RDN (FYM)	364.5	361.6	336.5	57.2	46.7	35.8	494.0	459.6	442.8
75% RDN (DYS) + 25% RDN (FYM)	368.3	363.4	338.5	54.4	44.3	33.8	492.6	449.0	430.7
S.Em±	9.18	8.25	6.22	1.607	1.403	1.315	6.278	5.130	4.786
CD (0.05)	27.6	NS	18.7	4.8	4.3	3.9	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

Similarly at 50 DAT, the highest available P content in soil (48.4 kg/ha) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and lowest (37.9 kg/ha) in the treatment 100 per cent N (Urea).

Also at harvest, the highest available P (36.8 kg/ha) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and found on par with the treatments 100 per cent N (FYM), 75 per cent N (FYM) + 25 per cent N (Urea), 50 per cent (DYS) + 50 per cent N (FYM), 75 per cent (DYS) + 25 per cent N (FYM) which recorded 36.67, 33.21, 35.83 and 33.82 kg ha<sup>-1</sup>, respectively. The lowest available P content (25.62 kg/ha) in soil was found in the treatment 100 per cent N (Urea).

#### **4.6.3 Available potassium in soil (c.f. Table 9)**

The available potassium content in soil was not affected significantly by the sources of nitrogen. However at 25 DAT the highest available potassium (496.8 kg/ha) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and the lowest available potassium content (466.3 kg/ha) was observed in the treatment 100 per cent N (Urea).

Similarly at 50 DAT and at harvest the highest available potassium (462.7 kg/ha and 446.7 kg/ha, respectively) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). And the lowest available potassium content of 431.6 and 408.6 kg ha<sup>-1</sup> was observed at 50 DAT at harvest, respectively in the treatment 100 per cent N (Urea).

#### **4.7 DTPA EXTRACTABLE MICRONUTRIENTS IN SOIL**

The data on DTPA extractable micronutrients (Fe, Mn, Cu and Zn) as influenced by different sources of nitrogen is depicted in Table 10.

**Table 10. Effect of distillery yeast sludge on soil available micronutrients at different growth stages of cabbage**

Treatments	Iron (ppm)			Manganese (ppm)			Copper (ppm)			Zinc (ppm)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
	100% RDN (Urea)	8.2	8.1	8.0	4.5	4.5	4.4	1.3	1.2	1.2	1.9	1.8
100% RDN (DYS)	8.5	8.4	8.2	4.7	4.6	4.6	1.4	1.3	1.3	2.1	2.0	2.0
75% RDN (DYS) + 25% RDN (Urea)	8.4	8.4	8.2	4.6	4.6	4.5	1.4	1.3	1.3	2.0	1.9	1.9
50% RDN (DYS) + 50% RDN (Urea)	8.3	8.3	8.2	4.6	4.5	4.5	1.4	1.3	1.3	2.0	1.9	1.9
100% RDN (FYM)	8.5	8.4	8.3	4.8	4.7	4.7	1.5	1.4	1.3	2.1	2.0	2.0
75% RDN (FYM) + 25% RDN (Urea)	8.5	8.4	8.2	4.6	4.5	4.5	1.4	1.3	1.2	2.1	2.0	2.0
50% RDN (FYM) + 50% RDN (Urea)	8.3	8.3	8.2	4.6	4.5	4.5	1.3	1.2	1.2	1.9	1.9	1.8
25% RDN (DYS) + 75% RDN (FYM)	8.6	8.5	8.3	4.9	4.8	4.7	1.6	1.5	1.4	2.2	2.1	2.1
50% RDN (DYS) + 50% RDN (FYM)	8.5	8.4	8.3	4.9	4.8	4.7	1.5	1.4	1.3	2.0	1.9	1.9
75% RDN (DYS) + 25% RDN (FYM)	8.4	8.3	8.2	4.6	4.5	4.5	1.4	1.3	1.3	2.0	1.9	1.9
S.Em±	0.45	0.422	0.414	0.196	0.204	0.96	0.196	0.084	0.077	0.163	0.159	0.159
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

#### **4.7.1 Iron (c.f. Table 10)**

The DTPA extractable iron in soil was not affected significantly in soil due to sources of nitrogen. However, highest iron content of 8.6, 8.5 and 8.3 ppm was observed at 25, 50 DAT and at harvest, respectively in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest available iron content in soil (8.2, 8.1 and 8.0 ppm at 25, 50 DAT and at harvest, respectively) was found in the treatment 100 per cent N (Urea).

#### **4.7.2 Manganese (c.f. Table 10)**

The DTPA extractable manganese content in soil was not affected significantly due to sources of nitrogen. However, highest manganese content of 4.8, 4.7 and 4.7 ppm was observed at 25, 50 DAT and at harvest, respectively in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest manganese content (4.5, 4.5 and 4.4 ppm at 25, 50 DAT and at harvest, respectively) was found in the treatment 100 per cent N (Urea).

#### **4.7.3 Copper (c.f. Table 10)**

The DTPA extractable copper content in soil was not affected significantly due to sources of nitrogen. However, highest Cu content of 1.6, 1.5 and 1.4 ppm was observed at 25, 50 DAT and at harvest, respectively in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest Cu content (1.3, 1.2 and 1.2 ppm at 25, 50 DAS and at harvest, respectively) was found in the treatment 100 per cent N (Urea).

#### **4.7.4 Zinc (c.f. Table 10)**

The DTPA extractable zinc in soil was not influenced significantly due to sources of nitrogen. However, highest Zn content of 2.2, 2.1 and 2.1 ppm

was found at 25, 50 DAT and at harvest, respectively in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest manganese content (1.9, 1.8 and 1.7 ppm at harvest, respectively) was found in the treatment 100 per cent N (Urea).

#### **4.8 SOIL BIOLOGICAL PROPERTIES**

The data on soil microbial population and soil enzymes (dehydrogenase and urease) activity at different growth stages of crop growth as influenced by different source of nitrogen are depicted in Table 11 and 12.

##### **4.8.1 Microbial population (c.f. Table 11)**

###### **4.8.1.1 Bacterial population**

The bacterial population in soil was significantly influenced by the different sources of nitrogen at all the stages of crop growth.

At 25 DAT significantly highest bacterial population ( $61.70 \times 10^6$ ) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par ( $61.00 \times 10^6$ ) with 50 per cent N (DYS) + 50 per cent N (FYM). The lowest bacterial population ( $38.30 \times 10^6$ ) was observed in the treatment 100 per cent N (Urea).

At 50 DAT highest bacterial population ( $58.30 \times 10^6$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was on par with treatment 50 per cent N (DYS) + 50 per cent N (FYM) which recorded ( $57.70 \times 10^6$ /g soil). The lowest bacterial population ( $33.00 \times 10^6$ ) was found in the treatment 100 per cent N (Urea).

Similarly at harvest highest bacterial population ( $54.30 \times 10^6$ ) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was

Table 11. Effect of distillery yeast sludge on soil microbial population at different growth stages of cabbage

Treatments	Bacteria (No. x 10 <sup>6</sup> /g soil)			Fungi (No. x 10 <sup>4</sup> /g soil)			Actinomycetes (No x 10 <sup>4</sup> /g soil)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
	100% RDN (Urea)	38.30	33.00	31.70	35.30	33.00	30.00	33.70	30.30
100% RDN (DYS)	46.70	38.70	36.30	42.30	41.00	39.50	38.70	32.30	33.00
75% RDN (DYS) + 25% RDN (Urea)	45.30	39.70	37.00	40.30	38.70	37.30	38.00	33.70	32.30
50% RDN (DYS) + 50% RDN (Urea)	44.00	38.30	36.00	39.70	38.30	36.00	36.70	31.70	31.30
100% RDN (FYM)	53.30	40.70	47.70	46.70	40.30	42.70	41.30	38.00	37.70
75% RDN (FYM) + 25% RDN (Urea)	54.70	50.70	48.70	47.70	45.70	43.00	42.70	39.70	39.30
50% RDN (FYM) + 50% RDN (Urea)	53.70	52.30	49.30	47.30	45.30	43.70	42.00	37.70	36.70
25% RDN (DYS) + 75% RDN (FYM)	61.70	58.30	54.30	52.70	49.30	46.00	45.33	43.70	43.00
50% RDN (DYS) + 50% RDN (FYM)	61.00	57.70	53.70	50.70	48.00	45.70	45.00	43.00	42.70
75% RDN (DYS) + 25% RDN (FYM)	52.70	45.00	42.30	45.00	42.30	40.70	41.00	35.70	35.30
S.Em±	1.850	1.525	1.420	0.967	0.871	0.824	0.522	0.890	0.728
CD (0.05)	5.50	4.53	4.26	2.87	2.62	2.48	1.55	2.64	2.16

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure

found on par with the treatment 50 per cent N (DYS) + 50 per cent N (FYM) that recorded the count of  $53.70 \times 10^6 \text{ g}^{-1}$  soil. The lowest bacterial population ( $31.70 \times 10^6$ ) was found in the treatment 100 per cent N (Urea).

#### 4.8.1.2 Fungal population (c.f. Table 11)

The fungal population in soil was significantly influenced by different sources of nitrogen at all the stages of crop growth and followed the same trend as that of bacteria.

At 25 DAT significantly highest fungal population ( $52.70 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par ( $50.70 \times 10^4$ ) with the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest fungal population ( $35.30 \times 10^4$ ) was observed in the treatment 100 per cent N (Urea).

At 50 DAT significantly highest fungal population ( $49.30 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par ( $48.00 \times 10^4$ ) with the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest fungal population ( $30.00 \times 10^4$ ) was observed in the treatment 100 per cent N (Urea).

Similarly at harvest significantly highest fungal population ( $46.00 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par ( $45.70 \times 10^4$ ) with the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest fungal population ( $30.00 \times 10^4$ ) was observed in the treatment 100 per cent N (Urea).

#### 4.8.1.3 Actinomycetes population (c.f. Table 11)

The actinomycetes population in soil was significantly influenced by different sources of nitrogen at all the stages of crop growth and followed the same trend as that of bacteria.

At 25 DAT significantly highest actinomycetes population ( $45.33 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with ( $45.00 \times 10^4$ ) the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest actinomycetes population ( $33.70 \times 10^4$ ) was found in the treatment 100 per cent N (Urea).

At 50 DAT significantly highest actinomycetes population ( $43.70 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with ( $43.00 \times 10^4$ ) the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest actinomycetes population ( $30.30 \times 10^4$ ) was found in the treatment 100 per cent N (Urea).

At harvest significantly highest actinomycetes population ( $43.00 \times 10^4$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with ( $42.70 \times 10^4$ ) the treatment 50 per cent N (DYS) + 50 per cent N (FYM). The lowest actinomycetes population ( $28.30 \times 10^4$ ) was found in the treatment 100 per cent N (Urea).

#### 4.8.2 Soil enzymes activity

The data pertaining to soil enzymes activity is depicted in Table 12. In general the enzymes (dehydrogenase and urease) activity was found highest at 50 DAT followed by at harvest.

#### 4.8.2.1 Dehydrogenase enzyme activity (c.f. Table 12)

At 25 DAT significantly highest dehydrogenase activity ( $33.47 \mu\text{g TPF/g soil/day}$ ) recorded in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with treatment 50 per cent N (DYS) + 50 per cent N (FYM) ( $32.53 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>). The lowest dehydrogenase activity ( $20.10 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>) was recorded in the treatment 100 per cent N (Urea).

Similarly at 50 DAT highest dehydrogenase activity ( $36.90 \mu\text{g g}^{-1}$  of soil day<sup>-1</sup>) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with 50 per cent N (DYS) + 50 per cent N (FYM) which recorded  $35.77 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>. The lowest ( $21.98 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>) was found in the treatment 100 per cent N (Urea).

Similarly at harvest highest dehydrogenase activity ( $34.82 \mu\text{g g}^{-1}$  of soil day<sup>-1</sup>) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and was found on par with 50 per cent N (DYS) + 50 per cent N (FYM) which recorded  $32.67 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>. The lowest ( $20.57 \mu\text{g TPF g}^{-1}$  of soil day<sup>-1</sup>) was found in the treatment 100 per cent N (Urea).

#### 4.8.2.2 Urease activity (c.f. Table 12)

At 25 DAT significantly highest urease activity ( $58.93 \mu\text{g NH}_3/\text{g of soil/day}$ ) was observed in the treatment 25 per cent N (DYS) + 75 per cent N (FYM), which was found on par with the treatment 50 per cent N (DYS) + 50 per cent N (FYM) ( $57.67 \mu\text{g NH}_3 \text{g}^{-1}$  of soil/day). The lowest urease activity ( $44.63 \mu\text{g NH}_3 \text{g}^{-1}$  of soil day<sup>-1</sup>) was found in the treatment 100 per cent N (Urea).

Table 12. Effect of distillery yeast sludge on dehydrogenase and urease enzymes activity at different growth stages of cabbage

Treatments	Dehydrogenase ( $\mu\text{g}$ of TPF/g of soil/day)			Urease ( $\mu\text{g}$ of $\text{NH}_3$ /g of soil/day)		
	25 DAT	50 DAT	Harvest	25 DAT	50 DAT	Harvest
	100% RDN (Urea)	20.10	21.98	20.57	44.63	53.12
100% RDN (DYS)	25.13	26.86	25.22	49.67	58.70	52.18
75% RDN (DYS) + 25% RDN (Urea)	24.63	26.65	24.82	49.38	58.27	51.92
50% RDN (DYS) + 50% RDN (Urea)	24.03	25.94	24.28	49.13	57.40	51.64
100% RDN (FYM)	28.10	32.68	29.34	54.37	64.23	56.92
75% RDN (FYM) + 25% RDN (Urea)	28.47	32.23	29.69	54.52	63.74	57.15
50% RDN (FYM) + 50% RDN (Urea)	28.82	30.93	29.05	53.86	62.77	56.02
25% RDN (DYS) + 75% RDN (FYM)	33.57	36.90	34.82	58.93	67.20	62.89
50% RDN (DYS) + 50% RDN (FYM)	32.53	35.77	32.67	57.67	66.87	61.10
75% RDN (DYS) + 25% RDN (FYM)	28.70	31.13	29.12	54.17	63.00	56.46
S.Em $\pm$	1.233	1.265	1.258	1.314	1.364	1.361
CD (0.05)	3.72	3.84	3.81	3.95	4.10	4.06

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure

Similarly at 50 DAT highest urease activity ( $67.20 \mu\text{g NH}_3 \text{ g}^{-1}$  of soil  $\text{day}^{-1}$ ) with the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and lowest ( $53.12 \mu\text{g NH}_3 \text{ g}^{-1}$  of soil  $\text{day}^{-1}$ ) was found in the treatment 100 per cent N (Urea).

At harvest also highest urease activity ( $62.89 \mu\text{g NH}_3 \text{ g}^{-1}$  of soil  $\text{day}^{-1}$ ) was found in the treatment 25 per cent N (DYS) + 75 per cent N (FYM) and lowest ( $46.72 \mu\text{g NH}_3 \text{ g}^{-1}$  of soil  $\text{day}^{-1}$ ) was found in the treatment 100 per cent N (Urea).

#### **4.9 EFFECT OF SOURCES OF NITROGEN ON CONCENTRATION AND UPTAKE OF MAJOR NUTRIENTS**

The data on effect of sources of nitrogen on the nutrient concentration (%) and uptake (kg/ha) are depicted in Table 13, 14 and 15. In general the nutrient concentration decreased with the increase in the age of the crop, while uptake increased with increase in the age.

##### **4.9.1 Concentration and uptake of nitrogen (c.f. Table 13)**

The concentration of nitrogen in plants was not affected significantly due to sources of nitrogen. However, highest nitrogen concentration of 1.27 per cent at 25 DAT, 1.14 per cent at 50 DAT and 1.04 per cent at harvest in plant and 1.16 per cent in head was observed in the treatment 100 per cent N (Urea). The lowest concentration of 1.20 per cent at 25 DAT, 1.05 per cent at 50 DAT and 0.96 per cent at harvest in plant and 1.14 per cent in head was observed in the treatment 100 per cent N (FYM).

A significant effect of different sources of nitrogen on N uptake by cabbage was recorded at all the growth stages of crop growth. At 25 DAT 100 per cent N (Urea) recorded the highest uptake (8.46 kg/ha) and found on

Table 13. Effect of distillery yeast sludge on nitrogen concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (%)	Uptake (kg/ha)	Conc. (%)	Uptake (kg/ha)	Plant		Head	
					Conc. (%)	Uptake (kg/ha)		Conc. (%)
100% RDN (Urea)	1.27	8.46	1.14	31.36	1.04	37.75	1.16	83.02
100% RDN (DYS)	1.26	8.06	1.11	23.86	1.01	28.47	1.14	64.16
75% RDN (DYS) + 25% RDN (Urea)	1.25	7.85	1.12	27.55	1.02	33.04	1.15	74.06
50% RDN (DYS) + 50% RDN (Urea)	1.25	7.28	1.14	31.14	1.03	37.13	1.16	82.43
100% RDN (FYM)	1.20	4.75	1.05	18.56	0.96	22.89	1.14	54.71
75% RDN (FYM) + 25% RDN (Urea)	1.22	5.12	1.14	24.83	1.01	28.63	1.15	65.27
50% RDN (FYM) + 50% RDN (Urea)	1.23	5.30	1.12	27.46	1.02	32.39	1.15	73.17
25% RDN (DYS) + 75% RDN (FYM)	1.23	5.41	1.08	19.17	1.01	24.29	1.15	53.36
50% RDN (DYS) + 50% RDN (FYM)	1.24	5.63	1.09	19.31	0.98	23.89	1.15	56.04
75% RDN (DYS) + 25% RDN (FYM)	1.25	5.76	1.10	20.24	0.99	24.45	1.15	56.39
S.Em±	0.014	0.422	0.013	0.950	0.021	1.125	0.005	2.464
CD (0.05)	NS	1.27	NS	2.82	NS	3.34	NS	7.32

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

par with the treatments 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) with values of 8.06, 7.85 and 7.28 kg ha<sup>-1</sup>, respectively. The lowest uptake (4.75 kg/ha) was registered in the treatment 100 per cent N (FYM) and found on par with treatments involving FYM + Urea and DYS + FYM combinations.

At 50 DAT the highest uptake (31.36 kg/ha) was observed in the treatment 100 per cent N (Urea) and found on par (31.14 kg/ha) with the treatment 50 per cent N (DYS) + 50 per cent N (Urea). The lowest uptake (18.56 kg/ha) was observed in the treatment 100 per cent N (FYM) and found on par with treatments involving combinations of DYS + FYM.

Similarly at harvest the highest uptake (37.75 kg/ha in plant and 83.02 kg/ha in head) was observed in the treatment 100 per cent N (Urea) and found on par with treatment 50 per cent N (DYS) + 50 per cent N (Urea) which registered 37.13 kg ha<sup>-1</sup> in plant and 82.43 kg ha<sup>-1</sup> in head. The lowest uptake was registered (22.89 kg/ha in plant and 54.71 kg/ha in head) in the treatment 100 per cent N (FYM).

#### **4.9.2 Concentration and uptake of phosphorus (c.f. Table 14)**

The concentration of phosphorus was not affected significantly due to different sources of nitrogen. However, highest P concentration of 0.35 per cent at 25 DAT, 0.30 per cent at 50 DAT and 0.25 per cent at harvest in plant and 0.29 per cent in head was observed in the treatment 100 per cent N (Urea). The lowest concentration of 0.28 per cent at 25 DAT, 0.23 per cent at 50 DAT and 0.19 per cent at harvest in plant and 0.27 per cent in head was recorded in the treatment 100 per cent N (FYM).

At 25 DAT a significantly highest P uptake (2.33 kg/ha) was observed in the treatment 100 per cent N (Urea) and was found on par with the

Table 14. Effect of distillery yeast sludge on phosphorus concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (%)	Uptake (kg/ha)	Conc. (%)	Uptake (kg/ha)	Plant		Head	
					Conc. (%)	Uptake (kg/ha)	Conc. (%)	Uptake (kg/ha)
100% RDN (Urea)	0.35	2.33	0.30	8.25	0.25	9.08	0.29	20.76
100% RDN (DYS)	0.34	2.18	0.27	5.80	0.21	5.92	0.27	15.19
75% RDN (DYS) + 25% RDN (Urea)	0.34	2.14	0.28	6.89	0.22	7.13	0.29	18.68
50% RDN (DYS) + 50% RDN (Urea)	0.34	1.98	0.29	7.92	0.24	8.65	0.29	20.61
100% RDN (FYM)	0.28	1.11	0.23	4.06	0.19	4.53	0.27	12.84
75% RDN (FYM) + 25% RDN (Urea)	0.29	1.22	0.27	5.88	0.21	5.95	0.28	15.89
50% RDN (FYM) + 50% RDN (Urea)	0.29	1.25	0.28	6.87	0.22	6.98	0.28	17.82
25% RDN (DYS) + 75% RDN (FYM)	0.29	1.28	0.25	4.44	0.19	4.56	0.28	13.48
50% RDN (DYS) + 50% RDN (FYM)	0.32	1.45	0.25	4.47	0.20	4.88	0.28	13.64
75% RDN (DYS) + 25% RDN (FYM)	0.32	1.47	0.26	4.78	0.20	4.94	0.28	13.73
S.Em±	0.017	0.172	0.014	0.230	0.014	0.248	0.01	0.597
CD (0.05)	NS	0.52	NS	0.68	NS	0.736	NS	1.77

DYS : Distillery Yeast Sludge

FYM : Farmyard Manure

NS : Non significant

treatments 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) which registered 2.18, 2.14 and 1.98 kg ha<sup>-1</sup>, respectively. The lowest uptake (1.11 kg/ha) was registered in the treatment 100 per cent N (FYM) and found on par with treatments involving the combinations of FYM + Urea and DYS + FYM.

At 50 DAT the highest uptake (8.25 kg/ha) was observed in the treatment 100 per cent N (Urea) and found on par (7.92 kg/ha) with the treatment 50 per cent N (DYS) + 50 per cent N (Urea). The lowest uptake (4.06 kg/ha) was observed in the treatment 100 per cent N (FYM) and found on par with the treatments involving combinations of DYS + FYM.

Similarly at harvest the highest uptake (9.08 kg/ha in plant and 20.76 kg/ha in head) was observed in the treatment 100 per cent N (Urea) and found on par with treatment 50 per cent N (DYS) + 50 per cent N (Urea) which registered 8.65 kg ha<sup>-1</sup> in plant and 20.61 kg ha<sup>-1</sup> in head. The lowest uptake was registered (4.53 kg/ha in plant 12.81 kg/ha in head) in the treatment 100 per cent N (FYM).

#### **4.9.3 Concentration and uptake of potassium (c.f. Table 15)**

The concentration of potassium was not affected significantly due to sources of nitrogen. However, highest K concentration was found in the treatment 100 per cent N (Urea) (1.23% at 25 DAT, 1.10% at 50 DAT and 0.97% at harvest in plant and 1.12% in head). The lowest K concentration of 1.16 per cent at 25 DAT, 1.01 per cent at 50 DAT and 0.92 per cent in plant at harvest and 1.12 per cent in head was observed in the treatment 100 per cent N (FYM).

At 25 DAT significantly highest K uptake (8.19 kg/ha) was observed in the treatment 100 per cent N (Urea) and was found on par with the

Table 15. Effect of distillery yeast sludge on potassium concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (%)	Uptake (kg/ha)	Conc. (%)	Uptake (kg/ha)	Plant		Head	
					Conc. (%)	Uptake (kg/ha)	Conc. (%)	Uptake (kg/ha)
100% RDN (Urea)	1.23	8.19	1.10	30.23	0.97	35.21	1.12	80.16
100% RDN (DYS)	1.21	7.75	1.06	22.79	0.97	27.34	1.10	61.91
75% RDN (DYS) + 25% RDN (Urea)	1.20	7.54	1.08	26.57	0.97	31.42	1.11	71.48
50% RDN (DYS) + 50% RDN (Urea)	1.22	7.11	1.10	30.04	0.96	34.61	1.11	78.88
100% RDN (FYM)	1.16	4.59	1.01	17.85	0.92	21.94	1.12	53.28
75% RDN (FYM) + 25% RDN (Urea)	1.18	4.95	1.07	23.36	0.97	27.49	1.11	62.99
50% RDN (FYM) + 50% RDN (Urea)	1.18	5.09	1.07	26.23	0.97	30.80	1.11	70.63
25% RDN (DYS) + 75% RDN (FYM)	1.22	5.37	1.04	18.46	0.96	23.08	1.12	53.91
50% RDN (DYS) + 50% RDN (FYM)	1.21	5.49	1.05	18.77	0.93	22.68	1.11	54.09
75% RDN (DYS) + 25% RDN (FYM)	1.21	5.57	1.07	19.69	0.95	23.46	1.11	54.43
S.Em±	0.014	0.248	0.014	0.907	0.016	1.050	0.008	2.331
CD (0.05)	NS	0.74	NS	2.69	NS	3.15	NS	6.99

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

treatments 100 per cent N (DYS), 75 per cent N (DYS) + 25 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) which recorded 7.75, 7.54 and 7.1 kg ha<sup>-1</sup> of potassium uptake, respectively. The lowest uptake (4.59 kg/ha) was registered in the treatment 100 per cent N (FYM) and found on par with treatments involving the combinations of FYM + Urea and DYS + FYM.

At 50 DAT the highest uptake (30.23 kg/ha) was registered in the treatment 100 per cent N (Urea) and found on par with the treatment 50 per cent N (DYS) + 50 per cent N (Urea) which registered 30.04 kg ha<sup>-1</sup>. The lowest uptake (17.85 kg/ha) was observed in the treatment 100 per cent N (FYM) and found on par with the treatments involving combinations of DYS + FYM.

Similarly at harvest the highest uptake (35.21 kg/ha in plant and 80.16 kg/ha in head) was recorded in the treatment 100 per cent N (Urea) and found on par with treatment 50 per cent N (FYM) + 50 per cent N (Urea) which registered 34.61 kg ha<sup>-1</sup> in plant and 78.88 kg ha<sup>-1</sup> in head. The lowest uptake (21.94 kg/ha in plant and 53.28 kg/ha in head) was observed in the treatment 100 per cent N (FYM).

#### **4.10 EFFECT OF SOURCES OF NITROGEN ON CONCENTRATION AND UPTAKE OF MICRONUTRIENTS**

The data on effect of sources of nitrogen on micronutrient concentration (ppm) and uptake (g/ha) are depicted in Table 16, 17, 18 and 19. In general, the concentration of nutrients in plants decreased as the age of the crop increased.

**Table 16. Effect of distillery yeast sludge on iron concentration and uptake at different growth stages of cabbage**

Treatments	25 DAT		50 DAT		Harvest		
	Plant		Plant		Head		
	Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)	Uptake (g/ha)
100% RDN (Urea)	57.0	37.97	31.9	87.74	18.5	67.16	187.52
100% RDN (DYS)	63.0	39.77	37.2	79.97	25.0	70.47	180.09
75% RDN (DYS) + 25% RDN (Urea)	63.3	40.33	37.2	91.52	25.1	81.29	202.22
50% RDN (DYS) + 50% RDN (Urea)	59.5	34.65	34.8	90.03	19.7	71.02	187.94
100% RDN (FYM)	61.7	24.41	36.9	65.21	23.5	56.04	144.62
75% RDN (FYM) + 25% RDN (Urea)	60.5	25.37	35.8	77.97	22.3	63.21	166.29
50% RDN (FYM) + 50% RDN (Urea)	58.5	25.23	33.7	82.63	20.3	64.46	173.59
25% RDN (DYS) + 75% RDN (FYM)	63.8	28.08	37.8	67.11	25.8	62.04	156.92
50% RDN (DYS) + 50% RDN (FYM)	61.7	28.03	37.0	66.16	23.6	57.55	149.11
75% RDN (DYS) + 25% RDN (FYM)	60.7	27.98	35.9	66.05	22.5	55.58	145.16
S.Em±	2.443	2.661	2.525	6.302	2.007	6.009	14.849
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

#### **4.10.1 Concentration and uptake of iron (c.f. Table 16)**

Iron concentration in plants was not affected significantly due to the sources of nitrogen. However, highest concentration of iron was found (63.8 ppm at 25 DAT, 37.8 ppm at 50 DAT and 25.8 ppm in plant at harvest and 32.6 ppm in head) in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest concentration was found (57.0 ppm at 25 DAT, 31.9 ppm at 50 DAT and 18.5 ppm in plant at harvest and 26.2 ppm in head) in the treatment 100 per cent N (Urea).

Similarly uptake also not found significantly influenced by the sources of nitrogen. However, highest uptake was found (40.33 g/ha at 25 DAT, 91.52 g/ha at 50 DAT and 81.29 g/ha in plant at harvest and 202.22 g/ha in head) in the treatment 75 per cent N (DYS) + 25 per cent N (Urea). The lowest uptake was observed (24.41 g/ha at 25 DAT, 65.21 g/ha at 50 DAT and 56.04 g/ha in plant at harvest and 144.62 g/ha in head) in the treatment 100 per cent N (FYM).

#### **4.10.2 Concentration and uptake of zinc (c.f. Table 17)**

Zinc concentration in plants was not affected significantly due to the sources of nitrogen. However, highest concentration was found (35.4 ppm at 25 DAT, 24.7 ppm at 50 DAT and 17.0 ppm in plant at harvest and 18.3 ppm in head) in the treatment 25 per cent N (DYS) + 75 percent N (FYM). The lowest concentration was found (28.3 ppm at 25 DAT, 17.5 ppm at 50 DAT and 10.6 ppm in plant at harvest and 12.6 ppm in head) in the treatment 100 per cent N (Urea).

The uptake of zinc also not found significantly influenced by the sources of nitrogen. However highest uptake was found (20.29 g/ha at 25 DAT, 52.89 g/ha at 50 DAT and 45.22 g/ha in plant at harvest and 104.32

Table 17. Effect of distillery yeast sludge on zinc concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)	Plant		Head	
					Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)
100% RDN (Urea)	28.3	18.55	17.5	48.22	10.6	38.47	12.6	90.18
100% RDN (DYS)	34.5	20.08	24.0	51.59	15.8	45.02	17.7	99.61
75% RDN (DYS) + 25% RDN (Urea)	32.3	20.29	21.5	52.89	13.9	45.22	16.2	104.32
50% RDN (DYS) + 50% RDN (Urea)	29.5	17.18	18.7	51.08	11.1	40.02	13.4	95.22
100% RDN (FYM)	33.3	13.18	22.5	39.76	14.9	35.53	17.2	81.82
75% RDN (FYM) + 25% RDN (Urea)	32.4	13.59	21.6	47.04	14.1	39.96	16.3	92.51
50% RDN (FYM) + 50% RDN (Urea)	30.1	12.98	21.4	52.39	12.0	38.10	13.9	88.45
25% RDN (DYS) + 75% RDN (FYM)	35.4	15.58	24.7	43.25	17.0	40.88	18.3	88.09
50% RDN (DYS) + 50% RDN (FYM)	33.4	15.17	22.6	40.40	14.9	36.34	17.3	84.29
75% RDN (DYS) + 25% RDN (FYM)	32.4	14.93	21.6	39.74	14.0	34.58	16.2	79.44
S.Em±	1.877	2.630	1.967	4.625	1.577	3.703	1.814	7.455
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

g/ha in head) in the treatment 75 per cent N (DYS) + 25 per cent N (Urea). The lowest uptake was found (13.18 g/ha at 25 DAT, 39.76 g/ha at 50 DAT and 35.53 g/ha in plant at harvest and 81.82 g/ha in head) in the treatment 100 per cent N (FYM).

#### **4.10.3 Concentration and uptake of manganese (c.f. Table 18)**

Manganese concentration in plants was not affected significantly due to the sources of nitrogen. However, highest concentration was found (37.8 ppm at 25 DAT, 27.7 ppm at 50 DAT and 19.5 ppm in plant at harvest and 26.3 ppm in head) in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest concentration was found (30.2 ppm at 25 DAT, 20.9 ppm at 50 DAT and 14.2 ppm in plant at harvest and 17.2 ppm in head) in the treatment 100 per cent N (Urea).

The uptake of manganese also not found significantly influenced by sources of nitrogen. However, highest uptake was found (23.80 g/ha at 25 DAT, 68.39 g/ha at 50 DAT and 58.95 g/ha in plant at harvest and 145.54 g/ha in head) in the treatment 75 per cent N (DYS) + 25 per cent N (Urea). The lowest uptake (13.79 g/ha at 25 DAT, 45.77 g/ha at 50 DAT and 41.97 g/ha in plant at harvest and 114.65 g/ha in head) was found in the treatment 100 per cent N (FYM).

#### **4.10.4 Concentration and uptake of copper (c.f. Table 19)**

Copper concentration in plants was not influenced significantly due to the sources of nitrogen. However, highest concentration was found (16.3 ppm at 25 DAT, 8.7 ppm at 50 DAT and 5.4 ppm in plant at harvest and 6.3 ppm in head) in the treatment 25 per cent N (DYS) + 75 per cent N (FYM). The lowest concentration was found (10.3 ppm at 25 DAT, 5.9 ppm at 50

Table 18. Effect of distillery yeast sludge on manganese concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)	Plant		Head	
					Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)
100% RDN (Urea)	30.2	20.12	20.9	57.48	14.2	51.54	17.2	123.11
100% RDN (DYS)	35.9	22.98	27.9	59.97	19.0	53.56	25.9	145.76
75% RDN (DYS) + 25% RDN (Urea)	37.8	23.80	27.8	68.39	15.2	58.95	22.6	145.54
50% RDN (DYS) + 50% RDN (Urea)	30.8	17.94	21.7	59.27	14.3	51.55	17.5	124.35
100% RDN (FYM)	38.2	15.07	25.9	45.77	17.6	41.97	24.1	114.65
75% RDN (FYM) + 25% RDN (Urea)	32.9	13.79	24.7	53.79	16.3	46.91	22.9	129.96
50% RDN (FYM) + 50% RDN (Urea)	31.2	13.45	22.6	55.41	14.3	45.41	21.2	134.89
25% RDN (DYS) + 75% RDN (FYM)	35.8	15.80	27.7	49.18	19.5	46.89	26.3	126.59
50% RDN (DYS) + 50% RDN (FYM)	34.4	15.62	25.9	46.31	17.8	43.41	24.4	118.89
75% RDN (DYS) + 25% RDN (FYM)	33.1	15.26	24.9	45.81	16.5	40.76	23.4	114.75
S.Em±	2.398	1.507	2.778	4.048	1.839	3.982	2.348	10.819
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

Table 19. Effect of distillery yeast sludge on copper concentration and uptake at different growth stages of cabbage

Treatments	25 DAT		50 DAT		Harvest			
	Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)	Plant		Head	
					Conc. (ppm)	Uptake (g/ha)	Conc. (ppm)	Uptake (g/ha)
100% RDN (Urea)	10.3	6.85	5.9	16.22	2.9	10.53	3.9	27.89
100% RDN (DYS)	14.8	9.47	8.6	18.48	5.6	15.79	6.3	35.46
75% RDN (DYS) + 25% RDN (Urea)	15.2	9.55	8.2	20.17	5.2	18.87	5.9	37.99
50% RDN (DYS) + 50% RDN (Urea)	14.3	8.33	8.3	22.67	4.3	15.50	4.7	33.39
100% RDN (FYM)	15.4	6.09	8.4	14.85	4.4	10.49	5.1	24.26
75% RDN (FYM) + 25% RDN (Urea)	15.7	6.58	8.3	18.08	5.0	14.17	5.0	28.38
50% RDN (FYM) + 50% RDN (Urea)	14.3	6.17	8.3	20.35	4.7	14.92	5.3	33.72
25% RDN (DYS) + 75% RDN (FYM)	16.3	7.17	8.7	15.44	5.4	12.96	6.3	30.33
50% RDN (DYS) + 50% RDN (FYM)	15.6	7.09	8.6	15.38	5.3	12.92	6.3	30.69
75% RDN (DYS) + 25% RDN (FYM)	14.2	6.54	7.2	13.25	3.9	9.63	4.9	24.03
S.Em±	1.312	0.758	0.603	1.786	0.507	1.071	0.495	2.751
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure  
 NS : Non significant

DAT and 2.9 ppm in plant at harvest and 3.9 ppm in head) in the treatment 100 per cent N (Urea).

The uptake of copper was also not influenced significantly due to the sources of nitrogen. However highest uptake (9.55 g/ha at 25 DAT, 20.17 g/ha at 50 DAT and 18.87 g/ha in plant at harvest and 37.99 g/ha in head) was found in the treatment 75 per cent N (DYS) + 25 per cent N (Urea). The lowest uptake (6.09 g/ha at 25 DAT, 14.85 g/ha at 50 DAT and 10.49 g/ha in plant and 24.26 g/ha in head at harvest) was found in the treatment 100 per cent N (FYM).

#### **4.11 CORRELATION STUDIES**

Correlation co-efficient studies between yield V/s growth, yield parameters and uptake of nutrients are depicted in Table 21. A positive and correlation was observed between yield of cabbage and other characters except number of days required for initiation of head which was negatively correlated.

#### **4.12 ECONOMICS (c.f. Table 20)**

The treatment 100 per cent N (Urea) recorded the highest gross returns (85074 Rs/ha) and highest net return (62086 Rs/ha). While, the treatment 100 per cent N (FYM) recorded lowest gross and net returns (53064 and 26086 Rs/ha, respectively).

The treatment 50 per cent N (DYS) + 50 percent N (Urea) registered the highest B:C ratio (3.71) followed by the treatment 100 per cent N (Urea) (3.70). The lowest B:C ratio (1.97) was observed in treatment 100 per cent N (FYM).

**Table 20. Economic analyses on cabbage as influenced by different source of nitrogen**

Treatments	Cost of N (Rs.)	Other costs (Rs.)	Total costs (Rs.)	Yield (t/ha)	Gross return (Rs.)	Net returns (Rs.)	B:C ratio
100% RDN (Urea)	1451.10	21536.55	22987.65	38.67	85074.0	62086.35	3.70
100% RDN (DYS)	-	20691.45	20691.45	29.28	64416.0	43724.55	3.11
75% RDN (DYS) + 25% RDN (Urea)	362.78	21066.75	21429.53	33.45	73590.0	52160.47	3.43
50% RDN (DYS) + 50% RDN (Urea)	725.55	21416.85	22142.40	37.34	82148.0	60005.60	3.71
100% RDN (FYM)	6750.00	20227.05	26977.05	24.12	53064.0	26086.95	1.97
75% RDN (FYM) + 25% RDN (Urea)	5425.28	20716.65	26141.78	29.56	65032.0	38890.20	2.49
50% RDN (FYM) + 50% RDN (Urea)	4100.55	21050.55	25151.10	33.27	73194.0	48042.90	2.91
25% RDN (DYS) + 75% RDN (FYM)	5062.50	20259.45	25321.95	24.48	53856.0	28534.05	2.13
50% RDN (DYS) + 50% RDN (FYM)	3375.00	20290.05	23665.05	24.82	54604.0	30938.95	2.31
75% RDN (DYS) + 25% RDN (FYM)	1687.50	20317.05	22004.55	25.12	55264.0	33259.45	2.72

DYS : Distillery Yeast Sludge  
 FYM : Farmyard Manure

**Table 21. Correlation coefficient between yield and growth, yield parameters and nutrient uptake of cabbage as influenced by distillery yeast sludge**

	Parameters	r value
I	Growth parameters	
	No. of leaves per plant	0.989**
	Plant spread	0.997**
	Dry matter production	0.996**
	No. of days required for initiation of head	-0.903**
II	Yield parameters	
	Diameter of head	0.971**
	Fresh weight of head	0.998**
	No. of inner leaves per head	0.979**
III	Quality parameters	
	Protein content	0.469*
	Ascorbic acid content	0.221*
IV	Nutrient uptake	
	Nitrogen	0.739**
	Phosphorus	0.996**
	Potassium	0.989**
	Zinc	0.503**
	Copper	0.377*
	Iron	0.817**
	Manganese	0.453*

\*Significant at 5%

\*\* Significant at 1%

*Discussion*

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## V. DISCUSSION

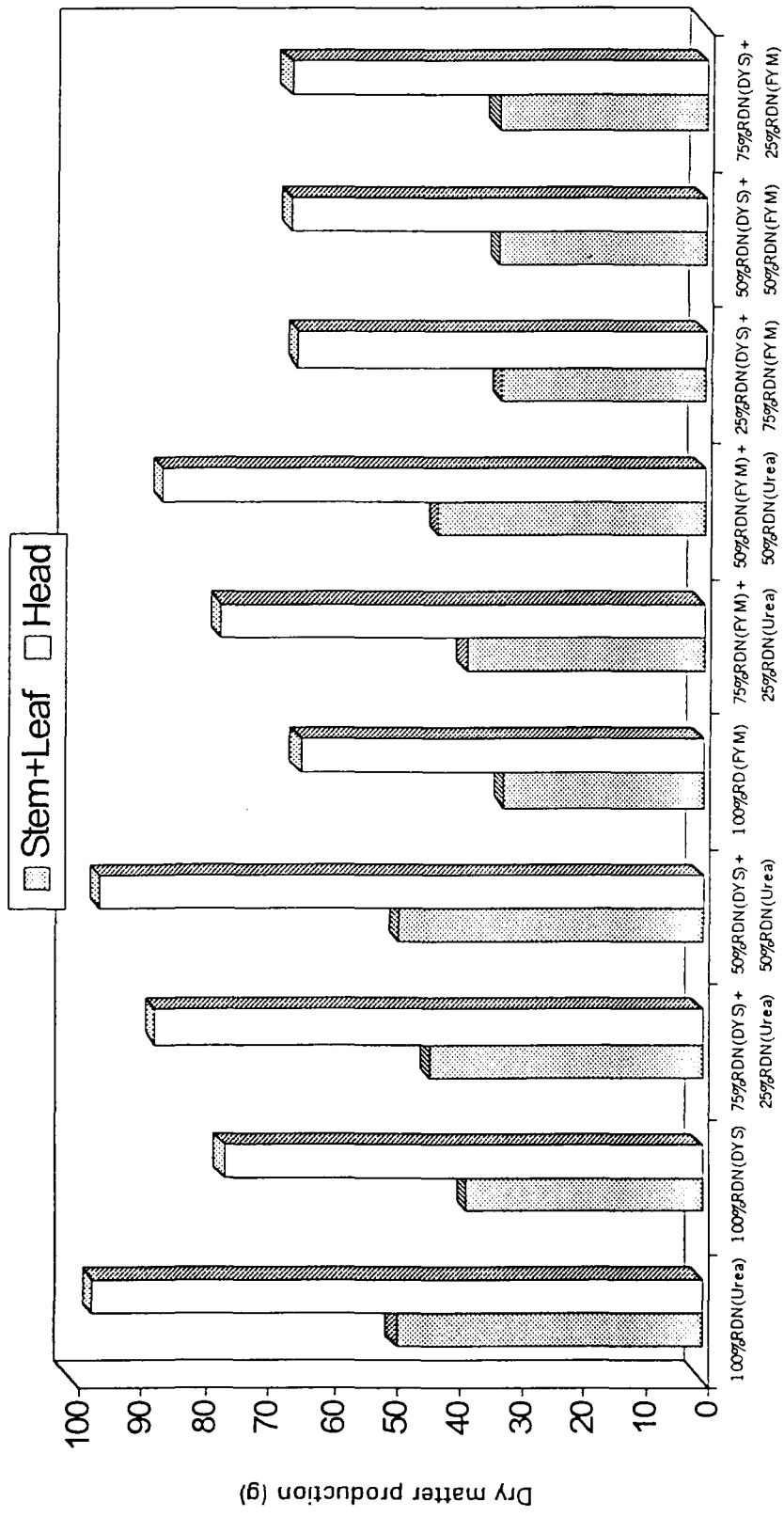
The results of the field experiment conducted during *rabi* season of 2001-02 to study the effect of distillery yeast sludge as a source of nitrogen on growth, yield and certain quality parameters of cabbage and soil properties are discussed in this chapter.

### 5.1 GROWTH, YIELD AND YIELD ATTRIBUTES OF CABBAGE AS INFLUENCED BY DIFFERENT SOURCES OF NITROGEN

The yield of cabbage differed significantly due to different sources of nitrogen. Application of nitrogen as 100 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea) recorded higher yields over all other treatments. These results are in conformity with the findings of Sukanya (2002), who also observed higher yields of maize and wheat when recommended dose of nitrogen was supplied as 100 per cent N through urea and 50 per cent N (DYS) + 50 per cent N (Urea).

Among the treatments involving FYM, application of nitrogen through FYM along with urea produced higher yields compared to when N was applied as FYM. These results corroborate the findings of Kropiszcz (1992) in cabbage, and Subbaiah *et al.* (1983) in brinjal.

Distillery yeast sludge proved to be better source of nitrogen which gave higher yields (29.28 t/ha) when applied at the rates of recommended dose of nitrogen compared to N applied through FYM (24.12 t/ha). These results confirm the superiority of yeast sludge over FYM. According to the findings of Mbagwuu and Ekwealor (1990) who also reported higher yields of maize due to brewer's spent grain over inorganic fertilizers.



Treatments

Fig. 2. Effect of distillery yeast sludge on dry matter production of cabbage at harvest

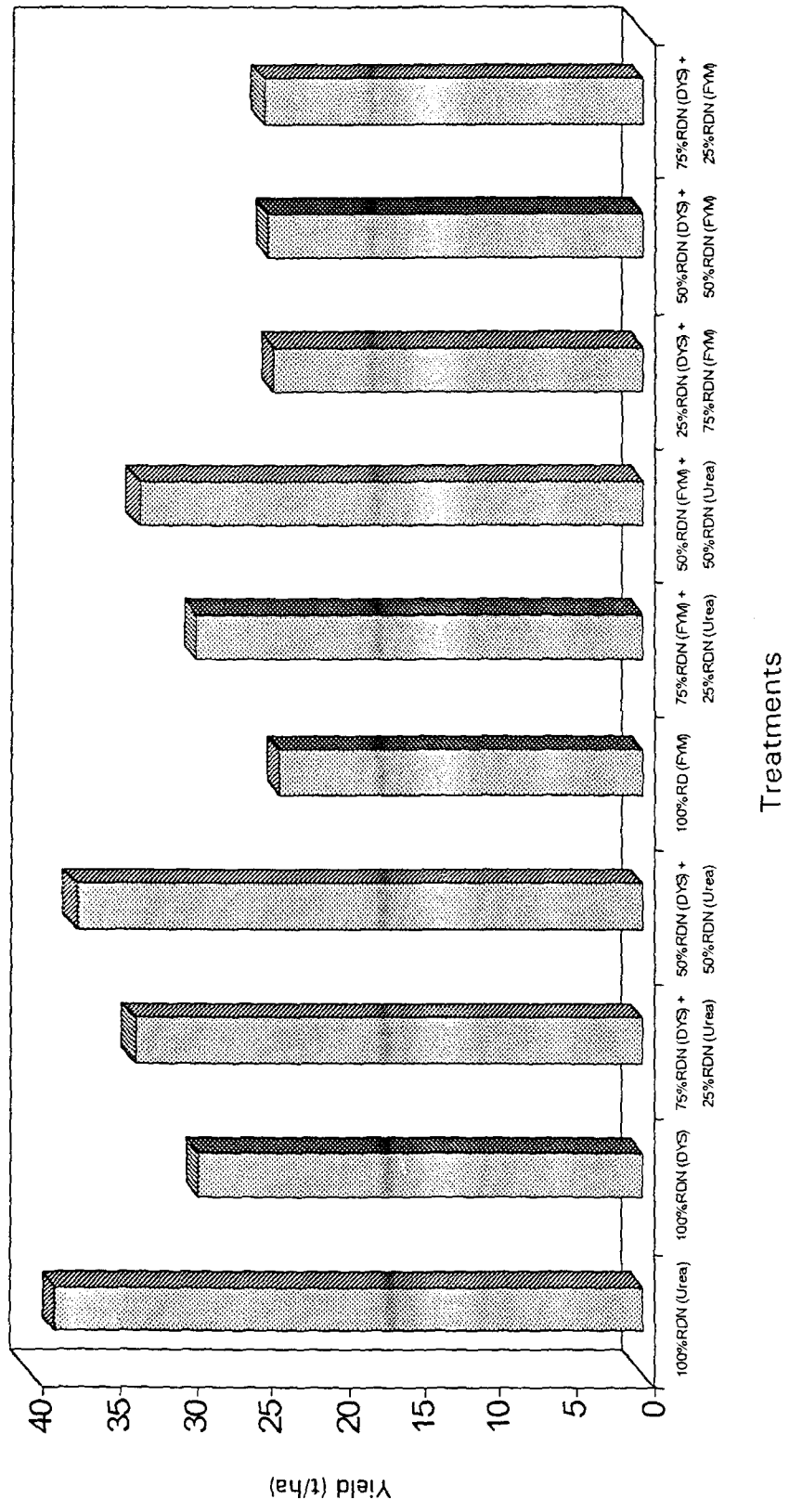


Fig. 3. Effect of distillery yeast sludge on yield of cabbage

Yield is the manifestation of yield attributing characters like fresh weight of head, head diameter and number of inner leaves. The significant increase in yield of cabbage due to sources of nitrogen could be attributed to increased growth and vigour of plant as evidenced by increased growth attributes like number of leaves, plant spread, total dry matter production and number of days required for initiation of head. This in turn might have increased the yield attributing characters like photosynthetic potential, biomass total dry matter and diameter of head.

The increase in the yield and yield attributing characters with the application of 100 per cent N through urea and the treatment 50 per cent N (DYS) + 50 per cent N (Urea) is attributed to the readily available nitrogen and other nutrients, in soil, which have provided a suitable medium for enhanced growth. The treatments receiving 100 per cent recommended dose of N through yeast sludge and yeast sludge in combination with urea increased yield and yield attributing characters over treatments receiving N through FYM. This is because of faster mineralization of nitrogen due to narrow C:N ratio (11:1) as evidenced by its chemical composition. These results are similar to the findings of Larry (1984), who observed the higher mineralization of nitrogen in fermentation wastes. Thus the crop has suffered for the want of nitrogen and hence reduced growth and lesser yields.

## 5.2 QUALITY PARAMETERS

The quality parameters like protein and ascorbic acid content in cabbage did not differ significantly due to sources of nitrogen. Mohan Singh *et al.* (1993) observed no changes in quality parameters of cane juice due to application of distillery effluent upto 500 m<sup>3</sup> ha<sup>-1</sup>. However numerically higher

ascorbic acid content was observed in the treatment receiving N through yeast sludge and FYM compared to urea.

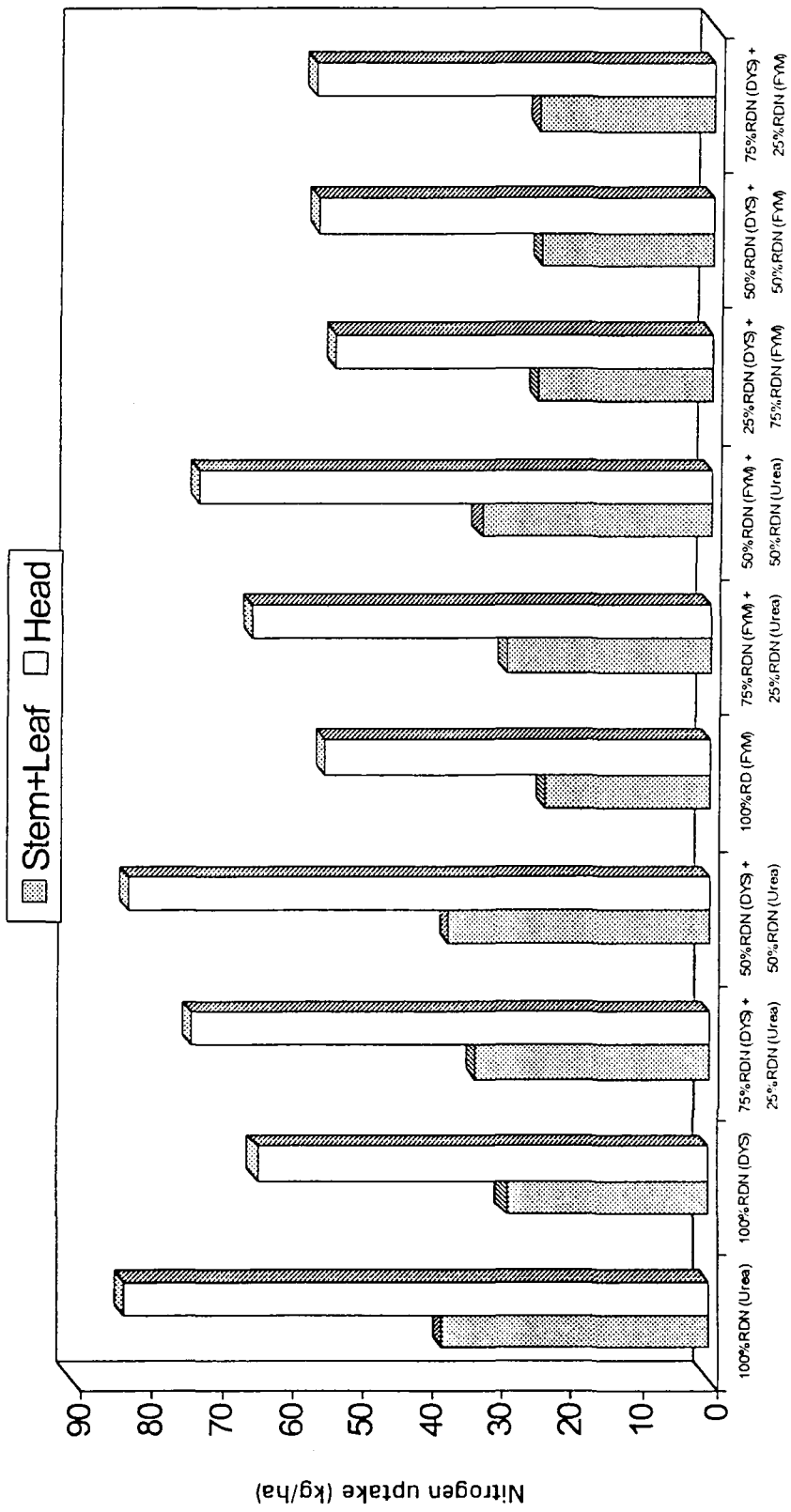
### 5.3 NUTRIENT CONTENT AND UPTAKE

The nutrients play a major role in increasing growth and ultimately yield of crop. The concentration of nutrients in plants decreased with the age of crop. This is attributed to the dilution effect caused by the increase in plant biomass and translocation of nutrients from vegetative parts to the reproductive parts (Mahendran *et al.*, 1996).

The nitrogen uptake was found highest in the treatment 100 per cent N (Urea) followed by the treatment 50 per cent N (DYS) + 50 per cent N (Urea). The probable reason was due to the supply of N in most readily available form to the crop through out the growing period. While, the FYM treated plots recorded lower uptake compared yeast sludge. This is because of the immobilisation of nitrogen by soil microorganisms and hence slower release. So crop recorded lesser of nitrogen. Chatterjee *et al.* (1979) also reported that FYM did not release as much available N as spent hop (Waste from brewarage industry) applied @ 10 t ha<sup>-1</sup> for rice crop.

Similarly the phosphorus and potassium uptake was found highest in the treatments 100 per cent N (Urea) and 50 per cent N (DYS) + 50 per cent N (Urea). This is because of the enhanced growth of the crop which had absorbed more nutrients than a crop with slow growth.

The micronutrient uptake in the yeast sludge treated plots were found non significant. This is because of higher nitrogen content, consequently lower quantities of sludge were added to the plots to supplement substituted quantities of recommended dose of nitrogen. Sukanya (2002) also observed



Treatments

Fig. 4. Effect of distillery yeast sludge on nitrogen uptake by cabbage at harvest

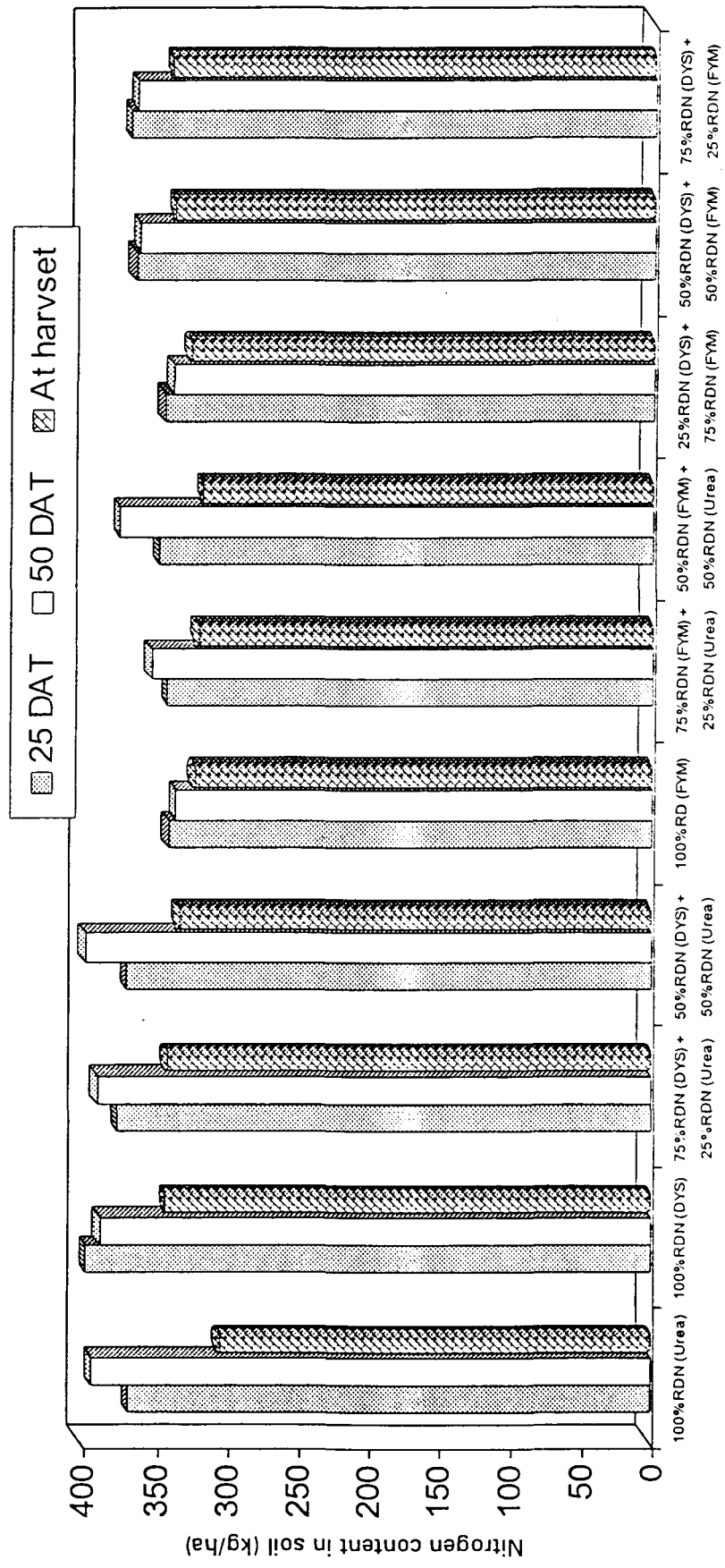
similar results when yeast sludge was used to substitute recommended doses of N for maize and wheat crops. On the other hand Paulraj and Sree Ramulu (1994) observed higher micronutrient content and uptake by okra, amaranthus and tomato with the higher doses (20 t/ha) of sewage sludge.

#### 5.4 PHYSICO-CHEMICAL PROPERTIES

The physico chemical properties of the soil *viz.*, bulk density infiltration rate, organic carbon, cation exchange capacity, pH and EC were not significantly influenced by the sources of nitrogen. Among all the treatments, plots receiving FYM have recorded higher organic carbon, CEC, IR and lower bulk density over the plots treated with yeast sludge. This is because of the addition of higher organic carbon through FYM compared to yeast sludge. The non-significant change in the physical properties is attributed to the smaller quantities of yeast sludge addition for only one season. Jeffrey *et al.* (1993) observed non significant changes in pH, EC and CEC of the soil due to the application of sewage sludge @ 8 and 24 t ha<sup>-1</sup> for four years. On the other hand Zibilske *et al.* (2000) observed the significant changes in the soil bulk density and organic carbon due to the application of paper mill sludge @ 90 t ha<sup>-1</sup> and above rates for four years in maize cropping system.

#### 5.5 AVAILABLE NUTRIENTS IN SOIL

Application of yeast sludge had a marked influence on the available nitrogen content of the soil. Among different treatments yeast sludge treatments recorded higher nitrogen in soil compared to FYM treated soil. The increased nitrogen status may be attributed to the high N content and faster mineralization of nitrogen from yeast sludge due to its narrow C:N ratio (11:1) as evidenced by its chemical composition. On the other hand the wider C:N ratio of FYM was responsible for lesser release because of the immobilization



Treatments

Fig. 5. Effect of distillery yeast sludge on soil available nitrogen content at different growth stages of cabbage

of N by microorganisms. Chatterjee *et al.* (1979) also observed lesser release of nitrogen from FYM compared to spent hop (waste from brewerage industry) in paddy soils. The higher nitrogen status of soil in inorganic treatment was due to the faster release of nitrogen from urea.

The phosphorus and potassium contents in soil was found to be higher in the treatments involving FYM compared to yeast sludge. This is because of the addition of increased amount of P and K through FYM besides the application of P and K through inorganic fertilizers.

The micronutrient status in soil did not differ significantly. This might be because of addition of smaller quantities of yeast sludge to supplement recommend dose of N to the soil. Sukanya (2002) also found non-significant changes in the micronutrient status of the soil when yeast sludge was used to supplement the recommended dose of nitrogen for maize and wheat. However, the treatments receiving N from FYM recorded numerically higher micronutrient status because of the higher addition of micronutrients through FYM.

## **5.6 MICROBIAL POPULATION**

The application of organic sources of nitrogen had a marked influenced on the microbial population in soil. The addition of recommended dose of nitrogen through FYM recorded the higher microbial population compared to yeast sludge. This might be because of the higher addition of organic carbon and microbial load through FYM compared to yeast sludge. The addition of recommended dose of nitrogen through urea recorded the lowest microbial population. This might be because increased microbial population in soil due to the addition of organic carbon, which is the substrate for growth and development.

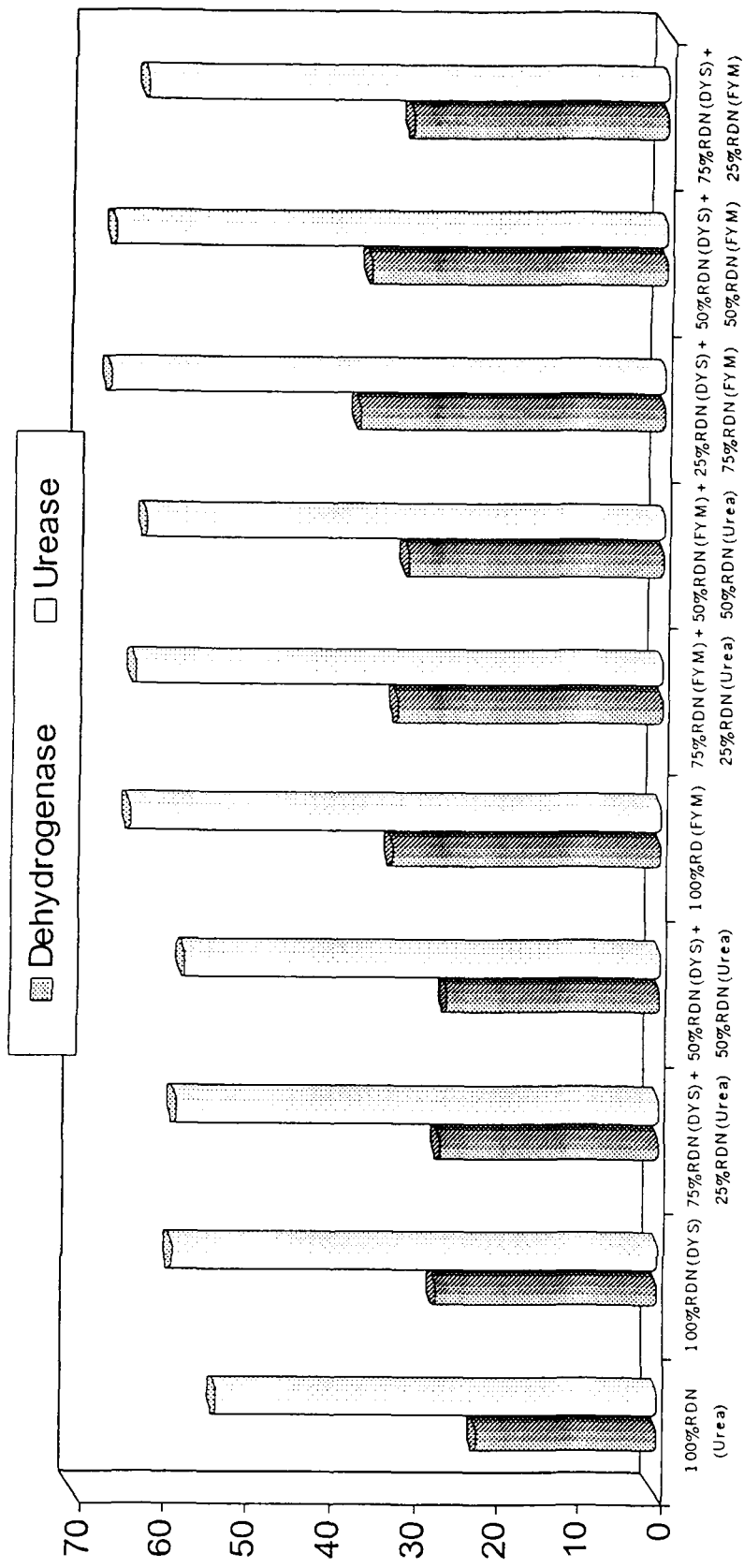
## 5.7 SOIL ENZYMES ACTIVITY

The soil enzymes dehydrogenase and urease activity increased with the increase in the addition of organic carbon through FYM and sludge. The addition of inorganic fertilizers had no influence on the enzyme activity. This could be due to the lower microbial count in these treatments. The increase in dehydrogenase activity in FYM treated plots compared to yeast sludge was attributed to the increase in microbial population. Goyal and Kapoor (1995) also reported that the dehydrogenase activity is directly related to the microbial count in soil.

Similarly the urease activity was found highest in FYM treated plots compared to yeast sludge and other treatments. This is because, the urease activity is directly related to the organic carbon content in soil. On the other hand the addition of urea did not influence the urease activity. These results confirm the findings of Bari *et al.* (1978) who reported that urease activity was controlled by soil organic carbon rather than the addition of urea upto 250 ppm.

## 5.8 ECONOMICS

Economic analysis of sources of nitrogen involving FYM, yeast sludge and urea indicated that application of organic manures (FYM) at different levels decreased the B:C ratio. The decrease in B:C ratio was due to increase in cost of cultivation. The cost of cultivation in treatments containing FYM increased over other treatments because of application of relatively more quantities of FYM which increased the cost of cultivation to substitute the given levels of nitrogen.



Treatments

Fig. 6. Effect of distillery yeast sludge on dehydrogenase (μg of TPF/g soil/day) and urease (μg of NH<sub>3</sub>/g soil/day) enzymes activity at 50 days after transplanting cabbage

The B:C ratio was highest (3.71) in the treatment 50 per cent N (DYS) + 50 per cent N (urea) because of lower cost of cultivation as DYS was available free of cost. Recommended dose of nitrogen supplied through urea showed a B:C ratio (3.70) which was nearest to the treatment 50 per cent N (DYS) + 50 per cent N (urea).

Thus from the foregone discussion it is clear that application of yeast sludge to substitute costly inorganic nitrogen fertilizer seems to be beneficial. The treatment 50 per cent N (DYS) + 50 per cent N (urea) is better treatment which recorded results on par with respect to growth and yield of cabbage as compared to 100 per cent N (Urea), besides improving the biological and physical properties of soil.

#### **FUTURE LINE OF WORK**

- 1) **More adaptive research is needed to study the long term effect of distillery yeast sludge on soil properties especially physical and chemical properties.**
- 2) **Research is needed to study the higher rates of application of distillery yeast sludge on crops and soil.**
- 3) **Studies are also needed to find out the nitrogen mineralizing pattern and leaching losses of nitrogen.**
- 4) **The accumulation of heavy metals on plants and soils especially lead needs to be studied.**

*Summary*

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## VI. SUMMARY

A Field experiment was conducted at Garag village of Dharwad district during *rabi* 2001-02 with an objective of studying the effect of distillery yeast sludge as a source of nitrogen on growth and yield of cabbage and soil properties and also to explore the probability of using yeast sludge as an organic manure. The experiment was laid out in randomized complete block design with three replications. The salient findings of this investigation are summarized here under.

1. Application of 50 per cent N (DYS) + 50 per cent N (urea) recorded higher growth and growth attributes (no. of leaves, dry matter and plant spread of cabbage) which were found on par with the treatment 100 per cent N (urea). The treatment 50 per cent N (DYS) + 50 per cent N (urea) produced significantly higher growth of cabbage compared to the treatment 50 per cent N (FYM) + 50 per cent N (urea).
2. A significantly highest yield (38.37 t/ha) of cabbage was recorded in the treatment 100 per cent N (urea) and was found on par (37.34 t/ha) with the treatment 50 per cent N (DYS) + 50 per cent N (urea). The lowest yield (24.12 t/ha) was recorded in the treatment 100 per cent N (FYM).
3. The quality parameters *viz.*, protein and ascorbic acid content of cabbage did not differ significantly due to different sources of nitrogen.
4. The physico-chemical properties of the soil did not differ significantly due to different sources of nitrogen. However, an improvement in the physical properties was observed in FYM applied treatments followed by yeast sludge.

5. The highest microbial count (bacteria :  $54.30 \times 10^6$ , fungi  $46.00 \times 10^4$  and actinomycetes :  $43.00 \times 10^4$ /g soil) was observed in the treatment 25 per cent N DYS + 75 per cent N FYM. Similarly the enzymes activity was found highest in the treatment 25 per cent N DYS + 75 per cent N FYM (dehydrogenase  $34.82 \mu\text{g}$  of TPF/g soil/day and urease  $62.89 \mu\text{g}$  of  $\text{NH}_3$ /g soil/day) was observed. The lowest microbial count and enzymes activity was found in the treatment 100 per cent N (Urea).
6. The application of yeast sludge resulted in higher nutrient uptake  $119.56 : 29.26 : 113.49$  NPK  $\text{kg ha}^{-1}$  in treatment 50 per cent N (DYS) + 50 per cent N (urea) and found on par with the treatment 100 per cent N (urea) which recorded the highest uptake ( $120.77 : 29.84 : 115.37$  NPK  $\text{kg ha}^{-1}$ ). The micronutrient uptake was not significantly influenced due to the application of different sources of nitrogen.
7. The application of recommended dose of nitrogen through (urea) gave highest net income of Rs. 62086/- and benefit : cost ratio of 3.70 followed by the treatment 50 per cent N (DYS) + 50 per cent N (urea) Rs. 60056/- with a B:C ratio of 3.71. The lowest net income of Rs. 26087/- and B:C ratio 1.97 was observed in the treatment where in 100 percent recommended dose of N was supplied through FYM.

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*Appendix*

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**Appendix I. Prices of inputs and produced used in cabbage cultivation**

Sl.No.	Inputs	Prices (Rs.)
1.	Cabbage seeds (Pride of India)	300/kg
2.	Fertilizers and manures	
	a. Urea	445/q
	b. Single super phosphate	320/q
	c. Muriate of potash	425/q
	d. FYM	225/t
	e. Distillery yeast sludge	-
3.	Plant protection chemicals	
	Dithane M-45	190/kg
	Quinalphos	250/l
	Endosulfan	220/l
	Nuvacron	280/l
	Curacron	380/l
4.	Knapsack sprayers	50/day
5.	Labour wages	
	a. Men	40/day
	b. Women	40/day
6.	Bullock pair with a man/day for 8 hours	150
7.	Miscellaneous	
	a. Marketing and handling charges	9/q
	b. Land rent	150/ha/season
	Out put	
1.	Market price of cabbage heads	2.20/kg

**Appendix II. Quantities of FYM, yeast sludge and fertilizers required for the experiment**

Sl. No.	Particulars	To supply 100 per cent RDN
1.	FYM	30 t/ha
2.	DYS	5.8 t/ha
3.	Urea	326.1 kg/ha
4.	SSP	625 kg/ha
5.	MOP	208.3 kg/ha



# **EFFECT OF DISTILLERY YEAST SLUDGE AS A SOURCE OF NITROGEN ON GROWTH AND YIELD OF CABBAGE AND SOIL PROPERTIES**

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**2002**

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## **ABSTRACT**

A field experiment was conducted at Garag village of Dharwad district during *rabi* 2001-02 on a clay soil to study the effect of distillery yeast sludge as a source of nitrogen on growth and yield of cabbage and soil properties. The treatments consisted of three sources of nitrogen (urea, DYS and FYM) and their combination at different levels. The experiment was laid out in randomised complete block design with ten treatments replicated thrice.

Among various treatments, maximum number of leaves (24.27), plant spread (33.31 cm) and head yield (38.67 t/ha) were recorded in the treatment 100 per cent N through urea. However, the results obtained were on par with the treatments receiving 50 per cent N through DYS + 50 percent N through urea. The protein and ascorbic acid contents of cabbage were not influenced by the different sources of nitrogen.

The soil analysis after the harvest of crop revealed that the soil physical properties were not significantly influenced by the treatments. The maximum available N (341.4 kg/ha) in soil was noticed in the treatment 100 per cent N through DYS. The highest available P and K content were observed in the treatment 100 per cent N through FYM. The micronutrient contents of soil remained unaffected. The highest microbial population and enzymes activity (dehydrogenase and urease) were recorded in the treatment 25 per cent N through DYS + 75 per cent N through FYM and was on par with 50 per cent N through DYS + 50 per cent N through FYM treatment.

Economic analysis indicated that application of organic sources of nitrogen increased the cost of cultivation. The highest net returns (Rs.62086) was obtained in the treatment 100 per cent N through urea. Whereas, the highest B:C ratio (3.71) was observed in the treatment 50 per cent N through DYS + 50 per cent N through urea.