

**MANAGEMENT OF CLAY SOILS OF SOUTH GUJARAT FOR
IMPROVING YIELD AND QUALITY OF ONION (*Allium cepa* L.)**

A

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**MANAGEMENT OF CLAY SOILS OF SOUTH GUJARAT FOR
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A B S T R A C T

The present study was carried out in three parts *viz.*, survey, incubation and field experiment. In order to obtain views of onion growers regarding cultural practices followed by them a survey was conducted. Simultaneously an incubation study was under taken for evaluating the effect of integrated nutrient management (INM) in presence and absence of soil conditioner (gypsum) on periodical nutrient availability under laboratory condition. Similarly, field experiment with 12 treatment combinations was carried out at Soil and Water Management Farm, Navsari Agricultural University, Navsari during *rabi* season of 2003-04 for assessing the effect of 2 land configuration (flat bed and raised bed), 2 levels of soil conditioner (gypsum 0 t/ha and 6t/ha) and 3 INM treatments : F₁= recommended dose (RD) through fertilizer, F₂ = ½ RD + FYM and F₃ = ½ RD + press mud (PM) on growth, yield, nutrient uptake, soil properties as well as on losses during storage and quality parameters of onion.

The survey data indicated that most of the farmers (90%) are planting onion on flat bed and did not apply gypsum (84%) as soil conditioner. Though, majority of the farmers are adopting integrated nutrient management system, yet the rate of application of organics was found to be very low.

The results of an incubation study indicated that in all the treatments involving fertilizer or fertilizer + organics and/or gypsum registered lower pH than absolute control. In case of soil salinity, significantly higher EC values were observed with treatments receiving gypsum or gypsum + organics and/or inorganic fertilizers. The organic carbon showed declining trend with increase in period of incubation. The treatments receiving $\frac{1}{2}$ RD + either FYM or PM in presence or absence of gypsum recorded significantly higher organic carbon content in soil as compared to control. The availability of N, P and K was higher with the treatments receiving RD through fertilizers alone and that of micronutrient availability was more with treatment receiving $\frac{1}{2}$ RD + PM followed by $\frac{1}{2}$ RD + FYM. The values of available N, P, K, S, Fe, Mn, Zn and Cu recorded at the end of incubation were 123.7, 25.08, 216.5, 31.7, 37.5, 53.8, 0.95 and 2.41 mg/kg, respectively, with treatment receiving $\frac{1}{2}$ RD + PM. The corresponding values with control were 100.9, 18.30, 147.8, 5.9, 26.6, 35, 0.57 and 2.20.

Better plant height and number of leaves per plant were recorded with raised bed planting than flat bed. An application of gypsum as a soil conditioner favourably influenced

the plant height, number of leaves and dry matter production at all the growth stages of onion. Irrespective of treatments, rate of dry matter production by onion was found to be maximum at 40 and 80 DAP. All the beneficial effects of land configuration and soil conditioner were positively reflected on bulb and leaves yields. The raised bed planting increased the bulb yield by 8.5 per cent over flat bed and application of gypsum as soil conditioner @ 6 t/ha improved bulb yield by 10 per cent over no gypsum application.

The treatment effects on periodical nutrient content in leaves and bulb were not affected significantly in most of the cases. Based on nutrient uptake pattern, N requirement of onion was found to increase up to grand growth stage (80 DAP) and declined thereafter, while K removal by onion during all the stages was almost equal. The proportion of S uptake at grand growth and harvesting stages was more or less similar but it was less at bulb initiation stage. Almost similar pattern of treatment effect was also observed for Fe uptake by onion at different growth stages, while in case of Zn its requirement was found to be maximum during 80-120 days after planting. Planting of onion on raised bed, application of gypsum and conjunctive use of organics and inorganic fertilizer maintained their superiority in nutrient uptake over respective controls. The TSS and reducing sugar content in onion tended to increase with storage time but non-reducing sugar as well as total sugar showed declining trend. Among the INM treatments, F₃ maintained its superiority in all the quality parameters during the whole period of storage over rest of the treatments (F₁ and F₂). At all the samplings (30, 60, 90 and 120 DAS), physiological loss in weight, sprouting and total losses were significantly lower with F₃ than F₁, whereas rotting loss was found to be minimum with F₂. Use of fertilizer alone

resulted in 27 per cent total loss of onion bulb as against 20 to 22 per cent total loss with INM treatments.

Raised bed land configuration registered lower EC values than flat bed while application of gypsum increased the soluble salt contents in soil at all the samplings *i.e.*, 40, 80 and 120 DAP. Amending soil with organics *viz.*, FYM or PM along with $\frac{1}{2}$ RD of fertilizer increased the organic C status of soil significantly as compared to RD only. The higher content of available N and P in soil was observed with FYM and PM after harvest of crop. An increase in available Fe content in soil was observed wherein gypsum and organics were applied.

Between the two land configurations, raised bed significantly improved the infiltration rate (IR) and water stable aggregates (WSA). Application of soil conditioner also enhanced both IR as well as WSA by 34 and 4 per cent, respectively over its no application. Use of FYM along with $\frac{1}{2}$ RD of NPK fertilizers tended to hasten IR and WSA by 29 and 11 per cent, respectively over use of fertilizer alone. Similarly, the extent of increase in IR and WSA with use of $\frac{1}{2}$ RD + PM was 23 per cent and 6 per cent, respectively over application of fertilizer alone.

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C E R T I F I C A T E

This is to certify that the thesis entitled, “**MANAGEMENT OF CLAY SOILS OF SOUTH GUJARAT FOR IMPROVING YIELD AND QUALITY OF ONION (*Allium cepa* L.)**” submitted by **Shri. SURESH BHAGWAN DODAKE** in partial fulfilment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY (Agriculture)** in the subject of Agricultural **Chemistry and Soil Science** of the Navsari Agricultural University, Navsari is a record of bonafide research work carried out by him under my guidance and supervision and that the thesis has not been previously formed the basis for the award of any degree, diploma or has been published for other similar title. All the assistance and help received during the course of the investigation have been duly acknowledged by him.

Place: Navsari

Date: December, 2005

(R.G. Patil)

Major Advisor

DECLARATION

This is to declare that the whole of the research work reported here in the thesis for the partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY in Agricultural Chemistry and Soil Science** by the undersigned is the result of investigation done by him under direct guidance and supervision of **Dr. R. G. Patil**, Research Scientist, Soil and Water Management Research Unit, NAU, Navsari, and no part of the work has been submitted for any other degree so far.

Place: Navsari

Date: December, 2005.

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(S.B. Dodake)

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I INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important conventional vegetable crops grown in India. It has been widely used in salads, pickles, chutney, stew for flavoring and as a cooked vegetables as well as for the preparation of other products and extracts like onion powder, onion salts etc. It contains vitamin B and C and traces of iron, calcium and sulphur. Besides, it has medicinal value also. Eleven of the common amino acids are found in significant amounts in onion bulbs. The carbohydrates make up the bulk of the dry matter of onion bulbs.

India is the second largest producer of onion in the world with annual production of 5.25 mt from an area of 0.49 mha during the year 2001. Onion constitutes around 8.2 per cent of the total cropped area covered under vegetable crops and it shares 6.0 per cent of the country's vegetable production (Rai and Pandey, 2005). The leading onion producing states in the country are Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh, Tamil Nadu and Uttar Pradesh. In Gujarat area under onion crop was around 51, 497 ha with an average productivity of about 25.54 t/ha during the 2003-04 (Anon., 2004). The major onion growing districts in Gujarat state are Bhavnagar, Amreli, Junagadh, Rajkot, Jamnagar, Surat and Valsad.

Onion responds remarkably to fertilizers and manures. But the liberal use of inorganic fertilizers alone led to stagnation or decline in the productivity possibly due to micronutrients

deficiency and degradation of soil biophysical conditions. Integrated use of fertilizer and organic manures seems to be a remedy to the existing situation. Owing to the energy crisis and high cost of fertilizers, microbial inoculants and organic manures for supplementing a part of nitrogen requirement has attained immense importance (Verma *et al.*, 2003).

Many by products obtained from factory/ industry have good potential for their use in agriculture. Carbonated or sulphonated press mud obtained as a by- product from sugar factory contained high amount of organic carbon, nutrients like N, P, K, S, micronutrient etc. (Abubacker and Rao, 1995). Efforts have been made by many workers (Patel and Singh, 1991; Dang and Verma, 1996, and Raman *et al.*, 1996) for using pressmud and other industrial solid wastes either as an alternative source of FYM or for partial substitution of inorganic fertilizer for improving soil fertility.

Soil conditioner plays an important role in increasing the crop yield by favourably influencing the soil physical conditions. These conditioners supply plant nutrients and also enhances the nutrient availability by improving the physical environment of soil. Calcium sulphate popularly known as gypsum is a by-product of fertilizer industry, which is amply available and generally inexpensive material. It has wide range of agronomic applications because of its favourable effect on both soil physical and chemical properties. The phosphogypsum was more effective in maintaining infiltration rate than mined gypsum

because of its much higher dissolution rate (Keren and Shaiberg, 1981). In the sodic soils with very poor physical properties, the use of gypsum for soil reclamation results in a marked improvement in tilth while on marginally sodic or non saline soils which are dispersive, gypsum usage may increase yield through improvement in infiltration and aggregation (Anon, 2003).

Land management also plays a major role in maximizing infiltration, minimizing soil erosion and improving water use efficiency of different crops. Broad bed and furrow system is an effective land configuration for maximizing rainfall infiltration, minimizing erosion, total run off, facilitated drainage and ultimately improves water use efficiency. The raised bed zone of broad bed and furrow system was better aerated with lower penetration resistance and favourable for deeper seed placement and better crop emergence (Jayapaul *et al.*, 1996). Land configuration comprising 6 or 9 m wide, 30-35 cm high raised beds intervened by sunken beds of 6 m width are suitable for improving productivity of Vertisols in Central India (Painuli *et al.*, 2002). Ridge planting not only improved the grain yield but also the crop growth in general was better as compared to flat bed (Tomar *et al.*, 1996).

Onion is perishable because of high moisture content in bulb at the time of harvesting. This crop has received very little attention on a nutritional aspect in relation to storage. Onion produced with farmyard manure alone or in combination with ammonium sulphate is believed to be safely stored. General belief

is that onions grown with FYM have more storage life than those grown with inorganic fertilizers (Anon., 1987).

In Gujarat, the productivity of onion is declining and consequently there is tremendous decrease in the area under this crop (Anon., 2001). Some of the causes responsible for low productivity of onion particularly in South Gujarat are: i) high clay containing soils, ii) puddling done for *Kharif* paddy further deteriorates soil physical conditions and iii) poor nutrient management. As such no work on increase in productivity of onion grown on heavy paddy soils with high clay content (> 45%) and to make it more remunerative through appropriate land configuration, use of soil conditioner and effective nutrient management has been done under South Gujarat conditions. Hence, present investigation was proposed to under take with the following objectives.

- 1) To study the effect of INM in presence and absence of soil conditioner (gypsum) on nutrient availability under laboratory condition.
- 2) To evaluate the individual and combined effects of land configuration, soil conditioner and INM on yield and quality of onion.
- 3) To investigate the individual and combined effects of land configuration, soil conditioner and INM on content and uptake of nutrients by onion.

- 4) To monitor the soil chemical and physical changes periodically as influenced by individual and combined effect of land configuration, soil conditioner and INM.
- 5) To study the individual and combined effects of land configuration, soil conditioner and INM on keeping quality and losses during storage of onion.

II REVIEW OF LITERATURE

The productivity and storage quality of onion bulbs largely depends on many factors like climate, soil type, proper dose and time of fertilizer application, irrigation schedule, cultivars, season of planting and plant density. Among these, judicious use of organic and inorganic fertilizers coupled with appropriate land configuration and use of soil conditioner are major factors, which govern the yield and storage quality of onion bulb. The work done especially on these aspects of onion crop is very meager and hence similar work on the other crops has also been included whenever felt necessary. An attempt is made here to review the research work done related to only these aspects under the following subheads:

- 2.1. **Effect of nutrient management on yield**
 - 2.1.1. Effect of inorganic fertilizers
 - 2.1.2. Effect of integrated nutrient management
- 2.2. **Effect of nutrient management on chemical composition of plant**
- 2.3. Effect of nutrient management on storage and quality parameters
 - 2.3.1. Effect on storage losses
 - 2.3.2. Effect on quality parameters
- 2.4. Effect of land configuration on yield and soil properties
- 2.5. Effect of soil conditioners on yield and properties of soil
- 2.6. Effect of nutrient management on soil properties
- 2.1** **Effect of nutrient management on yield**
- 2.1.1** **Effect of inorganic fertilizers on yield**

Narang and Dastane (1971) conducted green house and

field trials and obtained high responses of onions to nitrogen, moderate to phosphate and no response to potash and negative to sulphur. Maximum bulb yield was obtained with 70 kg N/ha.

Pande and Mundra (1971) reported that application of N significantly increased the plant height, number of leaves, diameter of bulbs, fresh and dry weight of top growth and yield of bulbs per hectare. Application of P also significantly increased all the growth parameters which were increased by N, however, K application did not increase the growth and yield characters of onion bulbs.

Jogoda *et al.* (1972) studied the effect of irrigation, mineral and organic fertilizers on onion and observed that sprinkler irrigation plus fertilizers resulted in a 60-70% increase in commercial onion yield. The optimum N rates for irrigated and unirrigated plants were 133-200 and 67-133 kg/ha, respectively.

Bhuiya *et al.* (1974) in a fertilizer trial on onion observed that application of N, P K each @ 56.05 kg/ha significantly increased the yield.

The manurial requirement of onion in Gangetic alluvium of Uttar Pradesh was assessed by Agrawal *et al.* (1981). They found that the growth and yield of onion improved significantly by nitrogen fertilization. The effect of P and K on the yield of onion was not significant. The optimum economic dose of nitrogen was worked out to be 105 kg N /ha. The

treatments of N₁₆₀ P₄₀ K₄₀ and N₈₀ P₄₀ K₄₀ being at par among themselves and showed significant improvement in plant growth, bulb development and yield of onions over rest of treatment combinations.

Saimbhi and Randhawa (1983) studied influence of 6 levels of N (0, 25, 50, 75, 100 and 125 kg/ha) 3 levels of P₂O₅ (0, 30 and 60 kg/ha) and reported that levels of N higher than 75 kg/ha and levels of K₂O higher than 60 kg/ha did not cause significant influence on bulb yield and total dry matter. The P₂O₅ level of 60 kg/ha gave the maximum bulb yield and dry matter/ha.

Palled *et al.* (1988) reported that application of 100 kg N/ha had 12.2 and 26.6% higher yield over 75 and 50 kg N /ha respectively.

Shukla and Prabhakar (1989) carried out field experiment at IIHR; Bangalore to study the effect of spacing, nitrogen and phosphorus levels on onion and observed that closer spacing (15 x 10 cm) and N fertilization with 75 kg N/ha were found optimum for onion (cv. Nasik Red) grown on sandy clay loam soil of Bangalore.

Singh *et al.* (1987) reported that with increasing levels of nitrogen from 0-120 kg/ha brought spectacular increase towards bulb yield and other attributes with yield and quality parameters. Highest bulb yield i.e. 19.2 t/ha was obtained due to combine use of twenty irrigations + 120 kg N/ha.

Srinivas and Naik (1987) carried out experiment in

order to study the growth and yield of onion cultivars in relation to nitrogen fertilization and found that higher dry matter production, leaf area index and leaf area duration were obtained with cv. Arka Niketan. Nitrogen fertilization enhanced the dry matter production and the highest bulb yield was recorded with 200 kg N /ha however, the optimum nitrogen dose worked out to be 191 kg/ha with yield level of 55.5 t/ha.

Singh and Dhankhar (1989) in a two years trial with cultivars Pusa Red and Hisar-2, different levels of N, P and Zn significantly affected growth, yield and quality of onion. Higher levels of nitrogen (N 160; 120 kg/ha) increased plant growth. Application of potash (K_2O 100 kg/ha) alone and in combination with Zn (K_2O 100 kg/ha + $ZnSO_4$ 25 kg/ha) reduced bolting, neck thickness and increased plant growth dry matter and bulb yield.

Jana and Kabir (1990) evaluated the response of onion cv. Nasik Red to sulphur under hilly region of Darjeeling, West Bengal. They found that the application of 30 kg sulphur per hectare along with 100 kg N, 60 kg P and 100 kg K was the ideal combination of nutrient for raising maximum yield of onion.

Patel and Patel (1990) carried out field experiment in *rabi* seasons for three years with view to find optimum dose of nitrogen and phosphorus for getting maximum onion yield. The treatment combinations comprised of five levels of nitrogen (0, 30, 60, 90 and 120 kg/ha) and three levels of phosphorus (0, 30 and 60 kg/ha). They found that differences in yield of bulbs due to levels of nitrogen were found to be significant; however, it

remained unaffected by varying levels of phosphorus. The nitrogen dose of 100 kg/ha was found to be the optimum for security high yield of onion per hectare.

Singh and Rajput (1992) observed that application of varying levels of nitrogen and phosphorus markedly stimulated various growth characters and yield. The high dose of N (200 kg N /ha) maximally promoted to the vegetative growth and yield of *Kharif* onion crop. Application of phosphorus was also effective but not to the extent of nitrogen in stimulating the various growth characters and yield.

Kar and Tiwari (1993) reported that the best morphological characters (number, length, fresh weight and dry weight of leaves and roots), and length, diameter, fresh weight, dry weight and volume of bulbs and significantly highest bulb yield was obtained with CaSO₄ @ 24 kg/ha.

Singh *et al.* (1993) evaluated the response of *rabi* onion to nitrogen and potassium application on growth and yield. They observed that application of 100 kg N /ha without potassium have been found to be most beneficial dose for obtaining vigorous growth and highest yield of onion bulb.

Singh and Tiwari (1993) studied the effect of micronutrients (Fe, Mn, Zn, Cu and B) on yield and quality of onion and observed that highest bulb yield were recorded in combined spray of Cu (1 ppm), (3 ppm), B (0.5 ppm) and Fe (100 ppm) done at 60 and 70 DAT.

Patel and Vachhani (1993) conducted experiment at Navsari to study the effect of NPK fertilizers on the growth and yield of onion in a split plot design with three levels of nitrogen (0, 50, 150 kg/ha) and three levels of phosphorus (25, 50, 75 kg P₂O₅/ha) as main plot treatments and three levels of potash (50, 100 and 150 kg K₂O/ha) as sub plot treatments replicated thrice and reported that significantly highest plant height, number of leaves per plant, weight of bulb, diameter of bulb and bulb yield were recorded with highest level of nitrogen (150 kg/ha) and phosphorus (75 kg/ha). Application of potash did not manifest its significant effect on growth parameters and onion yield.

Sadaria *et al.* (1996) reported that application of 75 kg N/ha was found to be the optimum dose in respect of bulb yield, net return and WUE. Though the effect of P on bulb yield was found non-significant 37.5 kg P₂O₅ kg/ha registered numerically higher bulb yield.

Chopade *et al.* (1998) observed that the treatment of drip irrigation plus recommended dose of fertilizer is found superior method of irrigation and fertilization for onion. Among fertigation treatments the treatment of fertigation by liquid fertilizer at the rate of 50 per cent recommended dose of solid fertilizer is better treatment accounting 50 percent saving in fertilizer usage.

Kumar *et al.* (1998) found that the dose 150 kg N/ha was better for maximum height, length of the longest leaf, diameter of the thickest stem, number of leaves per plant, diameter

of bulb, fresh and dry weight of bulb, number of roots per plant and maximum yield of bulb onion in comparison of lower dose i.e. 75 kg N /ha ad control.

Singh *et al.* (2000) reported that 75 kg P₂O₅/ha was found better for all growth parameters and yield of onion in comparison to higher dose (100 kg P₂O₅/ha), lower dose (50 kg and 25 kg P₂O₅/ha) and control.

Singh *et al.* (2001) evaluated integrated nutrient management in rainy season onion and observed that the average weight/bulb and bulb yield increased significantly upto N 120 kg/ha and FYM 10 t/ha. However, the maximum net returns and benefit: cost ratio was recorded with N application @ 150 kg/ha and FYM application @ 10 t/ha. When the bulb yield was described as quadratic function of N x F, a combination of 148.88 kg N + 10 t FYM/ha was found to be an optimum requirement of N and FYM for maximizing onion bulb yield.

Nandi *et al.* (2002) carried out field investigations to study the effect of irrigation and fertilization on growth and yield of onion on sandy loam soil and found that the highest yields were recorded where irrigation was given at 0.55 atm. tension with the application of 150 kg N, 180 kg K and 60 kg S/ha.

Tiwari *et al.* (2002) reported that application of 75 kg N /ha gave better yield than 100 kg N /ha. Incorporation of foliar spray of N proved better than non-spray treatment for growth and yield traits.

Sharma *et al.* (2002) while studying the response of sulphur to onion observed that plant height, bulb diameter and bulb yield increased significantly with each successive increase in dose up to 30 kg/ha in heavy and 45 kg/ha in light textured soil. The increase in bulb yield at S₁₅ and S₃₀ were 8.44% and 14.66% over control in heavy textured soil while in light textured soil the values were 8.30, 15.20 and 20.27% at S₁₅, S₃₀ and S₄₅ respectively.

Qureshi *et al.* (2003) reported that nitrogen when applied as Nitro gold; a slow release source had significant effect on the growth parameters of the onion. However, the same had no influence to improving the thickness and T.S.S.

Singh *et al.* (2004) studied the effect of N and K on growth and yield of onion cv. Pusa Red and recorded significantly maximum values of various growth parameters with highest level (150 kg N/ha) over its preceding levels. Application of potassium @ 120 kg/ha significantly showed superior values of plant height, leaf length, fresh weight of onions over its preceding levels.

Dimri and Singh (2005) reported that application of FYM @ 15 t/ha produced the highest bulb weight i.e. 74.45 g with total onion yield of 29.1 t/ha. Nitrogen dose @ 120 kg/ha applied at least three split i.e. 40 kg basal, 40 kg at 30 days and the remaining 40 kg at 45 days after transplanting recorded the maximum yield of 18.80 t/ha.

2.1.2. Effect of integrated nutrient management on yield

Muzika (1986) reported that the best results were observed with the application of FYM @ 30 t/ha + N : P₂O₅ : K₂O at 120 : 90 : 90 kg/ha, which increased the onion bulb yield either grown as a one or a two years crops.

Reddy (1985) conducted a field experiment during *rabi* season on a Alfisol at Rajendra Nagar, Hyderabad and found that an application of FYM to onion @ 25 t/ha with 60 kg N/ha as basal dressing and 15-60 kg N/ha either broadcasted or incorporated had no significant effect during the early stages of growth.

Warade *et al.* (1995a) studied the effects of organic, inorganic and bio-fertilizers on yield of onion bulbs Cv. B-780 and found that increased onion yield can be obtained by applying FYM @ 40 t/ha along with mineral fertilizer @ 75 : 50 : 50 NPK kg/ha and inoculation with *A. brasilence*, thereby 25% saving in the nitrogen.

Dixit (1997) tried five levels of nitrogen (0, 45, 80, 120 and 160 kg N/ha) and 2 levels of FYM (0 and 20 t/ha) in 10 combinations. He found that, an increase in N levels increased the bulb yield of onion consistently and significantly upto 120 kg N/ha but non-significantly at higher level (160 kg N/ha). Application of FYM @ 20 t/ha also significantly increased (6.23%) onion yield compared with the control. The interaction effect of N and FYM on onion yield showed that at both the levels of FYM (0 and 20 t/ha) the effect was significant upto 120 kg N /ha, and the levels of 160 and 120 kg/ha were at par with

each other. The effect of 20 t FYM/ha compared with the control was significant except at 160 kg N/ha. Nitrogen and FYM increased the plant growth and yield characters *viz.* plant height, number of leaves, and polar diameter of bulb which ultimately increased crop yield. He concluded that application of N @ 120 kg/ha with FYM @ 20 t/ha was superior over the rest of all the treatments which increased the yield by 42.79% compared with control.

The effect of NICAST (organic manure) in comparison to recommended doses of manure and fertilizers in onion was studied by Yadav (2001). They found that out of 10 different treatments the treatment receiving recommended dose of FYM (30 t/ha) + recommended dose of N : P : K (100 : 50 : 100 kg/ha) gave the highest bulb yield (37.03 t/ha) with maximum net return and highest B : C ratio (2.79).

Geetha *et al.* (2002) studied the effect of individual and combined application of FYM (at 0, 12.5 and 25 t/ha) and K fertilizer (as muriate of potash at 0, 50, 100 and 200 kg K₂O/ha) on yield of onion cv. Nasik Red. They found that FYM @ 25 t/ha and K@ 200 kg/ha, applied individually and in combination, significantly increased the dry matter production and bulb yield at harvest.

Jayathilake *et al.* (2002) conducted experiment with 12 treatments including 2 kinds of organic manure FYM and vermi-

compost and 2 kinds of bio-fertilizers (*Azotobacter* and *Azospirillum*) either alone or in combination with chemical fertilizer and found that significantly higher plant height, leaf area, bulb weight, bulb diameter and bulb yield were recorded with application of *Azospirillum* in combination with 50% recommended N through vermi-compost and rest of N and PK through chemical fertilizers.

Alkaff *et al.* (2002) reported that the highest rate of increase in total bulb yield of onion was recorded with FYM followed by; mineral fertilizer and bio-fertilizer.

Singh *et al.* (2003) while studying the effect of FYM (25 or 40 t/ha) combined with foliar application of NPK mixture (100: 50: 50) and micronutrients (Zn, Cu and B) on growth and yield of onion. They observed that basal and foliar treatments had no significant effect on neck thickness of onions. The bulb diameter, dry matter, average weight of bulb, gross and marketable yield were highest with basal application of NPK and foliar application of 1 per cent Multik 30, 45 and 60 DAT.

On the basis of pooled data for the three years Yadav *et al.* (2004) concluded that 75 per cent recommended dose of nitrogen along with *Azospirillum* application gave significantly highest bulb yield (32.8 t/ha) in onion var Ro-1.

Dimri and Singh (2005) reported that application of FYM @ 15 t/ha produced the highest bulb weight i.e. 74.45 g with the total onion yield of 29.1 t/ha.

2.2. Effect of nutrient management on chemical composition of plant

The concentration of nutrient present in the *rhizosphere* would effect the chemical composition of the plant.

Normally, on increase in the concentration of an element in the soil would increase its content and uptake by plant. However, the response of a plant to nutrient is an integration of the effects of many factors such as soil type, soil environment and the presence of interacting nutrient in soil.

Hegde (1986) reported that N fertilizer decreased the relative water content, osmotic potential and canopy temperature but increased the N uptake and water use efficiency. The optimum level of N was found to be 150 kg/ha for onion crop.

Patel *et al.* (1992) conducted an experiment at Junagadh during winter (*rabi*) season of 1988-89 to work out irrigation, N and P requirement of onion and found that N uptake increased remarkably with an increase in N level to 80 kg/ha, but P uptake favorably influenced only when 120 kg N/ha was applied. Phosphorus had marked effect on N and P uptake. The N and P uptake increased significantly with each increment of P application. They further observed that the application of higher dose of P was responsible for better root and shoot development and resulted in higher leaf and bulb yields and consequently higher N and P uptake.

Based on the findings from a sand culture experiment on onion crop, Kumar and Singh (1994) observed that sulphur deficient plants had poor utilization of nitrogen, phosphorus and potash at all ages of growth till maturity compared to those which were supplied with sulphur. There was also definite reduction of sulphur content and catalase activity of sulphur deficient plants at

all ages.

Yadav *et al.*(1994) carried out a pot culture experiment on quality and chemical composition of bulb and leaf parts of three onion varieties as influenced by different levels of exchangeable sodium percentage and found that in onion bulb and leaf portion, concentration of P, Ca, Mg, S and Zn decreased with the increasing content of Na in plant tissue. Among the three onion genotypes Pusa Red showed maximum uptake of in (P, Na, K, Ca, Mg and Zn).

Patel and Vachhani (1994) conducted field experiment at Navsari during *rabi* season and reported that quality of onion bulb was not much affected due to nitrogen application, except for N content which was found to be significantly increased. They further observed that nitrogen and phosphorus content in the bulb accelerated with increased P levels. Similarly potassium application enhanced the nitrogen and potassium content in onion bulb but the sulphur and phosphorus content in bulb remained unaffected.

Sharma and Raina (1994) reported that P application to onion crop grown on a hill acid soil had a tremendous positive influence on P uptake. However incorporation of FYM along with P further improved the P uptake. The P use efficiency both from fertilizer and native soil source was maximum at lower dose of applied P and declined correspondingly as P application rates increased.

Singh and Pandey (1995) conducted pot culture experiment, on ten soils (inceptisols) collected from different soil series of Delhi with onion and reported that total S uptake was

significantly affected by type of soil as well as sulphur application. The uptake values obtained with 20 and 40 ppm S were significantly higher as compared to no S application.

Singh and Singh (1995) conducted study to evaluate the effect of N, P and Zn levels and FYM on yield, composition and uptake of nutrients by onion and found that nitrogen application through fertilizer at increasing rates caused a significant increase in N content in onion bulb. Application of FYM@ 10 t/ha alone and in combination with 40 kg N /ha through fertilizer was as good as 80 kg N/ha applied through urea alone. Zinc sulphate addition also enhanced the concentration of N in onion bulb significantly over control.

Meena and Singh (1998) conducted a pot culture experiment on a sandy Aridisol, sandy clay loam Inceptisol and clayey Vertisol during the *rabi* season of 1995-96 with onion as test crop and reported that sulphur uptake increased due to S application at all three levels along with Zn. A moderate dose of 20 mg S per kg soil from low S soils (Aridisol, Inceptisol) and low dose of 10 mg S, for Vertisol along with 5 mg Zn/kg soil was found to be the most appropriate. Total S removal which was enhanced by S and Zn application, particularly at the low and moderate levels.

Nagaich *et al.* (1999) studied the effect of 4 graded levels of each sulphur (0, 20, 40 and 60 kg/ha) and potassium (0, 40, 80 and 120 kg/ha) on onion and found that uptake of P, K and S significantly enhanced upto 60 kg S/ha. Uptake of P, K and S

nutrients were significantly higher under 80 kg K₂O/ha.

Mengistu and Singh (1999) reported that uptake N and P by onion bulb was superior under the treatment which received bio-fertilizers along with 50% reduced doses of N and P fertilizers. *Azospirillum* was better in improving the N uptake than P uptake while VAM was good in P uptake more than N.

Jha *et al.* (2000) conducted experiment to study the effect of P on yield and the pattern of its uptake and utilization in onion at different stages of crop growth and reported that P uptake and utilization pattern suggest that onion crop required constant supply of P at all stages of growth. Graded levels of P brought about a significant increase in total P uptake. However, the effects of applied P were more conspicuous at lower doses of P (50 kg P₂O₅/ha). Radio chemical analysis showed a steady and significantly increases in per cent phosphorus derived from fertilizer as a result of increasing levels of applied P.

Neeraja *et al.* (2001) studied the effect of irrigation and nitrogen on onion and found that nitrogen application significantly increased the total uptake of NPK. They further stated that due to higher levels synthesis of more chlorophyll and amino acids accelerated which subsequently might have been resulted in greater synthesis and translocation of photosynthates from source (leaf) to sink (bulb).

Sarode *et al.* (2001) reported that application of fertilizers to onion crop as per the test values showed

significantly higher nutrient uptake of N (52.84 kg/ha), P (19.98 kg/ha), K (58.65 kg/ha) and Cu (0.240 kg ha⁻¹) over other treatments. The highest uptake of Zn (0.126 kg/ha), Fe (2.250 kg/ha) and Mn (0.647 kg/ha) were recorded in soil test treatments. They further observed that excess uptake of one nutrient has antagonistic effect on the other elements.

Singh and Verma (2001) reported that uptake of N and K increased with increasing levels of K₂O upto 120 kg/ha. Application of sulphate of potash increased utilization of N, Ca and Mg compared with muriate of potash. Split application of K increased the utilization of N, K, Ca and Mg compared with its basal application. Uptake of N increased upto 3 splits of K. Increasing levels of K₂O upto 120 kg/ha increased the carbohydrate content in bulb.

Attia (2002) studied the influence of filter mud cake, sulphur applications and micronutrient fertilization on onion and observed that application of sulphitation filter mud cake, elemental S and micronutrients (Fe, Mn and Zn) significantly enhanced the total N, P, K, Fe, Mn and Zn contents of onion bulbs. The highest values of alone said parameters were obtained with sulphitation filter mud cake @ 5 t/h and S applied at 50% pre-transplanting + 50% post transplanting and foliar application of micronutrients.

Geetha *et al.* (2002) found that FYM @ 25 t/ha and K @ 200 kg/ha applied individually and in combination, significantly increased the uptake and content of K at harvest.

FYM @ 12.5 t/ha produced positive effect on total K uptake, similar to FYM @ 25 t/ha when applied in combination with K at 200 kg/ha.

An investigation was carried out by Muthuramalingam *et al.* (2003) to assess the influence of plant densities and applied nutrients on uptake of NPK. They found that closer spacing of 45 x 5cm registered the maximum uptake of N, P and K. The plot treatment with closer spacing of 45 x 5 cm and higher dose of manurial treatment 60 : 60 : 30 NPK kg/ha along with FYM @ 25 t/ha along with *Azospirillum* at 2kg/ha and *phosphobacterium* @ 2kg/ha recorded highest uptake of N, P and K.

Singh *et al.* (2002) studied the effect of VAM and inorganic fertilizers on N, P content and uptake in onion and found that the maximum leaf N content was recorded with VAM + P + K and it ranged between 2 per cent (control) and 3.5 per cent (VAM + N + P + K). The bulb N content was found maximum to time of 3.62 per cent in VAM + N + P + K treatment to 2.45 per cent under control. The uptake of N also showed a significantly maximum value (293.5 mg N /bulb) as against control (92.7 mg N/bulb). In contrast, P content was influenced by VAM, however, it was at par with VAM + N + P + K (0.40%) and VAM + 1/2N + 1/2P + K (0.37). The P uptake was 32.8 mg/bulb under VAM + N + P + K which was 142 per cent more over control (13.55 mg/bulb).

Sharma *et al.* (2003) while studying the combined effect of N, P, K and FYM in onion under high hills, dry

temperate conditions of North-western Himalayas observed that, uptake of N, P and K increased significantly with the successive increase in N, P, K doses with and without FYM compared with control.

Paula *et al.* (2003) studied the effect of potassium sources and phosphogypsum on leaf mineral content of onion. In the first year, 3 potassium sources (KCl, K₂SO₄ and K₂SO₄.MgSO₄) and 4 phosphogypsum rates were added to KCl (0.5, 1, 2 and 3 times the SO₄ amount added as K₂SO₄) were applied. A second experiment was conducted in the same plots with the same treatments but without gypsum. They found that gypsum addition to KCl improved bulb storage and increased leaf and soil S content compared with KCl alone.

Nasreen and Hossain (2004) reported that application of N, P, K, S and Zn and application of organic manure only, also showed significant influence on nutrient uptake. They further observed that uptake of leaf nutrient increased upto 70 DAT and there after declined, while bulb accumulated nutrients upto 110 DAT.

Navale *et al.* (2004) conducted field experiment during 2000-01 with onion and found that inoculation with VAM and or *Azospirillum* along with graded levels of fertilizer *viz.* 25, 50, 75 and 100 kg N/ha significantly improved N and P uptake at all the four levels of nitrogen while uptake of micronutrients (*viz.*, Fe, Mn and Zn) was significantly increased at the level of N increased.

Nasreen and Huq (2005) studied the content and uptake of sulphur at successive stages of growth in onion with application of 0, 15, 30, 45, 60, 75 and 90 kg S/ha. They observed that sulphur content in leaves at 45 DAT and in bulbs at 110 DAT was highest; its content in leaves decreased with advancement in crop age. Uptake of sulphur into bulb increased upto 75 DAT while bulbs uptake continued to increased upto 75 DAT. Increasing the levels of sulphur upto 45 kg/ha increased the sulphur content, uptake throughout the season while zero kg S/ha showed the lowest uptake.

Studies were undertaken to evaluate the effect of fly ash and FYM on nutrient uptake by Patil *et al.* (2005). They used four levels of fly ash and FYM each (0, 5, 15 and 30 t/ha) with their sixteen combinations. The results indicated that with the increasing levels of fly ash and FYM there was corresponding increase in uptake of nitrogen, phosphorus and potassium.

Sankaran *et al.* (2005) reported that effect of sulphur application through SSP at 45 kg/ha increased the uptake of N, P, K and S by onion crop.

2.3. Effect of nutrient management on storage and quality parameters

2.3.1. Effect of nutrient management on storage losses

Huge losses during the storage of onion bulbs are a serious problem vitally important for growers, traders as well as for consumers. The magnitude of storage loss depends upon the cultivars, chemical composition of bulb and storage conditions. The onion bulbs are generally stored from May to October. The major causes of storage losses were physiological loss in weight, rotting losses and sprouting losses.

Gaylord (1927) was the first to study the storage behaviour of onion with a view to determine the losses in 35 storage houses in India during 1925-26. He reported 11.35 per cent actual loss in weight. However, Patil (1960) concluded that the loss in weight of onion bulbs in storage varied for 14 to 17 per cent. The reports of several studies have revealed that the magnitude of storage loss was about 50 per cent, which was mainly due to shrinkage (PLW) (about 30%), rotting (10-20%) and sprouting (15-20%). The losses due to sprouting increased towards the end of storage period when temperature drops while the highest percent of rotting losses occurred during May to June when the temperatures were high (Rao, *et al.* 1967, Patil and

Kale, 1985, Shinde, *et al.* 2001).

Wayse (1967) studied the keeping quality of onion bulbs and observed that keeping quality of *kharif* onions was much poorer than *rabi* onions; he reported that N application significantly resulted in the loss in weight during storage, while sprouting was significantly increased in *kharif* and was observed to be decreased in *rabi* crop.

Jagoda *et al.* (1972) studied the effect of irrigation and mineral and organic fertilizers on yield and storage quality of onion. They observed that the application of FYM @ 300 to 600 q/ha had no effect on storage quality where as nitrogen at higher doses had an adverse effect on storage. Similar observations were also made by Painter (1977), Madan and Sandhu (1983) and Gopalkrishnana (1990) where as P and K at higher rates improved the storability of onions.

Chanwal (1975) studied the effect of N, P and K on keeping quality of onion bulbs cv. N-2-4-1 and reported that although N caused maximum sprouting and rotting of bulbs; the total loss due to N application was not more than that of the non-treated treatments. Painter (1977) also observed that addition of N fertilization did not have any beneficial effect on storage quality of onion bulbs. Percentage of sprouting and rotting of bulbs increased with increased N dose. Muzika (1986) also observed that rising of N rate to 180 kg/ha reduced the storability.

Hassanapour (1983) in her study found that the storage losses of onion bulbs in cv. N-53

and N-2-4-1 could be minimized with application of N @ 150 kg/ha, 75 mm CPE irrigation level and spraying MH-2500 ppm three weeks before harvest and stored after field currying for 15 days.

Kristove *et al.* (1986) reported that the best keeping quality in ventilated storage was shown by untreated controls and bulbs grown with K alone (86% sound healthy bulbs after 6 months) and P and K treatments (85% sound bulbs); N application reduced the storability and losses were mainly due to sprouting and weight reduction rather than decay.

Nagre and Kulwal (1987) studied the storage behaviour of onion bulbs of cv. Local white and reported that planting of onion in demander suffered more due to rotting while sprouting losses were more in produce of February planting. Bigger sized bulbs suffered more due to rotting and sprouting while the smaller sized bulbs showed more loss due to shrinkage.

Patil and Kale (1989) screened 37 onion cultivars for storage losses and reported that the cultivar Seroli-1 recorded the least storage losses (29.25%) while cultivar VL-1 recorded highest storage losses (94.00%). The mean PLW and rotting losses were highest during first month of storage while sprouting and total losses were maximum during last month of storage.

Bhujbal (1989) in his studies observed that application of 20 tonnes of FYM + 100 kg N + 50 kg P₂O₅ and K₂O caused minimum physiological and total weight loss.

Shukla *et al.* (1989) studied the effect of different

levels of N (0, 40, 80, 120, 160 kg/ha) on storage losses and reported that nitrogen levels did not affect the storage quality of bulbs. They further surmised that the loss during storage was mainly due to changes in moisture, which predisposes the bulbs to sprouting and fungal infection.

Singh and Dhankhar (1991) conducted experiment to study the effect of nitrogen, potash and zinc on storage loss of onion for 4 months under room temperature. They found that with increasing levels of nitrogen (80-160 kg/ha) increased rotting, sprouting and loss in total weight. Rotting, sprouting and loss in total weight was reduced considerably in the bulbs produced by application of 100 kg K₂O/ha during storage. Application of 100 kg K₂O in combination with 25 kg zinc sulphate/ha increased rotting, sprouting and total weight loss. Bulbs grown under 80 kg N along with 100 kg K₂O/ha recorded lowest rotting, sprouting and total loss in weight.

Kale *et al.* (1992) reviewed the decade of research in storage of onion under ambient conditions at MPKV, Rahuri and reported that the total storage losses ranged from 29.25 to 95.86 per cent with mean storage losses of 75.5 per cent depending upon the cultivars during six months of storage from June to November. They further observed that the onion nutrition has important role in storage quality. The application of 40 tonnes FYM and seed treatment with biofertilizers (*Azospirillum* @ 2.5 kg/ha of seed) recorded 10-12% lower storage losses as compared

to the recommended practice of manures and fertilizer i.e. 20 tonnes FYM with 100 kg N, 50 kg P₂O₅ and 50 kg K₂O per hectare in respect of the recommended cultivars (B-780 and N-2-4-1).

Wright (1993) reported that stored onion bulbs were affected by rates and application times of N fertilizer, time of lifting and water during the field curing period. Bulbs of onion crop receiving 240kg N /ha (double the recommended rate) had more rotting loss during storage than onions that received no N or 120 kg N ha⁻¹. There were no noticeable differences in levels of rots in onion that were lifted at 50-70 per cent top down or at > 90 per cent top sown in each of the treatments when N treatments were compared, the percentage of storage rots was higher in onion that were given supplementary water during field curing than in non-irrigated onions.

Singh *et al.* (1994) conducted experiment to determine the optimum level of nitrogen for yield and storage quality of onion bulb and reported that at different six levels of nitrogen (0, 40, 80, 120, 160 and 200 kg/ha), 80 kg N was enough for higher production as well as for better storage quality of onion. Nitrogen more than 80 kg/ha generally deteriorate storage quality.

Warade *et al.* (1996) screened different cultivars of onion at MPKV, Rahuri to study the storage behavior and reported that the performance of cultivars N-2-4-1 (49.57%) and AFLR (51.23%) were found best for storage of 8 months than other cultivars.

Shinde *et al.* (2001) reviewed the storage of onion under ambient conditions and observed that while going for storage for a longer period, some points should be considered. These includes selection of suitable cultivars for storage, effect of crop management practices on storage quality (nutrition and irrigation), effect of integrated approach for increasing storability on onion, use of various chemicals and irradiation treatments for reducing storage losses, proper utilization of storage systems and structure with better ventilation.

Singh *et al.* (2003) evaluated ten onion cultivars grown in Nasik, Maharashtra during 2001 and found that significantly lowest moisture content and highest soluble solids (TSS; 19.05%) and dry matter (21.68) were recorded in Agri found Red. The reducing sugar ranged from 0.96 (Agri found Rose) to 4.79 per cent (agri found white), while non-reducing sugar varied from 5.32 (Pusa Madhvi) to 11.45 per cent (Agri found Rose) and total sugar from 7.64 (Pusa Madhvi) to 12.61 (Arka Bindu).

Singh *et al.* (2003) reported that the lowest decay and total loss of onion were recorded with basal application of 25 t FYM/ha which was at par with 40 t FYM/ha. Foliar application of urea + Zn + Cu resulted in the lowest decay and total loss in stored onions.

2.3.2. Effect of nutrient management on quality parameters

Musa *et al.* (1974), Chang (1979) observed that good

keeping quality of onion appeared to be associated with high proportion of sucrose, low proportion of reducing sugar and low content of protein.

Saimbhi and Randhawa (1983) undertaken an investigation at Jalandhar, Punjab on sandy loam soil to study the influence of nitrogen and phosphorus on the yield and quality of onion. They observed that both TSS and dry matter content were decreased successively by an increase in the level of N.

Elkner *et al.* (1984) reported that bulbs of high quality (high content of dry matter, total sugars and reducing sugars) at the beginning of storage retained the quality during harvest and during storage, total sugars decreased and reducing sugars increased. Onion varieties (Shiroli, Adsali and Pusa Red) with higher TSS and dry matter (13.1 to 14%) had lowest storage losses (Patil and Kale, 1985).

Shukla *et al.* (1989) studied the effect of nitrogen on bulb yield keeping of onion at Bangalore and reported that nitrogen levels did not affect the storage quality and there was no significant interaction between N levels and storage period of any of the characters studied. Arka Niketan stored well possibly due to higher firmness of the bulbs (9.5 kg) and total soluble solids.

Shukla and Prabhakar (1989) conducted a field experiments to study the effect of nitrogen and phosphorus levels on quality of onion and reported that dry weight and total soluble solids were unaffected by N and P levels.

Singh and Dhankar (1989) carried out a field study to study the effect of nitrogen, potash and zinc on yield and quality of onion at Hissar. There were three levels of nitrogen (80, 120 and 160 kg N/ha), two levels of potash (0, 100 kg K₂O/ha) and one in combination with zinc (100 kg K₂O + 25 kg ZnSO₄/ha) and varieties (Pusa Red and Hissar-2). They found that there was increase in total soluble solids, dry matter, reducing sugar, and contents of bulb under 80 kg N/ha. Application of potash (K₂O 100 kg/ha) alone and in combination with zinc (K₂O 100 + ZnSO₄ 25 kg/ha) increased TSS, dry matter, sugar and sulphur content of bulbs.

Rao and Srinivas (1990) studied the storage behaviour of onion as influenced by nitrogen fertilization. They found that nitrogen fertilization failed to show significant differences in TSS, reducing and non-reducing sugars.

Comparative studies on changes in bio-chemical constituents and hydrolytic enzymes in N-53 and N-2-4-1 varieties of onion during storage were carried out (Anon., 1987). They found that protein, reducing sugars, phenolic compounds increased steadily while dry matter, non-reducing sugars and crude fat decreased gradually during storage. There was considerable increase in activities of amylases and proteases during storage of onion.

Kale *et al.* (1992) reported that the storage losses were positively correlated with protein content and reducing sugars, while they were negatively correlated with percent non-reducing

sugars, potash, dry matter and T.S.S.

Singh and Dhankhar (1992) studied the biological changes of onion bulbs during storage as influenced by pre-harvest treatments of maleic hydrazide (MH) and found that total sugar which is some of reducing and non-reducing sugars of bulbs decreased in all treatments including control with increase in storage period.

A pot culture experiment was carried out by Yadav *et al.* (1994) on quality and chemical composition of bulb of three onion varieties as influenced by different levels of exchangeable sodium percentage. They observed that with increasing ESP level there was increase in the TSS, sugar and ascorbic acid content.

Sharma *et al.* (1997) evaluated eight onion genotypes at Ludhiana for biochemical compositions. They found that dry matter content varied from 10.9 to 14.10 per cent while T.S.S. content varied from 9.73 to 13.13 per cent.

Chopade *et al.* (1998) conducted a field experiment with onion on sandy clay loam soil to optimize the use of water and fertilizers in order to better productivity through different methods of irrigation and different forms of inorganic fertilizers. They found that drip irrigation by liquid fertilization by liquid fertilizer at the rate of 50 per cent recommended dose of solid fertilizer is superior method as this treatment recorded significantly higher TSS (12.58%) than remaining treatments.

Tiwari *et al.* (2002) studied the effect of doses and

methods of nitrogen on quality of 'Pusa Red' onion and reported that TSS was not affected significantly by various treatments; however the highest TSS was recorded with treatment receiving 60 kg N basal + 4 foliar spray, of 10 kg N.

2.4 Effect of land configuration on yield and soil properties

Choudhury and Bhatia (1971) conducted experiment at IARI, New Delhi to study the effect of planting on field pulses and reported that *kharif* pulses yield much higher than the average even under the adverse soil conditions if they are planted on ridges instead of the standard practice of sowing them on flat beds.

Rasve *et al.* (1983) carried out investigation to study the effects of irrigation and method of cultivation on yield and quality of groundnut grown on Vertisol during summer and observed that groundnut grown on ridges and furrow with 0.40 mm irrigation water which was applied in equal amounts at 10 days interval produced significantly higher pod yield over flat bed method of cultivation.

Singh *et al.* (1986) reported that maximum seed yield of soybean was obtained under ridges and furrow method by dry sowing followed by irrigation method of sowing.

Lawand *et al.* (1994) conducted field experiment at Marathwada Agricultural University, Parbhani to study the effect of planting methods on growth and yield of cowpea under rain fed condition and reported that cowpea sowing at the side of ridges and after about one month the ridges were modified in such a way that the stem of plants were placed in the centre of ridges recorded significantly more growth in terms of plant height, number of leaves per plant as well as fruit yield over the other methods of planting. While the crop from flat bed made poor growth and also produced low yield.

Hadvani *et al.* (1993) carried out experiment at Navsari to study the effect of different levels of sulphur and methods of sowing on concentration and uptake of sulphur in *summer* groundnut variety GG2. They reported that

different methods of sowing (ridge-furrow, Broad bed-furrow and flat bed) significantly increased the S content in kernel. The highest S content in kernel was under ridge a furrow method (0.825%) which was significantly superior to flat bed sowing (0.681%). The uptake of S was the highest under ridge furrow method (43.67 kg/ha) followed by broad bed furrows (32.72 kg/ha) and flat bed method (24.72 kg/ha), with significant difference among them.

Mamo *et al.* (1994) reported that sowing on broad beds gave significantly higher grain (54%) and straw (41%) yields than sowing on flat beds in case of chickpea.

Field investigations were carried out by Jayapaul *et al.* (1996) at the Agriculture College and Research Institute, Maduri with view to find out the suitable land configuration methods, irrigation regimes and moisture conservation amendments far irrigated soybean. They observed that land management system of broad beds and furrow showed its supremacy in producing higher yield of soybean by 7.3 and 15.5 in *summer* and 7.4 and 16 per cent in *kharif* over ridges and furrows and check basin, respectively.

Jain and Dubey (1998) carried out a field experiment on Vertisol to study the productivity and economic viability of soybean with respect to planting systems in Vertisols and reported that maximum grain yield, straw yield and net returns were provided by ridge planting with two rows while minimum were with conventional planting (flat bed).

Shaikh and Mungse (1998) studied the influence of planting system and fertilizer levels on growth and yield of late sown chickpea at Rahuri and reported that ridges and furrows system of planting recorded significantly higher LAI, LAD and total dry matter/plant than flat bed planting system at all the growth stages.

Desai *et al.* (2000) studied the effect of different land configuration treatments (flat bed, ridge and furrow, 1 furrow after 2 rows, 1 furrow after and 1 furrow after 4 rows) on grain yield of pigeon pea. They reported that providing 1 furrow after 4 rows of pigeon pea recorded highest grain yield which was significantly superior to flat bed as well as ridge and furrow sowing.

Jain *et al.* (2000) carried out studies at three locations Amreli (Gujarat), Mandore (Rajasthan) and Vridhachalam (Tamil Nadu) on land configuration and seed hardening on productivity of sesame. The soil types were Vertisols at Amreli, Aridosol and Mandore and Alfisol at Vridhachalam. They observed that on Vertisols at Amreli, seed hardening resulted in higher seed yield during all the years. On Aridosols at Mandore planting on broad ridges and furrows, ridge and furrow and seed hardening were significantly superior to other treatments. On Alfisols at Vridhachalam seed hardening and sowing on broad ridges and furrows, ridge and furrow had no advantage over normal sowing.

Influence of planting layouts organic manure and levels of sulphur on growth and yield of groundnut was studied by Kadam *et al.* (2000). They observed that the broad bed furrows registered maximum and significantly higher dry pod as well as haulm yields than those observed in the rest of planting layouts.

Shinde *et al.* (2000) evaluated the three field layouts and four fertilizer levels in order to study the effects on productivity of chickpea and observed that the values of all yield contributing characters observed on ridges and furrows with 60 cm and 90 cm width were significantly higher than those recorded in flat bed.

Aulakh and Mahey (2000) laid out experiment to study the influence of date and method of sowing on the growth and seed yield of sunflower at Ludhiana and reported that ridge sown crop recorded significantly higher LAI than flat sown crop. The ridge sown crop produced 19.8 per cent higher dry matter than flat bed grown crop.

Patel *et al.* (2000) conducted field experiment at GAU, Anand to study the response of groundnut to different methods of sowing in sandy soils of North Gujarat and reported that potential yield of *summer* groundnut can be obtained by adopting sowing of paired row at 30 cm apart in middle of raised bed having 45 cm width along with furrow opened between two beds.

Ugale *et al.* (2000) studied the response of chickpea to field layouts and irrigation depths at Rahuri. A set of ten treatment combinations due to five layouts and two depths of irrigation were tried. They observed that the

maximum seed yield was found in ridges furrows opened at 90 cm width with two lines. The productivity of chickpea increased by 18.52 per cent over flat bed layout.

Pendke *et al.* (2001) studied the impact of land configuration on hydrological properties of soil and yield of cotton. They observed that land configuration of ridges and furrow was found to be the best effective and feasible treatment for higher productivity of cotton.

Sagare *et al.* (2001) carried out field experiment to study the effect of land configuration and gypsum levels on dynamics of soil properties and productivity of cotton and reported that the furrow opening after two rows and incorporation of gypsum @ 50 per cent G.R. is necessary to increase cotton yield and improving physico-chemical parameters of sodic vertisols.

Shivakumar and Mishra (2001) conducted a field experiment to assess the utility of land configuration, residual effect of phosphorus, Stover management and nitrogen levels on growth and yield of wheat under limited water supply condition. They found that no difference in grain yield was noticed due to broad bed and furrow sowing compared to flat bed sowing in spite of higher growth and yield attributes.

The land layout broad bed furrow (BBF) is the better practice in Vertisols than flat bed as the percentage of transmission pores are more in BBF than flat bed system. (Jayasree *et al.* 2002).

2.5. Effect of soil conditioners on yield and properties of soil

Gattani *et al.* (1976) studied the effect of continuous use of chemical fertilizers and manures on soil physical and chemical properties and reported that continuous use of FYM helped in improving physical properties *viz.* bulk density, water stable aggregates, water holding capacity and hydraulic conductivity on the contrary, the nitrogenous fertilizers slightly deteriorated soil physical properties but gave higher yield due to higher availability of N.

Patel and Suthar (1993) carried out experiment at Junagadh to study the effect of gypsum on properties of sodic soils, infiltration rate and crop

yield. They found that the initial average infiltration rate for gypsum treated soil was much higher than that for untreated soil. The average value for cumulative infiltration after four hours was 29.3 mm in treated and 13.26 mm in untreated soil.

More (1994) conducted experiment to study the effect of term wastes and organic manures on soil properties on sodic vertisol at M.A.U; Parbhani and reported that the infiltration rate increased due to addition of different organic. Materials to sodic soils. The application of FYM @ 50 t/ha have shown highest infiltration rate. There was decline in bulk density but it was not statistically significant.

Raman *et al.* (1996) evaluated feasibility of some industrial wastes for soil improvement and crop production. They reported that the effect of the industrial wastes on the infiltration rate of the clayey soil was found to be significant. The lowest infiltration rate was observed in control and the maximum in the treatment receiving pressmud @ 6 t/ha + rice straw @ 5t/ha. The effect of other amendments like gypsum and fly ash alone as well as incorporated with rice straw also significantly increased the infiltration rate. The water stable aggregates were also significantly higher in the amended soils and pressmud was found to be the best.

Tiwari *et al.* (1998) conducted a field experiment on Vertisols at Jabalpur to assess the effect of various fertilizer treatments on soil aggregation. They reported that per cent water stable aggregates > 1mm and 0.5 mm were significantly higher in 100 per cent NPK + FYM treatments as compared to control and 100 per cent N alone treatments. Further, they found that 100 per cent N application alone as against control had adverse effect indicating deterioration being brought in soil structure. The structural coefficient and mean weight diameter were also significantly superior in 100 per cent NPK + FYM treatments over rest of the treatments.

Malewar *et al.* (2000) carried out experiment to study the influence of fly ash with and without FYM and fertilizer on soil properties of sunflower and cotton growing soils at Parbhani. They reported that use of fly ash decreased bulk density and increased porosity, infiltration rate. Fertilizer,

FYM and fly ash interaction were found positive in improving soil physical properties.

Sheeba and Chellamuthu (2002) studied the effect of continuous cropping and fertilizer use on structural properties of Vertic Ustochrepts soils at Coimbatore. They found that conjoint use of FYM with NPK over a long period had improved bulk density, particle density, aggregate stability, and mean weight diameter and per cent water stable aggregates.

Application of phosphogypsum @ 2 or 3 t/ha increased the groundnut pod yield by 10.3 and 13.9 per cent, respectively. With increasing the rate of phosphogypsum there was increase in available S status and EC of the soil. Similarly, water stable aggregates having size greater than 1 mm size tended to increase due to application of phosphogypsum in heavy clayey soils of South Gujarat (Anon., 2003).

Patil *et al.* (2003) conducted a field experiment to study the effect of fly ash, FYM on physical properties of soil at Parbhani. There were sixteen treatment combinations of fly ash and FYM. They reported that application of fly ash @ 30 t/ha showed reduction in bulk density and water holding capacity of soil and increase in porosity and infiltration rate. Application of FYM showed decrease in bulk density and increase in water holding capacity, porosity and infiltration rate.

2.6. Effect of nutrient management on soil properties

Satyanarayana *et al.* (1975) conducted a field experiment on acidic soils of Bangalore to study the influence of sulphur on groundnut. They observed that there was a gradual decline of soil pH with increased level of gypsum from 0 to 15 t/ha.

Mathur *et al.* (1983) conducted micro plot experiment on acid sandy loam soil to study the use of calcium as nutrient for legume crops. They reported that soil pH remained practically unaffected between 5.0 to 5.6 due to application of calcium sulphate levels. However there was greater rise in the exchangeable calcium due to application of gypsum.

Raikhy *et al.* (1985) conducted pot culture experiment to study the effect of pyrites and gypsum application on pH in acids sandy soils. They reported that pH of soil decreased gradually with successive doses of sulphur.

The reduction was relatively higher with the use of pyrites than.

Sagare and Bhalkar (1986) studied the effect of various levels of sulphur and phosphorus on availability of nutrients in clay soil (pH 8.3). They reported that the graded level of S application from 0 to 75 kg/ha increased the availability of S from 20 to 29.60 mg/kg, respectively after 45 days of incubation.

Gupta *et al.* (1986) conducted a green house experiment to study the effect of pressmud and zinc on yield and uptake of zinc and nitrogen by corn and reported that pressmud application increases the organic matter and available zinc content of soil whereas zinc application increased the available soil zinc only.

Application of pyrites and sulphitation pressmud to calcareous saline sodic soils of north Bihar resulted in appreciable decrease in pH, electrical conductivity, ESP and increase in available phosphate of soil (Singh *et al.*, 1986).

Kanwar *et al.* (1987) evaluated the effect of three organic manures *viz.*, farm yard manure, sulphitation and carbonated pressmud alone @ 20 t/ha and in combination with supplementary inorganic nitrogen on yield and quality of sugarcane. They reported the post harvest soil analyses showed higher organic carbon, available N and P in plots of organic manures.

Patel and Singh (1991) under taken a comparative study on the effect of gypsum, pressmud and pyrites on leachate composition, soil properties and yields of rice and wheat on a sodic soil. They reported that gypsum, presumed and pyrite treatments significantly reduced pH, ESP and increased exchangeable Ca and Mg of soil at all levels of application. However, it was significantly higher with gypsum treatments than those with pressmud and pyrites because of direct supply of soluble Ca with gypsum.

Anand Swarup (1991) in a pot experiment on sodic soil evaluated the effects of gypsum, gypsum + green manure dhiancha (*Sesbania aculeate*) and gypsum + FYM with and without zinc application on the yield and nutrition of rice and the availability of Zn, Fe and Mn. They found that application of gypsum markedly decrease the pH and ESP of the soil and increased

significantly the yield and Zn, Fe and Mn concentration of the crop. With green manure and FYM in conjunction with gypsum, irrespective of Zn application, substantial reduction in pH and ESP of the soil and increases in availability of Zn, Fe and Mn were observed.

Kumar and Mishra (1991) conducted a greenhouse experiment to study the effect of two types of pressmud cake on growth of rice, maize and on soil properties. They reported that the soil pH increased and available P decreased by application of carbonation pressmud whereas no change in the pH occurred and available P content increased by addition of the sulphitation pressmud. Both types of pressmud increased the organic carbon and available K content of the soil but the effects of sulphitation pressmud were more pronounced than the carbonation pressmud.

Narwal *et al.* (1993) conducted a laboratory incubation study on a clay loam soil at Hisssar and reported that the $\text{NO}_3\text{-N}$ increased with increase in incubation period at all levels of N and with the addition of both types of pressmud. Addition of N and pressmud invariably increased the $\text{NO}_3\text{-N}$ at all the incubation periods. The increase was similar in both types of pressmud the $\text{NO}_3\text{-N}$ content is relatively more due to sulphitation pressmud application than the carbonation pressmud.

Patel and Suthar (1993) carried out experiment to study the effect of gypsum on properties of sodic soils at Junagadh and reported that the application of gypsum decreased the pH, EC and ESP after harvest of the crop at all the locations they tried.

Patil *et al.* (1993) under taken an incubation study to assess the decomposition rates of FYM, sunflower heads and wheat straw. They found that decomposition of FYM was slow but steady and more or less uniform. As an organic matter builder, FYM was found to be most effective. Available N and P_2O_5 were considerably increased due to incorporation of FYM, whereas available K_2O was increased with the addition of crop residues.

Deshmukh *et al.* (1993) carried out an experiment to study the effect of pressmud cake on the availability of nutrients in black soil. There were seven levels of PMC *viz.*, 0, 10, 20, 40, 60, 80 and 100 q/ha. They reported that the availability of N increases at all the levels of PMC upto 45 days of incubation

followed by small decrease upto 75 days of incubation. Phosphorus availability significantly increased over control with the application of PMC at all periods of incubation. Copper availability increased with increase in the PM rates. Application of PM @ 40 q/ha and above resulted in significantly higher available Cu over other levels.

More (1994) conducted experiment to study the effect of farm wastes and organic manures on soil properties, nutrient availability and yield of rice wheat grown on sodic vertisol. They found that all the treatments resulted in increasing the available nutrients in soil over control. FYM @ 50 t/ha showed highest increase in organic carbon (0.68%) and available N (385 kg/ha). Pressmud recorded highest available P (15.9 kg/ha) and available K (410 kg/ha). The same treatment resulted maximum decrease in soil pH explaining the increase in availability of P and K in soil.

Kapur (1995) reported that soil treated with sulphitation cane filter cake (SCFC) had higher contents of organic carbon, available N and Olsen's P.

Singh and Singh (1995) carried out a greenhouse experiment on a sandy loam soil in order to study the response of onion to N, P, Zn and FYM. They observed that available nutrients in soil after the harvest of crop increased significantly with increase in the rates of N application. The highest available N and P contents in soil were recorded for the treatment $N_{40}P_{60}$ + FYM @ 10 t/ha which were significantly higher than those under all other treatments. Available Zn decreased with the application of N but increased with FYM.

Dang and Verma (1996) conducted a greenhouse experiment to study the effect of sulphitation pressmud cake (SPMC) and carbonation pressmud cake (CMPC) to determine the fertilizer equivalence of pressmud cakes (PMC) for rice and the residual effect on succeeding wheat crop. Application of either type of cake was beneficial for both rice and wheat crops. The SPMC was better than the CPMC. Increase in organic carbon, available P, K and Zn in soil were more pronounced from SPMC than from the CPMC. However, the use of CPMC showed slight increasing trend in pH and $CaCO_3$ content.

Feasibility of some industrial wastes for soil improvement and crop production was evaluated by Raman *et al.* (1996) on Vertic Ustochrepts. They observed that application of gypsum reduced the soil pH and increased the electrical conductivity. Pressmud did not have any effect on soil pH and EC. The organic carbon content significantly increased due to pressmud application.

Tompe and More (1996) reported that higher doses of pressmud decreased pH and EC of soil. Maximum organic carbon content of soil was observed with 15 tonnes of pressmud cake/ha + $\frac{1}{4}$ recommended dose of fertilizer.

Mengistu and Singh (1999) studied the effects of bio-fertilizer on growth, yield and nutrient uptake of onion at Delhi on loamy soil. They reported that bio-fertilization had moderately enhanced the fertility level of soil after crop harvest. On supplementation with 50 kg N and 25 kg P, dual inoculation of *Azospirillum* and VAM resulted in 13.41 and 13.18 per cent increase in soil available P and N respectively compared to initial fertility status of the soil.

Poongothai *et al.* (1999) studied the influence of gypsum and green leaf manure application to rice and on soil deficient in sulphur on Typic Ustorthent at Coimbatore. They found that sulphur fertilization increased significantly the available sulphur content of the post harvest soil. Application of green leaf manure increased the available S content of the soil and the effect was more marked in the presence of gypsum.

Khankhane and Yadav (2000) conducted an incubation study with FYM, biogas slurry and sewage sludge on sandy clay loam soil @ 5, 10 and 15 t/ha with and without N-P fertilizer at Delhi. They found that $\text{NH}_4\text{-N}$ decrease in incubation period from 1 to 16 weeks in all the organic manures. Highest $\text{NH}_4\text{-N}$ was observed in sewage sludge followed by biogas slurry and FYM. Addition of urea and single super phosphate at 120 kg N and 60 kg P_2O_5 /ha enhanced the mineralization both the $\text{NH}_4\text{-N}$ and $\text{NO}_3 + \text{NO}_2\text{-N}$ contents.

Dixit and Gupta (2000) studied the effect to FYM, chemical and bio-fertilizers on yield and quality of rice and soil properties. They observed that

addition of FYM and blue green algae showed positive changes in organic carbon and N content of soil. There was a little variation in soil pH as affected by treatments. Available P and K content also showed increasing tendency due to the treatments.

Tripathi and Mishra (2001) carried out a laboratory experiment to study the kinetics of N mineralisation during rice straw decomposition. They found that mineralized nitrogen was significantly reduced due to rice straw and straw inoculated with cellulose decomposing fungi in soil during first two weeks of incubation, whereas application of nitrogen with rice straw was able to reduce the initial immobilization of nitrogen.

Toor *et al.* (2001) studied the available N release pattern from FYM, cage system and deep litter system of poultry manure with time on sandy loam soil at Hissar. They reported that available N content in the soil incubated without any organic source, remained almost constant throughout the incubation period. The difference between FYM and DLS-PM was not very high. Cage system poultry manure appears to be potentially better source of available N as compared to DLS-PM and FYM.

In order to study the effect of combined application of N, P, K and FYM in onion under high hills, dry temperature conditioners of north western Himalayas Sharma *et al.* (2003) carried out field experiment with cultivar N-53 at Leo, Himachal Pradesh. They observed that increasing levels of NPK increased the contents of available N, P and K significantly. Maximum improvement was recorded in available N, followed by K and minimum in P. Relatively higher values of available nutrients were recorded under conjoint use of fertilizers and FYM. However sole application of FYM could not improve status of these nutrients significantly.

Jagadeeswarn and Murugappan (2003) carried out experiment in order to study the effect of ferro gypsum on yield and uptake of nutrients in rice grown on an alkali soil at Coimbatore. Ferro gypsum was applied in comparison with gypsum with and without organic manures, besides a control. Ferrogypsum application @50 per cent of gypsum requirement resulted in increased grain and straw yield in rice over control. The nutrient uptake of N, P and K in grain and straw of rice were significantly increased

over control due to application of ferro- gypsum with and without organic manures.

Based on the present review, it is observed that though, adequate work on nutrient management in onion has been done, yet the work on land configuration particularly in paddy soils and use of soil conditioners is scanty. There is need to intensify research on these aspects in onion crop.

III MATERIAL AND METHODS

In order to accomplish the objectives, present investigation was divided into three separate studies. The material used and methods followed for each study are described separately in this chapter.

3.1 Survey related to onion cultivation in Navsari and Surat districts

3.2 Effect of integrated nutrient management (INM) in presence and absence of gypsum on nutrient availability under laboratory conditions (incubation study).

3.3 Effect of land configuration, gypsum and INM on yield and quality of onion grown after paddy (field study).

3.1 Survey related to onion cultivation in Navsari and Surat districts

3.1.1 Methodology

The survey work related to onion cultivation in Navsari and Surat districts was carried out in order to understand the constraints faced by onion growers. The list of farmers cultivating onion of both the districts was obtained from the Bardoli, Suruchi Farm which mainly supply the onion seedlings. The questionnaire was prepared in consultation with extension education experts. The personal interview of individual onion grower was carried out. All the responses recorded in the interview schedule were transferred to the master table and frequencies were found out. Wherever necessary numbers and percentage were given to the various frequency items.

3.2 Effect of INM in presence and absence of gypsum on periodical nutrient availability under laboratory conditions (incubation study)

An incubation study was under taken to study the effect of INM in presence and absence of gypsum on nutrient availability.

3.2.1 Material

a Soil

The bulk soil sample from 0-15 cm depth was collected from block E-15 of Soil and Water Management Farm of Navsari Agricultural University, Navsari. The soil was powdered using wooden mortar and pestle and passed through 2 mm sieve. The processed soil was used in incubation study and the physico-chemical properties of the same are given in table 1. Soil classification of experimental site is Vertic Ustochrepts at sub group level and it belongs to Jalalpor soil series. It is deep and moderately drained soil, containing pre-dominantly montmorillonite, clay mineral.

The soil is clayey in texture (63.99 % clay), high moisture retentive capacity (34.5 %) and low in organic carbon, medium in available phosphorus and fairly rich in available potash. It is not having any problem of sodicity or salinity as the values of pH and EC are below the critical limit.

Table 1: Physico-chemical properties of the experimental soil

| Sr. No. | Parameters | Content |
|--------------------|---|---------|
| A. Physical | | |
| 1 | Mechanical composition | |
| | a. Sand (%) | 11.66 |
| | b. Silt (%) | 24.34 |
| | c. Clay (%) | 63.99 |
| 2 | Texture | Clayey |
| 3. | Water stable aggregate > 1.0 mm (%) | 53.5 |
| B. Chemical | | |
| 1. | pH _{2.5} | 7.71 |
| 2. | EC _{2.5} (dS/m) | 0.40 |
| 3 | Organic carbon (%) | 0.45 |
| 4. | Available N (kg/ha) | 220 |
| 5. | Available P ₂ O ₅ (kg/ha) | 33 |
| 6. | Available K ₂ O (kg/ha) | 373 |
| 7. | Available S (mg/kg) | 5.42 |
| 8. | Micronutrients (mg/kg) | |
| | a. Fe | 13.05 |
| | b. Mn | 17.0 |
| | c. Zn | 0.49 |
| | d. Cu | 2.03 |

b. Manure

The plant nutrients were supplied through fertilizers viz., urea, single super phosphate

and muriate of potash for N, P and K, respectively. Along with this, FYM @ 15 t/ha and seasoned pressmud @ 6 t/ha were also used as the organic sources of nutrients. As a soil conditioner, phosphogypsum obtained from GSFC, Baroda was used in present study. The composition of FYM as well as pressmud and phosphogypsum used in present study are given in table 2 and 3, respectively.

c. Plastic bottle

The wide mouth plastic bottles having capacity 125 ml were used for incubation study.

Table 2: Chemical composition of organic manures

| Sr. No. | Element | FYM | Pressmud |
|---------|-----------------------------------|------|----------|
| 1 | N (%) | 1.0 | 1.6 |
| 2 | P ₂ O ₅ (%) | 0.32 | 2.82 |
| 3 | K ₂ O (%) | 0.68 | 1.54 |
| 4 | S (%) | 0.75 | 1.24 |
| 5 | Fe (mg/kg) | 7803 | 5174 |
| 6 | Mn (mg/kg) | 368 | 160 |
| 7 | Zn (mg/kg) | 99 | 49 |
| 8 | Cu (mg/kg) | 26 | 32 |

Table 3: Chemical composition of phosphogypsum

| Sr. No. | Characteristics | |
|---------|------------------|------|
| 1 | pH (1:10) | 3.02 |
| 2 | EC (1:10) (dS/m) | 4.00 |
| 3 | Moisture (%) | 7.27 |

| | | |
|----|-----------------------------------|-------|
| 4 | Purity | 93.08 |
| 5 | SO ₄ (%) | 42.20 |
| 6 | P ₂ O ₅ (%) | 0.92 |
| 7 | Fe mg/kg | 24.75 |
| 8 | Mn mg/kg | 1.38 |
| 9 | Zn mg/kg | 1.50 |
| 10 | Cu mg/kg | 0.75 |

d. Water

For maintaining the field capacity in plastic bottles, distilled water was added as and when required throughout incubation study.

3.2.2 Methods

The methodology followed for conducting incubation study is described here.

3.2.2.1 Experimental details

(a) Treatments:

T₁ = Absolute control

T₂ = Recommended dose (RD) of NPK (125: 50: 50 kg/ha)

T₃ = 50% RD + FYM @ 15 t/ha

T₄ = 50% RD + PM @ 6 t/ha

T₅ = RD + gypsum @ 6 t/ha

T₆ = 50% RD + FYM @ 15 t/ha + gypsum @ 6 t/ha

T₇ = 50% RD + PM @ 6 t/ha + gypsum @ 6 t/ha

(b) Repetitions : 4

(c) Design : CRD

(d) Method of sampling: Destructive, at each sampling one repetition was withdrawn for analysis

(e) Total No. of bottles : $7 \times 4 \times 3 = 84$

(f) No. of samplings : 3 i.e. 40, 80 and 120 (days after incubation) DAI

3.2.2.2 Incubation technique

For this, 100 g processed soil was placed in wide mouth plastic bottles and treatment wise organic manures, inorganic fertilizer and gypsum were added and mixed thoroughly. Subsequently, soils in the bottles were brought to field capacity by adding measured volume of water. All the 84 bottles were incubated under ambient conditions. The bottles were covered with muslin cloth in order to provide sufficient aeration. The moisture losses measured gravimetrically were compensated by adding the measured volume of water periodically throughout the incubation period.

3.2.2.3 Soil analysis

At each sampling *i.e.*, 40, 80 and 120 DAI treatment wise soil samples were obtained and analysed for pH, EC, available macro and micronutrients by using standard methods (Table 4).

3.2.2.4 Statistical analysis

The data obtained from the chemical analysis of soil samples at different incubation periods were statistically analysed by adopting the method as described by Cochran and Cox (1967).

3.3 Effect of land configuration, gypsum and INM on yield and quality of onion (field experiment)

For studying the effects of land configuration, soil conditioner and INM on growth, yield, nutrient uptake by onion and some soil properties one field experiment was conducted during *rabi* season of the year 2003-04. The details of experimental material used and methods employed are as under.

Table 4 : Methods of soil and plant analysis

| Sr. No. | Determination | Method | Reference |
|-----------------|---|---|----------------------------|
| Physical | | | |
| 1 | Mechanical analysis | International pipette | Piper (1950) |
| 2 | Infiltration rate | Double ring method | Piper (1950) |
| 3 | Water stable aggregate | Wet sieving | Black (1965) |
| Chemical | | | |
| 4 | pH _{2.5} | Potentiometric | Jackson (1967) |
| 5 | EC _{2.5} | Conductometric | Jackson (1967) |
| 6 | Organic carbon | Walkley and Black's titration method | Jackson (1967) |
| 7 | Available N | Alkaline permanganate extraction | Subbiah and Asija (1956) |
| 8 | Available P ₂ O ₅ | Extraction with 0.5 M NaHCO ₃ (pH 8.5) | Olsen <i>et al.</i> (1954) |
| 9 | Available K ₂ O | Extraction with 1 N NH ₄ OAc (pH 7.0) | Jackson (1967) |

| | | | |
|-----------------------|----------------|--|----------------------------|
| 10 | Available S | Turbidimetric (extraction with 0.15% CaCl ₂) | Chopra and Kanwar (1980) |
| 11 | Fe, Mn, Zn, Cu | Extraction with DTPA and estimated on Atomic absorption spectrophotometer. | Lindsay and Norvell (1978) |
| Plant analysis | | | |
| 12 | Nitrogen | Micro Kjeldahl | Chapman and Pratt (1961) |
| 13 | Phosphorus | Vanadomolybdo phosphoric acid yellow colour method | Jackson (1967) |

Contd.. Table 4

| Sr. No. | Determination | Method | Reference |
|---------|---------------------------------|--|---------------------------|
| 14 | Potassium | Flame photometric | Jackson (1967) |
| 15 | Sulphur | Turbidimetric | Chopra and Kanwar (1980) |
| 16 | Micronutrients (Fe, Mn, Cu, Zn) | Atomic absorption spectrophotometer | Elwell and Gridley (1967) |
| 17 | TSS | Hand refractometer | Chopra and Kanwar (1980) |
| 18 | Sugars | Lane and Eynon general volumetric method | Chopra and Kanwar (1980) |



Plate-I : General view of storage study



Plate-II : General view of field experiment

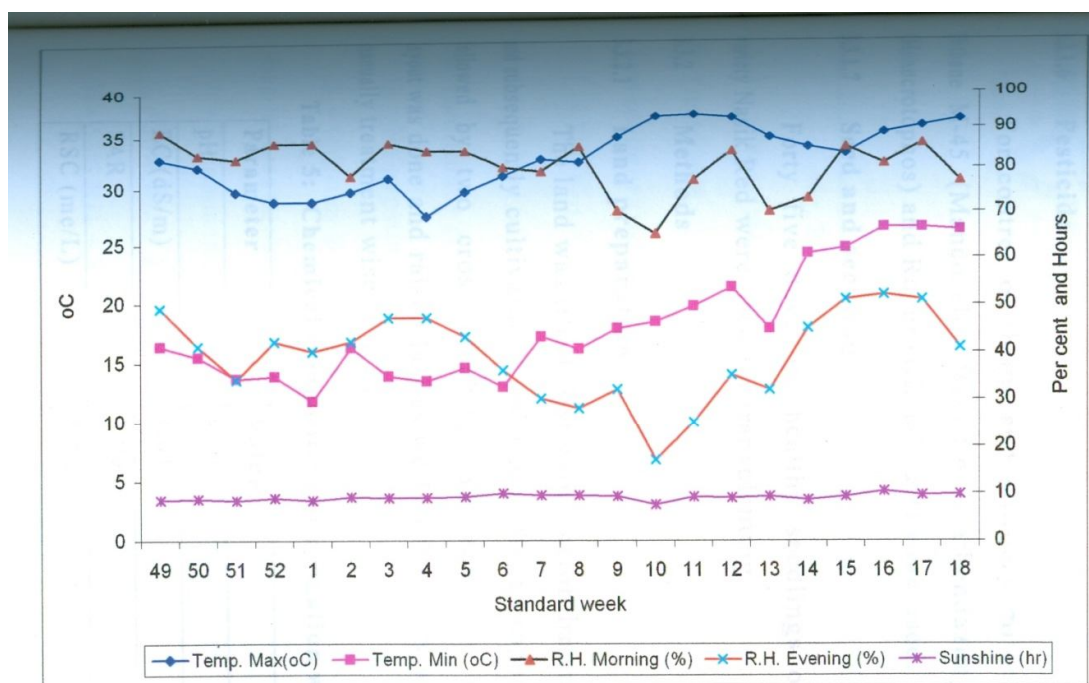


Fig. 1 : Weekly means of meteorological data recorded during crop growth period

3.3.1 Material

3.3.1.1 Experimental site

The present investigation was conducted at Soil and Water Management Farm, Navsari Agricultural University, Navsari, which is geographically located at 25° 57' N latitude and 72° 54' E longitude and has an altitude of 10 m.

3.3.1.2 Climate and weather

According to agro climatic conditions, Navsari falls in Agroecological situation III of South Gujarat heavy rainfall zone I, which is typically characterized by humid and warm monsoon with heavy rainfall (around 1500 mm), moderately cold winter and fairly hot and humid summer. In general, monsoon commences by the second fortnight of June and ceases by

September end. The winter season starts from November and ends by middle of February. The coldest months are December and January, whereas April and May are the hottest. The weather data recorded at the Meteorological Observatory, College Farm, N. M. College of Agriculture, NAU, Navsari during the crop growth period (2003-04) are depicted in fig. 1.

3.3.1.2 Description of soil (As per 3.2.1. a)

3.3.1.3 Manures (As per 3.2.1. b)

3.3.1.4 Irrigation water

Tube well water was used for irrigation purpose. The chemical composition of irrigation water used is given in table 5.

3.3.1.5 Weedicide

Pre-emergence application of pendimethalin @ 1.0 kg a.i. was done 2 days after planting for controlling weeds.

3.3.1.6 Pesticide

For control of thrips and powdery mildew of onion, Dithane M-45 (Mancozeb), Bavistin (Carbendazim), Nuvacron (Monocrotophos) and Rogar (Dimethoate) were used.

3.3.1.7 Seed and seedling

Forty five days old healthy seedlings of the onion variety Nasik Red were used for transplanting.

3.3.2 Methods

3.3.2.1 Land preparation

The land was tilled first with tractor drawn disc plough and subsequently cultivator in order to achieve proper tilth. It was followed by two cross planking. Subsequently, experimental layout was done and raised bed as well as flat beds were prepared manually treatment wise (Fig 2).

Table 5: Chemical composition of irrigation water

| Parameter | Value |
|------------|-------|
| pH | 8.74 |
| EC (dS/m) | 1.01 |
| SAR | 2.99 |
| RSC (me/L) | 1.45 |

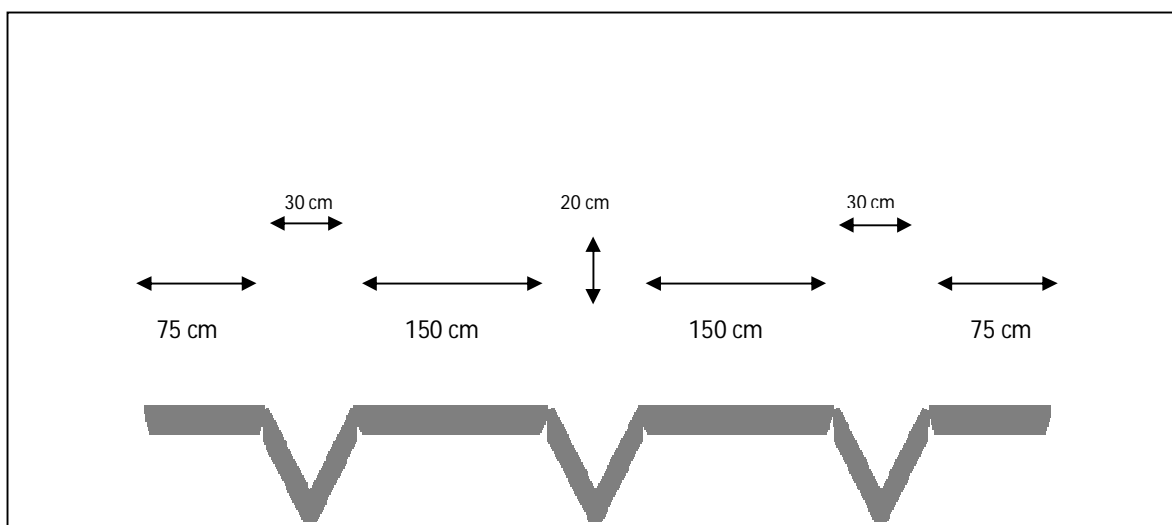


Fig. 2: Schematic diagram of raised bed

3.3.2.2 Experimental details

(i) Treatments

Land configuration (L)

L₁ = Flat bed

L₂ = Raised bed

Soil conditioner (G)

G₁ = No gypsum

G₂ = Gypsum @ 6 t/ha

Manurial treatments (F)

F₁ = Recommended dose (RD) of NPK (125:50:50 kg/ha)

F₂ = 50% RD + FYM @ 15 t/ha

F₃ = 50% RD + PM @ 6 t/ha

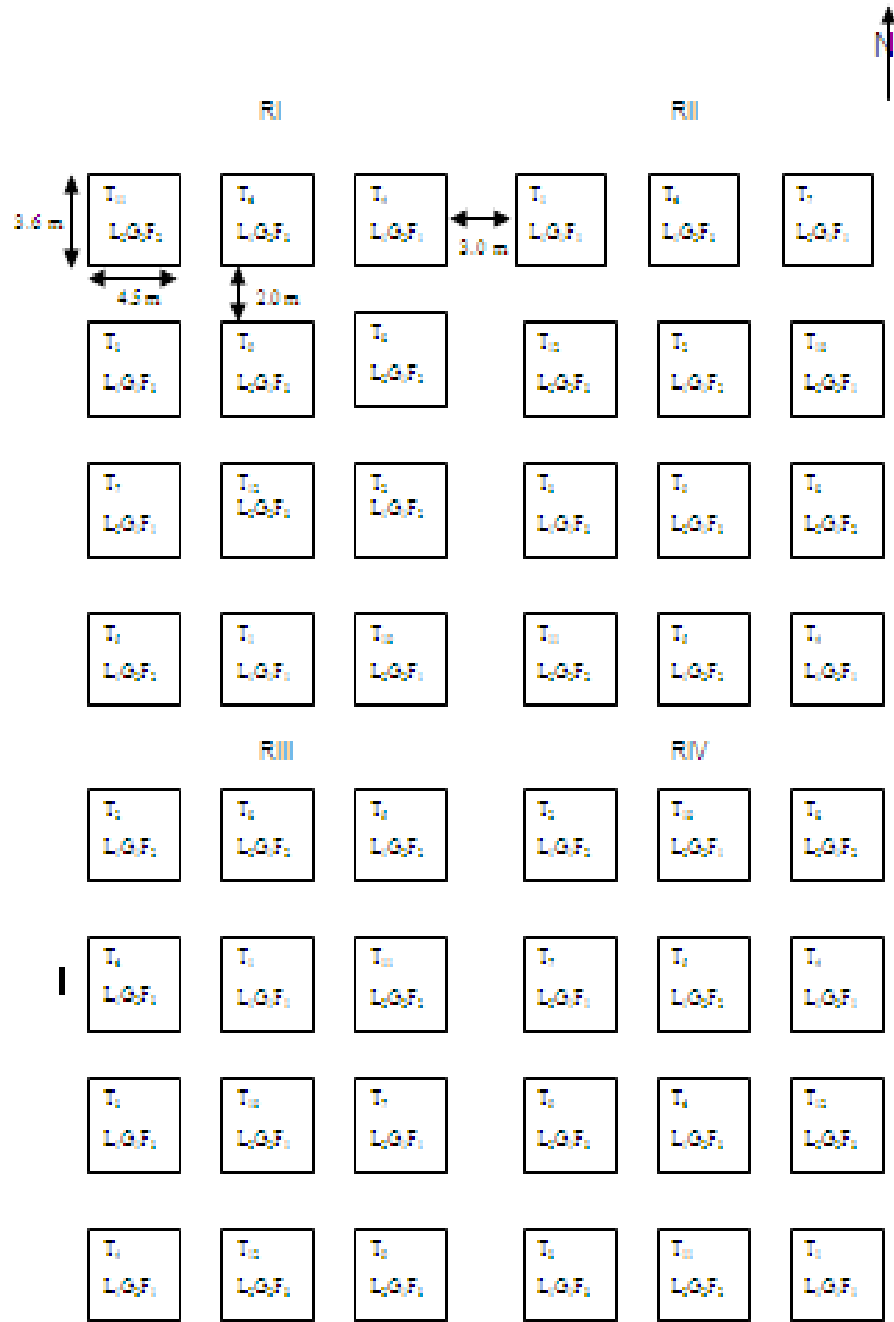


Fig. 3. Plan of layout

- (ii) The total treatment combinations: 12
- (iii) Design : FRBD
- (iv) Replications : Four
- (v) Plot size : Gross: 4.5 x 3.6 m²
: Net : 3.9 x 3.2 m²
- (vi) Spacing : 15 x 10 cm
- (vii) Total number of plots: 48

The cultural operations followed in present study are listed in table 6.

3.3.2.2 Application of soil conditioner and manures

After preparation of raised and flat beds treatment wise phosphogypsum was applied @ 6 t/ha. Similarly, FYM, pressmud and inorganic fertilizers were applied on dry weight basis as indicated in the treatment details. The whole quantity of P and K were applied as basal dose through single super phosphate and muriate of potash, respectively. Basal dose of 50 per cent N was applied through urea and remaining 50 per cent N was applied 30 days after transplanting.

3.3.2.3 Transplanting

The healthy seedlings of 45 days age were transplanted by keeping spacing row to row 15cm and plant to plant 10 cm.

3.3.2.4 Irrigation

The crop was irrigated with tube well water. Flood irrigation method was adopted for irrigating crop on flat bed. The

Table 6: Schedule of cultural operations performed in the experimental field during *rabi* 2003-04

| Sr. No. | Field operation | Date of operations |
|---------|--|---|
| 1 | Ploughing | 2-12-03 |
| 2 | Clod crushing and levelling | 8-12-03 |
| 3 | Lay out of field experiment | 10-12-03 |
| 4 | Preparation of flat and raised beds | 12-12-03 |
| 5 | Soil conditioner application | 14-12-03 |
| 6 | Manures application | 14-12-03 |
| 7 | Transplanting | 18-12-03 and 19-12-03 |
| 8 | Pre-emergence application of pendimethalin | 23-12-03 |
| 9 | Hand weedings | (i) 20-12-03 (ii) 4-3-04 |
| 10 | Irrigation | (i) 7-1-04 (ii) 31-1-04 (iii) 8-2-04 (iv) 6-3-04 (v) 21-3-04 |
| 11 | Plant protection measures | (i) 6-1-04 (ii) 16-2-04 (iii) 13-3-04 |
| 12 | Collection of soil and plant samples a) Soil sample (i) Soil sampling at BI stage (ii) Sol sampling at GG stage | 30-3-04 12-3-04 |

| | | |
|----|---|---------|
| | (iii) Soil sampling at harvest | 16-4-04 |
| | b) Plant sampling and recording of biometric observation | |
| | (i) First sampling at B.I. stage | 12-2-04 |
| | (ii) Second sampling at G.G. stage | 12-3-04 |
| | (iii) Third sampling at harvest | 10-4-04 |
| 12 | Harvesting | 12-4-04 |

care was taken while irrigating the onion on raised bed that water was applied only in ridges so that whole raised bed would become wet through lateral movement of water in soil.

3.3.2.5 Plant protection

The necessary plant protection measures were taken and the details are given in table 6.

3.3.2.6 Periodical soil and plant sampling

a. Soil sampling

In order to study the effect of land configuration, soil conditioner and INM on soil properties, periodical soil samples were collected at different growth stages of onion i.e. (i) at bulb initiation (BI) (ii) at grand growth stage (GG) and (iii) after harvest of crop (AH). The soil samples from each treatment were collected replication wise from 0-15 cm depth from five randomly selected spots and composite representative samples were obtained

for each treatment.

The collected soil samples were dried in shade and ground to pass through 2 mm sieve using wooden mortar and pestle. The processed samples were preserved for chemical analysis. The methods adopted for analyzing physical and chemical properties of soil are presented in table 1. However, the IR was determined under field conditions immediately after the harvest of crop.

b. Plant sampling

In order to study the pattern of content and uptake of nutrients by onion, the periodical plant samples were collected at different growth stages of crop viz., BI, GG and AH. Five randomly selected plants along with bulbs from plot were collected. After sampling, treatment wise, plant samples were separated into leaves and bulbs. For quick drying, the samples were cut into small pieces and dried in the hot air oven at $60^{\circ}\text{C} \pm 2^{\circ}\text{C}$. The dried samples were powdered using mixer (stainless steel blade).

c. Plant analysis

The powdered material of leaves and bulbs was preserved and used for estimation of total N, P, K, S, Fe, Mn, Zn and Cu (Table 4). The concentration of macronutrients was expressed in percent and those of micronutrients in mg/kg.

The uptake of nutrients by onion (bulb and leaves) was calculated by using the following formula.

$$\text{Nutrient uptake} = \frac{\text{Content (\%)} \times \text{Dry matter yield (g/plant)}}{\text{---}} \times 1000$$

(mg/plant)

100

$$\text{Nutrient uptake = } \frac{\text{Content (\%)} \times \text{Dry matter yield (kg/ha)}}{100}$$

(Kg/ha)

The details of the method used for determination of chemical parameters are presented in table 4.

3.3.2.7 Biometric observations

For recording biometric observations periodically, five plants from each treatment were selected randomly and growth observations were recorded.

Height: The height of five plants from ground level to the tip of the leaf was recorded and treatment mean values were obtained.

Number of leaves: The number of leaves per plant (total 5 plants) were counted and the treatment mean values were obtained.

3.3.2.8 Harvesting

The onion bulbs were uprooted from each net plot and were separated by cutting the leaves and roots. Subsequently, bulb yield for each net plot was recorded. Simultaneously, fresh and dry weights of leaves were also recorded treatment wise.

3.3.2.9 Onion bulb sampling

For knowing quality of onion bulb, at harvest ten healthy bulbs from each treatment were selected. These were cut into quarters and fresh onion bulb sample was used for quality studies. The onion bulb quality parameters viz., T.S.S., reducing sugar and non-reducing sugar were estimated (Table 4).

3.3.2.10 Quality parameters

Physical

Polar diameter: For each treatment polar diameter of the ten bulbs was measured with the help of Vernier calliper from the junction of root plate to the top of the bulb and mean polar diameter was worked out in cm.

Equatorial diameter: Like polar diameter, the maximum distance between opposite sides at right angles (to the polar diameter) was measured by Vernier calliper and the mean equatorial diameter for each treatment was worked out.

Average bulb weight: The weight of one kg healthy bulbs was recorded treatment wise and it was divided by number of bulbs to obtain average weight of bulb.

Chemical

Total soluble solids: Treatment wise total soluble solids were recorded with the help of pocket hand refractometer (Erma, Japan) having scale in the range of 0-32. For each treatment two readings were taken and average values were used for statistical analysis.

Reducing and non-reducing sugars: Fresh bulbs were cut into small pieces and mixed to get representative sample and was used for estimation of sugars as per the procedure described by Lane and Eynon (Table 4).

Total sugars: Total sugars present in onion bulbs was computed by summing the reducing and non-reducing sugars.

For storage study, 2 kg of healthy onion bulbs were stored treatment wise in bamboo baskets at room temperature upto 120 days. The bamboo baskets were protected from direct sunlight and rain. The observations on sprouting,

rotting and physiological weight loss were recorded at 0, 30, 60, 90 and 120 days of storage. Similarly, the chemical quality parameters of onion bulbs *viz.*, total soluble solids, reducing and non-reducing sugars were also estimated during these periods by following standard method (Table 4).

3.3.2.11 Losses during storage

a. Sprouting loss (%)

At every periodical observation, the sprouted bulbs separated from healthy bulbs and weighed and percentage was worked out.

b. Rotting loss (%)

The rotted bulbs were also separated and weighed and percent loss due to rotting was determined at every sampling.

c. Physiological loss (%)

The percent loss in weight due to both rotting and sprouting was subtracted from the total loss in weight and thus the physiological loss was calculated.

d. Total losses

The total loss in bulb weight at each sampling was computed by taking into consideration the initial weight of sample.

e. Cumulative loss (%)

At every periodical sampling, the progressive losses of sprouting, rotting, physiological loss in weight and total losses were worked out.

3.3.2.12 Statistical analysis and interpretation of data

The statistical analysis of the data was carried out by using the standard statistical method of “Analysis of variance” (Cochran and Cox, 1967).

IV EXPERIMENTAL RESULTS

The results obtained from survey work, incubation, field experiment and onion bulb storage studies with respect to constraints experienced by onion growers, nutrient availability, yield and its attributing parameters nutrient content and uptake, quality parameters and physico-chemical properties of soil after harvest of crop are described in this chapter under the following subtitles.

- 4.1 Survey
- 4.2 Incubation study
- 4.3 Field experiment

4.1 Survey

In order to probe into the cultivation practices followed by the farmers of South Gujarat for onion crop, a survey was conducted by randomly selecting 31 farmers from Surat and Navsari districts through personal interview using standard questionnaire. The responses of the farmers to various questions in term per cent of total respondent are reported in table 7. Of the total 31 farmers, 52 per cent are categorized into small holding group (< 2ha) and the remaining were almost equally distributed between medium (22%) and large classes (26%). The survey further revealed that small farmers are allotting 50 per cent of their holding to the onion crop during *rabi* season *i.e.*, mostly after *kharif* paddy. While, medium group farmers put 24 per cent

of their total holding under onion, the large group farmers use 38 per cent of land holding for this crop. With respect to onion variety, though, most of the farmers (74%) adopting improved varieties, the productivity of onion is quite low because of deteriorated soil physical conditions caused by puddling done in preceding *kharif* paddy. The main reason for low productivity could be due

to planting of onion in flat bed as 90 per cent farmers are following this practice. In addition to this, most of the farmers are predominantly following integrated nutrient management system with low rate of organics.

Table 7: Response (%) of farmers to different question related to onion cultivation

| Sr. No. | Particulars | Yes | No. | No response |
|---------|---|-----|-----|-------------|
| 1 | Use improved variety | 75 | 25 | - |
| 2 | Sowing on flat bed | 90 | 10 | - |
| 3 | Approximately follow recommended spacing | 61 | 39 | - |
| 4 | Apply organics (FYM/cake/ash) + inorganic fertilizer | 68 | 10* | 22 |
| 5 | Apply gypsum | 16 | 84 | - |
| 6 | Face irrigation problem due to irregular power supply | 64 | 23 | 13 |
| 7 | Experiences disease and pest problems | 58 | 32 | 10 |
| 8 | Experiences weed problem | 74 | 19 | 7 |
| 9 | Experience labour shortage at harvesting | 39 | 48 | 13 |
| 10 | Faces problem for storage | 74 | 10 | 16 |
| 11 | Onion cultivation profitable | 58 | 29 | 13 |

* use only inorganic fertilizers.

As far as irrigation is concerned, the major concern is irregular power supply, as about 64 per cent farmers have expressed concern about it. The other problems like pest and diseases, weed infestation *etc.*, are also experienced by the onion growers of South Gujarat. Apart from these constraints, farmers are not getting appropriate price of onion due to

inadequate storage facility. In spite of low productivity and rate of onion, majority of the farmers (58%) opined that its cultivation after *kharif* paddy under South Gujarat condition is of remunerative proposition.

4.2 Incubation study

In order to understand the effect of soil conditioner and INM on nutrient availability under laboratory conditions, an incubation study was conducted. The results obtained are presented below.

Soil reaction: The results pertaining to periodical changes in soil reaction due to treatments at different periods of incubation were determined and reported in table 8. It is evident that soil pH values at all the periods of incubation influenced significantly due to various treatments. Significantly higher value of soil pH (7.80) was obtained at 40 DAI with treatment T₁ (control), but it was at par with T₂, T₃ and T₄ treatments. At 80 DAI, the soil pH values were increased and that at 120 DAI slightly decreased. At 80 DAI the treatments T₁ and T₂ showed significantly higher values of 8.03 and 7.83 of soil pH, respectively as compared to rest of the treatments. An application of inorganic fertilizer either alone or in combination with organics and gypsum influenced the soil reaction significantly at 120 DAI. All these treatments, which were at par with each other, recorded significantly lower soil pH than control (8.11).

Table 8 : Effect of soil conditioner and INM on soil pH_{2.5}

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|------|------|
| | 40 | 80 | 120 |
| T ₁ | 7.80 | 8.03 | 8.11 |
| T ₂ | 7.70 | 7.83 | 7.82 |
| T ₃ | 7.65 | 7.79 | 7.77 |
| T ₄ | 7.61 | 7.78 | 7.75 |

| | | | |
|----------------|-------|-------|-------|
| T ₅ | 7.54 | 7.68 | 7.64 |
| T ₆ | 7.58 | 7.72 | 7.67 |
| T ₇ | 7.46 | 7.62 | 7.60 |
| S.Em. \pm | 0.068 | 0.079 | 0.082 |
| C.D. at 5% | 0.20 | 0.23 | 0.24 |
| C.V. % | 2.00 | 2.00 | 2.00 |

Electrical conductivity (EC): The impact of various treatments at different periods of incubation on EC of soil was assessed and the results are presented in table 9. In general, EC values of the soil increased with the advancement of incubation period irrespective of all the treatments. The results further revealed that the EC values of soil at all the periods of incubation were affected significantly due to various treatments. At 40 DAI, the treatment T₇ recorded maximum EC value (0.65 dS/m), which was significantly higher than T₁, T₂, T₃ and T₄ but remained at par with T₅ and T₇. Similarly at 80 DAI, significantly higher EC values were recorded with treatments T₅ and T₇ in comparison to rest of the treatments. The trend of EC at 120 DAI was found to be similar to that observed at 80 DAI. Amongst the different treatments significantly lower values of EC were recorded in treatment T₁ (control).

Table 9: Effect of soil conditioner and INM on soil EC_{2.5} (dS/m)

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|------|------|
| | 40 | 80 | 120 |
| T ₁ | 0.45 | 0.46 | 0.48 |
| T ₂ | 0.47 | 0.49 | 0.52 |

| | | | |
|----------------|-------|-------|-------|
| T ₃ | 0.50 | 0.54 | 0.56 |
| T ₄ | 0.56 | 0.57 | 0.62 |
| T ₅ | 0.62 | 0.67 | 0.70 |
| T ₆ | 0.63 | 0.58 | 0.66 |
| T ₇ | 0.65 | 0.68 | 0.71 |
| S.Em. \pm | 0.019 | 0.020 | 0.016 |
| C.D. at 5% | 0.06 | 0.06 | 0.05 |
| C.V. % | 7.00 | 7.00 | 5.00 |

Organic carbon(OC): The results pertaining to the effects of various treatments on organic carbon status of soil at different periods of incubation (Table 10) revealed that organic carbon content decreased progressively with advancement in incubation period in all the treatments. At 40 DAI, significantly lower organic carbon content in soil was recorded with control (0.52%), which remained at par with the treatments T₂ and T₅. The treatments T₆ wherein 50% RD of inorganic fertilizer + FYM @ 15t/ha + gypsum @ 6 t/ha were applied registered significantly higher status of organic carbon (0.69%) as compared to rest of the treatments. However, it was found to be at par with T₃, T₄ and T₇. In general, more or less similar trend of organic carbon status of soil was observed at 80 and 120 DAI.

Table 10: Effect of soil conditioner and INM on organic carbon content (%) in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|------|
| | 40 | 80 | 120 |
| T ₁ | 0.52 | 0.38 | 0.33 |
| T ₂ | 0.54 | 0.39 | 0.34 |
| T ₃ | 0.67 | 0.49 | 0.42 |
| T ₄ | 0.63 | 0.46 | 0.39 |
| T ₅ | 0.56 | 0.40 | 0.35 |
| T ₆ | 0.69 | 0.50 | 0.43 |
| T ₇ | 0.65 | 0.47 | 0.41 |
| S.Em. \pm | 0.016 | 0.016 | 0.01 |
| C.D. at 5% | 0.05 | 0.05 | 0.04 |
| C.V. % | 6.00 | 8.00 | 6.00 |

Available N: The values of available N as determined at 40, 80 and 120 DAI are presented in table 11. It is noticed that the values of available N at all the periods of incubation were significantly influenced due to various treatments.

At 40 DAI, the higher available N was recorded in the treatments receiving fertilizer either @ 50 or 100 per cent in combination with organics as compared to control (T₁). Similarly, treatment T₇ receiving ½ RD through inorganic fertilizers + PM @ 6 t/ha and gypsum @ 6 t/ha recorded significantly more amount of available N over control at 80 and 120 DAI, but it was at par with most of the treatments.

Table 11: Effect of soil conditioner and INM on available N (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|-------|
| | 40 | 80 | 120 |
| T ₁ | 92.0 | 96.4 | 100.9 |
| T ₂ | 109.0 | 112.9 | 117.8 |
| T ₃ | 100.0 | 109.4 | 116.1 |
| T ₄ | 103.1 | 112.5 | 121.4 |
| T ₅ | 104.0 | 110.3 | 117.0 |
| T ₆ | 104.9 | 112.5 | 120.1 |
| T ₇ | 106.2 | 115.3 | 123.7 |
| S.Em. ± | 2.5 | 2.9 | 3.3 |
| C.D. at 5% | 7.4 | 8.6 | 9.9 |
| C.V. % | 5.0 | 5.0 | 6.0 |

Available P₂O₅ : The periodical availability of P₂O₅ determined at different periods of incubation is given in table 12. It is observed that at 40 DAI, the treatments T₂ and T₅ receiving only inorganic fertilizers recorded significantly more available P₂O₅ than rest of all treatments. However, with the advancement of time *i.e.*, at 80 and 120 DAI this difference narrowed down. The available P₂O₅ determined at 40, 80 and 120 DAI in treatment T₁ (control) was 13.6, 15.7 and 18.3 mg/kg, respectively, which was significantly lower than rest of the treatments.

Available K₂O : The results pertaining to the effect of different treatments on periodical available K₂O content in soil are presented in table 13. The availability of K₂O increased with

Table 12 : Effect of soil conditioner and INM on available P₂O₅ (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|------|------|
| | 40 | 80 | 120 |
| T ₁ | 13.6 | 15.7 | 18.3 |
| T ₂ | 21.3 | 21.1 | 22.1 |
| T ₃ | 15.7 | 19.1 | 22.9 |
| T ₄ | 15.9 | 19.1 | 23.5 |
| T ₅ | 20.8 | 22.1 | 24.8 |
| T ₆ | 17.1 | 20.7 | 24.2 |
| T ₇ | 18.0 | 21.3 | 25.1 |
| S.Em. \pm | 0.81 | 1.1 | 1.2 |

| | | | |
|------------|-----|-----|-----|
| C.D. at 5% | 2.4 | 3.1 | 3.6 |
| C.V. % | 9 | 11 | 11 |

Table 13: Effect of soil conditioner and INM on available K₂O (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|-------|
| | 40 | 80 | 120 |
| T ₁ | 134.8 | 143.8 | 147.8 |
| T ₂ | 193.3 | 201.8 | 234.4 |
| T ₃ | 186.6 | 194.6 | 206.2 |
| T ₄ | 189.7 | 200.0 | 215.2 |
| T ₅ | 192.4 | 200.4 | 218.8 |
| T ₆ | 188.4 | 198.7 | 210.7 |
| T ₇ | 187.8 | 200.9 | 216.5 |
| S.Em. \pm | 5.57 | 6.74 | 7.63 |
| C.D. at 5% | 16.4 | 19.8 | 22.4 |
| C.V. % | 6 | 7 | 7 |

advancement of incubation period irrespective of all the treatments. The results revealed that significantly higher values of available K_2O was obtained with treatment T_2 at 40 and 80 DAI over control, however, at both the samplings it was at par with rest of the treatments. At 120 DAI also, treatment T_2 maintained its superiority over the rest of the treatments, but it remained at par with T_4 , T_5 and T_6 .

Available S: The results of available S content in soils as affected by various treatments are presented in table 14. From the results it could be seen that available S was significantly influenced by the different treatments at all the periods of incubation. The treatments receiving gypsum @ 6 t/ha showed significant increase in available S over rest of the treatments; however, these treatments remained at par with each other. The treatment T_7 registered higher available S and the values recorded at 40, 80 and 120 DAI were 20.1, 25.0 and 31.7 mg/kg, respectively.

Available Fe: The results presented in table 15 revealed that the effect of different treatments on available Fe at all the periods of incubation was found to be significant. At 40 DAI, the treatments T_3 , T_6 and T_7 registered relatively higher available Fe as compared to the remaining treatments. The minimum value of 16.8 mg/kg of available Fe was recorded with control (T_1) followed by the treatments T_2 (19.4 mg/kg) and T_5 (19.0 mg/kg) which received recommended dose of inorganic fertilizers and $\frac{1}{2}$ RD + gypsum respectively. The treatment T_4 and T_7 recorded significantly more available Fe at both 80 and 120 DAI than the

Table 14 : Effect of soil conditioner and INM on available S (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|------|------|
| | 40 | 80 | 120 |
| T ₁ | 5.2 | 5.7 | 5.9 |
| T ₂ | 5.8 | 6.2 | 7.1 |
| T ₃ | 6.0 | 6.5 | 7.5 |
| T ₄ | 6.4 | 6.6 | 7.6 |
| T ₅ | 18.6 | 22.0 | 28.2 |
| T ₆ | 19.7 | 23.0 | 30.3 |
| T ₇ | 20.1 | 25.0 | 31.7 |
| S.Em. \pm | 0.72 | 1.08 | 1.44 |
| C.D. at 5% | 2.1 | 3.2 | 4.2 |
| C.V. % | 12 | 16 | 17 |

Table 15 : Effect of soil conditioner and INM on DTPA extractable Fe (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|-------|
| | 40 | 80 | 120 |
| T ₁ | 16.8 | 16.6 | 24.6 |
| T ₂ | 19.4 | 18.6 | 27.5 |
| T ₃ | 24.2 | 21.6 | 32.7 |
| T ₄ | 26.6 | 25.5 | 38.2 |
| T ₅ | 19.0 | 18.0 | 27.2 |
| T ₆ | 24.1 | 21.0 | 32.1 |
| T ₇ | 26.5 | 23.5 | 37.5 |
| S.Em. \pm | 0.897 | 0.758 | 1.230 |
| C.D. at 5% | 2.6 | 2.2 | 3.6 |
| C.V. % | 8 | 7 | 8 |

other treatments. Further, it is revealed that values of available Fe at 80 DAI were decreased as compared to 40 DAI and again found to increase at 120 DAI.

Available Mn : The periodical availability of Mn as influenced by various treatments is given in table 16. It is seen that at all the samplings significantly higher available Mn was recorded with treatment T₄ than T₁, T₂ and T₅ however, it was found to be at par with T₃, T₆ and T₇ treatments. The values

of available Mn were found to decrease at 80 DAI than 40 DAI and again found to increase at 120 DAI.

Available Zn: The values of available Zn content in soil at different periods of incubation as influenced by various treatments are given in table 17. It is clear from the results that Zn availability decreased at 80 DAI and tended to increase at 120 DAI in all the treatments. The treatments receiving ½ RD of inorganic fertilizers + PM @ 6 t/ha showed significantly higher available Zn than rest of the treatments except T₇ which remained at par with T₄ at all the periods of incubation. The available Zn registered at 40, 80 and 120 DAI in treatment T₄ was 0.90, 0.86 and 0.97 mg/kg, respectively.

Available Cu: The results presented in table 18 revealed that the effect of different treatments on available Cu content in soil at various incubation periods was found to be significant. At 40 DAI, the treatment T₄ recorded more amount of available Cu than T₁ and T₂; however, it was at par with T₃, T₅, T₆ and T₇ treatments. Lower values of available Cu were registered with all

Table 16 : Effect of soil conditioner and INM on DTPA extractable Mn (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|------|------|
| | 40 | 80 | 120 |
| T ₁ | 24.6 | 17.5 | 35.0 |
| T ₂ | 26.2 | 18.6 | 38.6 |
| T ₃ | 30.4 | 20.7 | 56.9 |
| T ₄ | 32.0 | 22.7 | 56.9 |

| | | | |
|----------------|------|------|------|
| T ₅ | 26.5 | 18.3 | 37.2 |
| T ₆ | 30.1 | 19.9 | 42.0 |
| T ₇ | 31.6 | 21.9 | 53.8 |
| S.Em. \pm | 0.81 | 0.56 | 1.36 |
| C.D. at 5% | 2.4 | 1.6 | 4.0 |
| C.V. % | 6 | 6 | 6 |

Table 17 : Effect of soil conditioner and INM on DTPA extractable Zn (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|-------|
| | 40 | 80 | 120 |
| T ₁ | 0.54 | 0.51 | 0.57 |
| T ₂ | 0.59 | 0.55 | 0.63 |
| T ₃ | 0.80 | 0.77 | 0.89 |
| T ₄ | 0.90 | 0.86 | 0.97 |
| T ₅ | 0.60 | 0.56 | 0.65 |
| T ₆ | 0.78 | 0.72 | 0.87 |
| T ₇ | 0.87 | 0.81 | 0.95 |
| S.Em. \pm | 0.018 | 0.018 | 0.022 |

| | | | |
|------------|------|------|------|
| C.D. at 5% | 0.05 | 0.05 | 0.06 |
| C.V. % | 5 | 5 | 6 |

the treatments at 80 DAI than 40 DAI. Significantly higher value of available Cu was recorded with T₄ at 80 DAI, however, it remained at par with T₇ and T₃ treatments. At 120 DAI, treatment T₇ recorded higher amount of available Cu (2.41 mg/kg) followed by T₄ (2.39 mg/kg), which were at par with each other.

Table 18: Effect of soil conditioner and INM on DTPA extractable Cu (mg/kg) content in soil

| Treatments | Period of incubation (days) | | |
|----------------|-----------------------------|-------|-------|
| | 40 | 80 | 120 |
| T ₁ | 2.12 | 2.07 | 2.20 |
| T ₂ | 2.14 | 2.08 | 2.28 |
| T ₃ | 2.21 | 2.13 | 2.32 |
| T ₄ | 2.27 | 2.22 | 2.39 |
| T ₅ | 2.18 | 2.10 | 2.27 |
| T ₆ | 2.19 | 2.11 | 2.31 |
| T ₇ | 2.23 | 2.16 | 2.41 |
| S.Em. \pm | 0.031 | 0.031 | 0.042 |

| | | | |
|------------|------|------|------|
| C.D. at 5% | 0.09 | 0.09 | 0.12 |
| C.V. % | 3 | 3 | 4 |

4.3 Field experiment

Field experiment with 12 treatment combinations comprising of 2 land configuration (L₁: flat bed, L₂: raised bed), 2 levels of gypsum (G₁: No gypsum, G₂: with gypsum@ 6 t/ha) and 3 levels of fertilizers (F₁: RDF of NPK, F₂: ½ RD + FYM, F₃: ½ RDF + PM) was conducted in FRBD with 4 replications during *rabi* season of 2003-04. The observations *viz.*, periodical plant height, number of leaves and dry mater yield, average weight of bulb, polar and equatorial diameter of bulb as well as bulb yield recorded during he course of field study were subjected to statistical analysis. Similarly, the nutrient content and uptake, quality parameters of bulb and soil properties after harvest of crop were also determined and these data were also analysed statistically. The results thus obtained are interpreted in this part.

4.3.1 Growth parameters

Plant height: The results regarding plant height recorded at BI, GG and AH are presented in tables 19, 20 and 21 respectively. It is apparent that the individual effect of land configuration and soil conditioner as well as their interaction effects were significant on plant height at all three stages of crop growth. Significantly the higher plant height was observed on raised bed (L₂) at all the growth stages. Soil conditioner had remarkable positive effect on plant height at all the stages of growth. Among the first order interaction, only L x G effect was found to be significant on plant height. Among the combinations L₂G₂ showed superiority over rest of the combinations as it recorded plant height of 52.4, 60.0 and 63.1 and at BI, GG and AH, respectively. The remaining variables and interaction effects failed to exert significant impact on plant height of onion.

Number of leaves per plant: The results pertaining to the number of leaves per plant recorded at different growth stages are presented in tables 22 to 24. It is seen that the number of leaves per plant were influenced significantly only due to main effect of land configuration and soil conditioner. Significantly the higher

Table 19 : Effect of land configuration, soil conditioner and INM on plant height (cm) at BI stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 46.1 | 46.1 | 46.1 | 44.3 | 54.7 | 52.0 | 44.1 |
| F ₂ | 44.5 | 44.3 | 44.4 | 47.8 | 50.1 | 48.9 | 46.7 |
| F ₃ | 45.1 | 45.9 | 45.6 | 48.5 | 52.5 | 50.5 | 48.0 |
| Mean | 45.2 | 45.5 | 45.3 | 48.5 | 52.4 | 50.5 | - |
| G. Mean | G ₁ = 46.9 | | | G ₂ = 48.9 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.60 | 0.62 | 0.76 | 0.88 | 1.08 | 1.08 | 1.53 |
| C.D. at 5% | 1.8 | 1.8 | NS | 2.6 | NS | NS | NS |
| C.V. (%) | 6 | | | | | | |

Table 20: Effect of land configuration, soil conditioner and INM on plant height (cm) at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 54.6 | 54.5 | 54.6 | 55.8 | 61.3 | 58.5 | 56.5 |
| F ₂ | 51.8 | 51.9 | 51.9 | 51.9 | 58.1 | 54.9 | 53.4 |
| F ₃ | 51.9 | 54.1 | 52.9 | 55.5 | 60.7 | 58.1 | 55.5 |
| Mean | 52.8 | 53.5 | 53.1 | 54.4 | 60.0 | 57.2 | - |
| G. Mean | G ₁ = 53.6 | | | G ₂ = 56.7 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.74 | 0.74 | 0.91 | 1.04 | 1.28 | 1.28 | 1.81 |
| C.D. at 5% | 2.1 | 2.1 | NS | 3.0 | NS | NS | NS |
| C.V. (%) | 7 | | | | | | |

Table 21: Effect of land configuration, soil conditioner and INM on plant height (cm) at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 59.2 | 59.4 | 59.3 | 59.5 | 63.9 | 61.7 | 60.5 |
| F ₂ | 56.9 | 58.8 | 57.9 | 56.9 | 62.2 | 59.5 | 58.7 |
| F ₃ | 57.1 | 59.1 | 58.1 | 58.5 | 63.1 | 60.7 | 59.4 |
| Mean | 57.7 | 59.1 | 58.4 | 58.3 | 63.1 | 60.7 | - |
| G. Mean | G ₁ = 58.00 | | | G ₂ = 61.1 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.43 | 0.43 | 0.52 | 0.61 | 0.74 | 0.74 | 1.05 |
| C.D. at 5% | 1.2 | 1.2 | NS | 1.76 | NS | NS | NS |
| C.V. (%) | 4 | | | | | | |

Table22: Effect of land configuration, soil conditioner and INM on number of leaves per plant at BI stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|----------------------|----------------|-------|----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 4.9 | 5.1 | 4.9 | 5.1 | 5.4 | 5.3 | 5.1 |
| F ₂ | 4.5 | 4.7 | 4.6 | 4.7 | 5.1 | 4.9 | 4.8 |
| F ₃ | 4.7 | 4.9 | 4.8 | 4.9 | 5.3 | 5.1 | 4.9 |
| Mean | 4.7 | 4.9 | 4.8 | 4.9 | 5.3 | 5.1 | - |
| G. Mean | G ₁ = 4.8 | | | G ₂ = 5.1 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.086 | 0.086 | 0.105 | 0.121 | 0.149 | 0.149 | 0.210 |
| C.D. at 5% | 0.25 | 0.25 | NS | NS | NS | NS | NS |
| C.V. (%) | 9 | | | | | | |

Table 23: Effect of land configuration, soil conditioner and INM on number of leaves per plant at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|----------------------|----------------|-------|----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 7.2 | 7.5 | 7.3 | 7.8 | 8.2 | 7.9 | 7.6 |
| F ₂ | 6.7 | 6.9 | 6.8 | 7.3 | 7.7 | 7.5 | 7.1 |
| F ₃ | 6.8 | 7.4 | 7.1 | 7.5 | 7.9 | 7.7 | 7.4 |
| Mean | 6.9 | 7.2 | 7.1 | 7.5 | 7.9 | 7.7 | - |
| G. Mean | G ₁ = 7.2 | | | G ₂ = 7.6 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.118 | 0.118 | 0.145 | 0.167 | 0.205 | 0.205 | 0.290 |
| C.D. at 5% | 0.34 | 0.34 | NS | NS | NS | NS | NS |
| C.V. (%) | 8 | | | | | | |

Table 24: Effect of land configuration, soil conditioner and INM on number of leaves per plant at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|----------------------|----------------|------|----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 7.8 | 8.2 | 8.0 | 8.6 | 8.9 | 8.8 | 8.4 |
| F ₂ | 7.1 | 7.9 | 7.5 | 7.3 | 8.4 | 7.9 | 7.7 |
| F ₃ | 7.7 | 8.1 | 7.9 | 7.9 | 8.9 | 8.4 | 8.2 |
| Mean | 7.5 | 8.1 | 7.8 | 7.9 | 8.8 | 8.3 | - |
| G. Mean | G ₁ = 7.7 | | | G ₂ = 8.4 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.17 | 0.17 | 0.20 | 0.24 | 0.29 | 0.29 | 0.41 |
| C.D. at 5% | 0.48 | 0.48 | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | | | | | | |

number of leaves per plant were recorded on raised bed (L₂) at all the growth stages. Application of soil conditioner (G₂) significantly increased the number of leaves per plant at different growth stages. The individual effect of fertilizer as well as first and second order interactions were found to be non-significant on the number of leaves per plant.

Average bulb weight (g): The average bulb weight recorded at the time of harvesting was affected significantly due to only main effect of land configuration and soil conditioner (Table 25). An application of soil conditioner produced heavier bulb (80.3 g) than its no application (73.3 g). Similarly, significantly more average weight of bulb was recorded on raised bed planted onion (80.7 g) than the onion planted on flat bed (72.9 g).

Table 25: Effect of land configuration, soil conditioner and INM on average weight of onion bulb (g) at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 70.5 | 79.6 | 75.0 | 81.0 | 85.0 | 83.0 | 79.0 |
| F ₂ | 68.0 | 74.2 | 71.3 | 74.2 | 83.0 | 78.6 | 74.9 |
| F ₃ | 69.0 | 76.0 | 72.0 | 77.4 | 83.8 | 80.6 | 76.6 |
| Mean | 69.1 | 76.7 | 72.9 | 77.6 | 83.9 | 80.7 | - |
| G. Mean | G ₁ = 73.3 | | | G ₂ = 80.3 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.099 | 0.099 | 1.21 | 1.40 | 1.71 | 1.71 | 2.43 |
| C.D. at 5% | 2.8 | 2.8 | NS | NS | NS | NS | NS |
| C.V. (%) | 6 | | | | | | |

Polar and equatorial diameter: Apart from the average weight of bulb, its size is also important from marketing point of view. Hence, the polar and equatorial diameters of bulb were also measured and the results are reported in tables 26 and 27. In both the cases, among the variables, only main effect land of configuration was significant on bulb diameter. Between the two configurations, raised bed planting registered significantly higher polar (4.06 cm) and equatorial diameters (5.55 cm) as compared to flat bed planting.

Periodical dry matter production

The data pertaining to the periodical dry matter production of both bulb and leaves per five plants as affected by different treatments were recorded at BI, GG and AH and the results are presented here.

Dry matter production at BI stage: The dry matter production of whole plant at BI stage as influenced by various treatments are presented in table 28. It is evident from the results that individual effect of land configuration (L) and soil conditioner (G) was observed to be significant on dry matter yield of onion plant at BI stage. Between the two types of land configuration, L₂ produced significantly higher yield (12.31g/5 plants) as compared to L₁ (10.78 g/5 plants). As far as effect of soil conditioner is concerned, G₂ produced significantly higher dry matter (12.15g/5 plants) as compared to G₁ (10.94 g/5 plants).

Table 26: Effect of land configuration, soil conditioner and INM on polar diameter (cm) of onion at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|-------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 3.75 | 3.89 | 3.82 | 4.11 | 4.13 | 4.12 | 3.97 |
| F ₂ | 3.63 | 3.79 | 3.71 | 4.02 | 3.95 | 3.98 | 3.84 |
| F ₃ | 3.66 | 3.80 | 3.73 | 4.10 | 4.09 | 4.09 | 3.91 |
| Mean | 3.68 | 3.82 | 3.75 | 4.07 | 4.05 | 4.06 | - |
| G. Mean | G ₁ = 3.87 | | | G ₂ = 3.94 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.056 | 0.056 | 0.069 | 0.080 | 0.098 | 0.098 | 0.139 |
| C.D. at 5% | 0.16 | NS | NS | NS | NS | NS | NS |
| C.V. (%) | 7 | | | | | | |

Table 27 : Effect of land configuration, soil conditioner and INM on equatorial diameter (cm) on onion at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|-------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 4.91 | 5.34 | 5.12 | 5.43 | 5.48 | 5.45 | 5.29 |
| F ₂ | 4.96 | 5.30 | 5.13 | 5.53 | 5.74 | 5.63 | 5.38 |
| F ₃ | 5.30 | 5.50 | 5.40 | 5.41 | 5.70 | 5.55 | 5.47 |
| Mean | 5.05 | 5.38 | 5.21 | 5.45 | 5.64 | 5.55 | - |
| G. Mean | G ₁ = 5.25 | | | G ₂ = 5.51 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.092 | 0.092 | 0.112 | 0.130 | 0.159 | 0.159 | 0.225 |
| C.D. at 5% | 0.26 | NS | NS | NS | NS | NS | NS |
| C.V. (%) | 8 | | | | | | |

Table 28 : Effect of land configuration, soil conditioner and INM on dry matter (g/ 5 plants) at BI stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|--------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 10.86 | 11.79 | 11.32 | 12.38 | 13.95 | 13.196 | 12.24 |
| F ₂ | 10.13 | 10.40 | 10.26 | 10.24 | 12.76 | 11.50 | 10.88 |
| F ₃ | 10.83 | 10.67 | 10.75 | 11.20 | 13.33 | 12.26 | 11.50 |
| Mean | 10.60 | 10.95 | 10.78 | 11.27 | 13.34 | 12.31 | - |
| G. Mean | G ₁ = 10.94 | | | G ₂ = 12.15 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.314 | 0.314 | 0.384 | 0.444 | 0.544 | 0.544 | 0.769 |
| C.D. at 5% | 0.90 | 0.90 | NS | NS | NS | NS | NS |
| C.V. (%) | 13 | | | | | | |

Dry matter production at GG: The results of dry matter production by onion leaves and bulb recorded separately at GG stage are given in tables 29 and 30. From the results, it could be seen that the land configuration and soil conditioner significantly influenced the dry matter yield of both bulb and leaves at GG stage, however its interaction effects was found to be non significant. The land configuration L₂ registered significantly more dry matter of leaves (23.64 g/5plants) than L₁ (18.62 g/5 plants). Similarly, significantly higher dry matter production of leaves was obtained with G₂ (22.75 g/5plants) as compared to G₁

(19.51 g/ 5 plants). Similar trend was also observed in dry matter yield of onion bulb at GG stage (Table 30).

Dry matter production at harvest: The results regarding effect of land configuration, soil conditioner and INM on dry matter production of both leaves and bulb at harvest are presented in

Table 29 : Effect of land configuration, soil conditioner and INM on dry matter (g/5 plants) of onion leaves at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 18.08 | 20.46 | 19.27 | 22.87 | 27.62 | 25.24 | 22.26 |
| F ₂ | 17.03 | 18.26 | 17.64 | 19.45 | 24.10 | 21.77 | 19.71 |
| F ₃ | 17.69 | 20.21 | 18.95 | 21.95 | 25.89 | 23.92 | 21.43 |
| Mean | 17.60 | 19.64 | 18.62 | 21.42 | 25.87 | 23.64 | - |
| G. Mean | G ₁ = 19.51 | | | G ₂ = 22.75 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.62 | 0.62 | 0.76 | 0.87 | 1.07 | 1.07 | 1.52 |
| C.D. at 5% | 1.78 | 1.78 | NS | NS | NS | NS | NS |
| C.V. (%) | 14 | | | | | | |

Table 30: Effect of land configuration, soil conditioner and INM on dry matter (g/5 plants) of onion bulb at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|------------------------|----------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 28.84 | 33.05 | 30.94 | 39.22 | 41.95 | 40.58 | 35.76 |
| F ₂ | 24.75 | 29.52 | 27.14 | 35.89 | 37.47 | 36.68 | 31.91 |
| F ₃ | 28.79 | 31.85 | 30.32 | 38.10 | 38.99 | 38.54 | 34.43 |
| Mean | 27.46 | 31.48 | 29.47 | 37.73 | 39.47 | 38.60 | - |
| G. Mean | G ₁ = 32.60 | | G ₂ = 35.47 | | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.96 | 0.96 | 1.18 | 1.36 | 1.67 | 1.67 | 2.36 |
| C.D. at 5% | 2.78 | 2.78 | NS | NS | NS | NS | NS |
| C.V. (%) | 14 | | | | | | |

tables 31 and 32. It is observed that only individual effect of land configuration and soil conditioner and their interaction effect on dry matter accumulation in both onion bulb and leaves at harvest were found to be significant. Considerably higher dry matter accumulation of both bulb and leaves were recorded on raised bed planted crop (L_2) than that obtained on flat bed planted crop (L_1). The soil conditioner had significant and positive effect on dry matter production of onion bulb and leaves. The higher dry matter yield of onion bulb and leaves was recorded with G_2 *i.e.*, 61.5 and 23.42 g/5 plants respectively. As far as interaction effect of L x G is concerned, significantly higher dry matter yields of onion bulb and leaves (66.15 g/5 plants and 26.10 g/5 plants) were obtained with L_2G_2 combination in comparison to rest of the combinations. Of course, it was at par with rest of the combinations involving raised bed planting.

4.3.3 Yield

Bulb yield: The fresh bulb yield of onion as affected by various treatments are presented in table 33. The results implicit that bulb yield of onion was significantly affected due to main effects of land configuration (L) and soil conditioner (G). Between the two land configurations, L_2 (28.1 t/ha) recorded significantly higher bulb yield as compared to L_1 (25.9 t/ha). With respect to effect of soil conditioner on bulb yield, application of gypsum @ 6 t/ha produced remarkably higher bulb yield (28.3 t/ha) as compared to G_1 (25.7 t/ha) and the extent of increase in yield with G_2 over G_1 was 10 per cent. Effect of INM and all the possible interaction on

Table 31 : Effect of land configuration, soil conditioner and INM on dry matter (g/5 plants) of onion leaves at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 20.62 | 21.75 | 21.18 | 22.75 | 27.50 | 25.12 | 23.15 |
| F ₂ | 18.95 | 19.87 | 19.41 | 19.95 | 24.25 | 22.10 | 20.75 |
| F ₃ | 19.90 | 20.62 | 20.66 | 21.12 | 26.56 | 23.84 | 22.05 |
| Mean | 19.82 | 20.74 | 20.28 | 21.27 | 29.10 | 23.68 | - |
| G. Mean | G ₁ = 20.54 | | | G ₂ = 23.42 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.56 | 0.56 | 0.69 | 0.80 | 0.98 | 0.98 | 1.38 |
| C.D. at 5% | 1.63 | 1.63 | NS | 2.31 | NS | NS | NS |
| C.V. (%) | 13 | | | | | | |

Table 32: Effect of land configuration, soil conditioner and INM on dry matter (g/5 plants) on onion bulb at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 51.50 | 59.55 | 55.52 | 67.20 | 67.46 | 67.33 | 61.42 |
| F ₂ | 48.10 | 53.80 | 50.95 | 62.77 | 64.52 | 63.59 | 67.27 |
| F ₃ | 48.60 | 57.29 | 52.94 | 65.69 | 66.49 | 65.59 | 59.26 |
| Mean | 49.40 | 56.88 | 53.14 | 64.85 | 66.15 | 65.50 | - |
| G. Mean | G ₁ = 57.12 | | | G ₂ = 61.50 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 1.057 | 1.057 | 1.29 | 1.49 | 1.83 | 1.83 | 2.59 |
| C.D. at 5% | 3.04 | 3.04 | NS | 4.30 | NS | NS | NS |
| C.V. (%) | 9 | | | | | | |

Table 33: Effect of land configuration, soil conditioner and INM on onion bulb yield (t/ha)

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F₁ | 26.1 | 28.7 | 27.4 | 27.6 | 31.0 | 29.3 | 28.3 |
| F₂ | 23.3 | 25.0 | 24.2 | 25.7 | 28.9 | 27.3 | 28.7 |
| F₃ | 25.2 | 26.8 | 26.0 | 26.2 | 29.2 | 27.7 | 26.9 |
| Mean | 24.9 | 26.8 | 25.9 | 26.5 | 29.7 | 28.1 | - |
| G. Mean | G ₁ = 25.7 | | | G ₂ = 28.3 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.60 | 0.60 | 0.74 | 0.85 | 1.04 | 1.04 | 1.48 |
| C.D. at 5% | 1.7 | 1.7 | NS | NS | NS | NS | NS |
| C.V. (%) | 11 | | | | | | |

Table 34: Effect of land configuration, soil conditioner and INM on dry weight (kg/ha) of onion bulb at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 4173 | 4577 | 4375 | 4401 | 4442 | 4672 | 4524 |
| F ₂ | 3724 | 3991 | 3858 | 4106 | 4617 | 4361 | 4110 |
| F ₃ | 4029 | 4285 | 4157 | 4176 | 4668 | 4422 | 4289 |
| Mean | 3975 | 4285 | 4130 | 4227 | 4742 | 4485 | - |
| G. Mean | G ₁ = 4102 | | | G ₂ = 4513 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 96 | 96 | 118 | 137 | 167 | 167 | 236 |
| C.D. at 5% | 278 | 278 | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | | | | | | |

bulb yield failed to reach the level of significance. For computing nutrient uptake by onion dry weight of bulb was obtained and the results are given in table 34.

Leaves yield: After harvest of the crop, dry weight of onion leaves were also recorded (Table 35). The results revealed that as like bulb yield, only individual effects of L and G were significant on dry weight of leaves. Here also, the levels L₂ (1291

kg/ha) and G₂ (1299 kg/ha) performed better than L₁ (1189 kg/ha) and G₁ (1181 kg/ha).

Table 35: Effect of land configuration, soil conditioner and INM on dry weight (kg/ha) of onion leaves at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|------|-----------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 1202 | 13.18 | 1260 | 1267 | 1423 | 1345 | 1303 |
| F ₂ | 1072 | 1149 | 1111 | 1182 | 1329 | 1256 | 1183 |
| F ₃ | 1160 | 1234 | 1197 | 1202 | 1344 | 1273 | 1235 |
| Mean | 1145 | 1234 | 1189 | 1217 | 1365 | 1291 | - |
| G. Mean | G ₁ = 1181 | | | G ₂ = 1299 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 28 | 28 | 34 | 39 | 48 | 48 | 68 |
| C.D. at 5% | 80. | 80. | NS | NS | NS | NS | NS |
| C.V. (%) | 12 | | | | | | |

4.3.4 Nutrient content and uptake

The periodical plant samples collected at bulb initiation (total dry matter), grand growth (leaves and bulb) and harvesting (leaves and bulbs) stages were analysed for N, P, K, S, Fe, Mn, Zn and Cu content. The data were statistically processed and interpreted here under nutrient content and uptake subtitles.

Nutrient content: As the content of N, K, Fe, Mn, Zn and Cu in onion plant at different growth stages was not affected significantly due to individual as well as interactive effects, only

the results of main effects are reported here (Tables 36 to 47). However, only exception to this was the main effect of fertilizer treatment on N content in onion was significant at bulb initiation stage (Table 36). Among the fertilizer levels, application of recommended dose only through inorganic fertilizer recorded significantly higher N content (2.41%) in plant as compared to F₂ (2.15%) and F₃ (2.23%) levels, but the later two were at par with each other. At BI stage, main effects of G and F were significant on S content in onion plant (Table 43). The treatments, G₂ (0.65%) and F₃ (0.66%) registered significantly higher S content in onion plant as compared to the remaining levels. While at GG and harvesting stages, only G effect was significant on S content in leaves and bulb of onion. In all the cases, G₂ out scored the G₁ level.

In the case of P content in onion plant at BI stage it was influenced significantly only due to main effect of G and F (Table 37). Between the two levels of soil conditioner, gypsum application could enhance the P concentration (0.370%) in onion plant at BI stage significantly in comparison to its no application (0.348%). Among the F levels, all the levels differed significantly from each other by recording the P content of 0.395, 0.317 and 0.365 per cent in onion at BI stage with F₁, F₂ and F₃ levels, respectively. Here an interaction effect of G x F was also significant and the combination G₂F₁ recorded significantly higher P content in onion plant as compared to rest of the treatments.

Table 36 : Effect of land configuration , soil conditioner and INM on N content (%) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|----------------------|------|--------|------|--------|------|
| | | Leaves | Bulb | Leaves | Bulb |
| L₁ | 2.23 | 1.92 | 1.06 | 1.01 | 1.26 |
| L₂ | 2.29 | 1.96 | 1.06 | 0.96 | 1.24 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 2.24 | 1.94 | 1.07 | 1.00 | 1.27 |
| G₂ | 2.28 | 1.94 | 1.05 | 0.97 | 1.23 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F₁ | 2.41 | 1.83 | 0.98 | 0.92 | 1.18 |
| F₂ | 2.15 | 1.94 | 1.07 | 0.99 | 1.24 |
| F₃ | 2.23 | 2.05 | 1.12 | 1.04 | 1.32 |
| C.D. at 5% | 0.08 | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 5 | 4 | 15 | 14 | 13 |

Table 37 : Effect of soil conditioner and INM on P content (%) in onion plant at BI stage

| Treatment | F ₁ | F ₂ | F ₃ | Mean |
|----------------|----------------|----------------|----------------|-------|
| G ₁ | 0.375 | 0.320 | 0.350 | 0.348 |
| G ₂ | 0.415 | 0.315 | 0.380 | 0.370 |
| Mean | 0.395 | 0.317 | 0.360 | - |

| | L | G | F | L x G | L x F | G x F | L x G x F |
|------------|-------|-------|-------|-------|-------|-------|-----------|
| S. Em. ± | 0.004 | 0.004 | 0.005 | 0.006 | 0.007 | 0.007 | 0.011 |
| C.D. at 5% | NS | 0.012 | 0.015 | NS | NS | 0.021 | NS |
| C.V. (%) | 6 | | | | | | |

The P content in onion leaves and bulb at GG stage was significantly influenced due to main effects G and F. In both the parts at GG stage, G₂ treatment recorded considerably more P content than G₁ level. Similarly, among the F levels, F₃ recorded P content of 0.542 per cent in leaves and 0.590 per cent in bulb at GG stage, which was significantly superior to F₁ and F₂ levels in respective parts of onion (Table 38 and 39). The effect of L and all the interactions were found to be non-significant on P content in leaves at GG stage.

At harvesting stage, P content in leaves (Table 40) and bulb (Table 41) was influenced significantly due to individual effect of soil conditioner (G), fertilizer levels (F) and their interaction (G x F). In both leaves and bulbs at harvesting, significantly higher P content was recorded with G₂ in comparison to G₁ treatment. With respect to fertilizer effect on P

content in leaves and bulb at harvesting, application of ½ RD + PM registered significantly higher values which was followed by treatment receiving ½ RD + FYM and control. Among the different combinations, G₂F₃ showed its superiority to rest of the combinations by recording P content of 0.235 per cent in onion leaves at harvesting stage. Similarly, the P content in onion bulb at harvest was also significantly influenced by individual effects of G and F as well as their interaction (Table 40 and 41). Here G₂ (0.291) and F₃ (0.302) levels registered significantly higher P content in bulb over their respective levels. Like leaves, here also G₂F₃ (0.325%) maintained its superiority over the rest.

Table 38 : Effect of land configuration, soil conditioner and INM on P content (%) in leaves at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 0.400 | 0.520 | 0.460 | 0.450 | 0.530 | 0.490 | 0.475 |
| F ₂ | 0.480 | 0.530 | 0.505 | 0.480 | 0.540 | 0.510 | 0.507 |
| F ₃ | 0.500 | 0.550 | 0.525 | 0.520 | 0.600 | 0.560 | 0.542 |
| Mean | 0.460 | 0.530 | 0.496 | 0.483 | 0.556 | 0.520 | - |
| G. Mean | G ₁ = 0.471 | | | G ₂ = 0.545 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.0172 | 0.014 | 0.017 | 0.020 | 0.024 | 0.024 | 0.034 |

| | | | | | | | |
|------------|----|-------|-------|----|----|----|----|
| C.D. at 5% | NS | 0.041 | 0.050 | NS | NS | NS | NS |
| C.V. (%) | 14 | | | | | | |

Table 39 : Effect of land configuration, soil conditioner and INM on P content(%) in onion bulb at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 0.500 | 0.550 | 0.525 | 0.510 | 0.540 | 0.525 | 0.525 |
| F ₂ | 0.510 | 0.580 | 0.545 | 0.540 | 0.570 | 0.555 | 0.550 |
| F ₃ | 0.570 | 0.610 | 0.590 | 0.580 | 0.600 | 0.590 | 0.590 |
| Mean | 0.526 | 0.580 | 0.553 | 0.543 | 0.570 | 0.556 | - |
| G. Mean | G ₁ = 0.535 | | | G ₂ = 0.575 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.0135 | 0.135 | 0.165 | 0.0191 | 0.023 | 0.023 | 0.033 |
| C.D. at 5% | NS | 0.039 | 0.047 | NS | NS | NS | NS |
| C.V. (%) | 12 | | | | | | |

Table 40: Effect of soil conditioner and INM on P content (%) in onion leaves at harvest

| Treatment | F₁ | F₂ | F₃ | Mean |
|----------------------|----------------------|----------------------|----------------------|-------------|
| G₁ | 0.185 | 0.200 | 0.210 | 0.198 |
| G₂ | 0.181 | 0.217 | 0.235 | 0.210 |
| Mean | 0.182 | 0.208 | 0.222 | - |

| | L | G | F | L x G | L x F | G x F | L x G x F |
|-------------------|----------|----------|----------|--------------|--------------|--------------|------------------|
| S. Em. ± | 0.003 | 0.003 | 0.004 | 0.005 | 0.006 | 0.006 | 0.008 |
| C.D. at 5% | NS | 0.009 | 0.012 | NS | NS | 0.016 | NS |
| C.V. (%) | 8 | | | | | | |

Table 41: Effect of soil conditioner and INM on P content (%) in onion bulb at harvest

| Treatment | F ₁ | F ₂ | F ₃ | Mean |
|----------------|----------------|----------------|----------------|-------|
| G ₁ | 0.240 | 0.270 | 0.280 | 0.263 |
| G ₂ | 0.235 | 0.315 | 0.325 | 0.291 |
| Mean | 0.237 | 0.292 | 0.302 | - |

| | L | G | F | L x G | L x F | G x F | L x G x F |
|------------|-------|-------|-------|-------|-------|-------|-----------|
| S. Em. ± | 0.006 | 0.006 | 0.008 | 0.009 | 0.011 | 0.011 | 0.016 |
| C.D. at 5% | NS | 0.018 | 0.023 | NS | NS | 0.032 | NS |
| C.V. (%) | 11 | | | | | | |

Table 42 : Effect land configuration, soil conditioner and INM on K content (%) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|----------------|------|--------|------|--------|------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 2.65 | 1.63 | 1.03 | 0.82 | 1.27 |
| L ₂ | 2.68 | 1.68 | 1.04 | 0.84 | 1.29 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G ₁ | 2.60 | 1.67 | 1.04 | 0.82 | 1.28 |
| G ₂ | 2.73 | 1.63 | 1.03 | 0.85 | 1.29 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F ₁ | 2.58 | 1.54 | 0.97 | 0.81 | 1.25 |

| | | | | | |
|----------------------|------|------|------|------|------|
| F₂ | 2.66 | 1.66 | 1.03 | 0.83 | 1.29 |
| F₃ | 2.76 | 1.76 | 1.09 | 0.86 | 1.31 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | 15 | 14 | 7 | 5 |

Table 43: Effect land configuration, soil conditioner and INM on S content (mg/kg) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|----------------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L₁ | 0.63 | 0.69 | 0.62 | 0.59 | 0.80 |
| L₂ | 0.62 | 0.72 | 0.61 | 0.60 | 0.81 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 0.61 | 0.64 | 0.55 | 0.52 | 0.69 |
| G₂ | 0.65 | 0.78 | 0.67 | 0.68 | 0.92 |
| C.D. at 5% | 0.038 | 0.054 | 0.038 | 0.023 | 0.027 |
| F₁ | 0.60 | 0.67 | 0.59 | 0.58 | 0.78 |
| F₂ | 0.63 | 0.69 | 0.60 | 0.60 | 0.81 |
| F₃ | 0.66 | 0.75 | 0.64 | 0.61 | 0.82 |
| C.D. at 5% | 0.47 | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | 13 | 11 | 7 | 6 |

Table 44: Effect land configuration, soil conditioner and INM on Fe content (mg/kg) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|--------------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 39.97 | 98.53 | 50.25 | 45.85 | 92.70 |
| L ₂ | 40.37 | 106.40 | 52.90 | 47.83 | 44.35 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G ₁ | 39.35 | 99.60 | 51.40 | 45.96 | 92.70 |
| G ₂ | 41.00 | 105.33 | 51.75 | 47.71 | 94.35 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F ₁ | 39.22 | 97.20 | 50.50 | 45.15 | 92.17 |
| F ₂ | 39.97 | 102.20 | 51.45 | 47.07 | 93.60 |
| F ₃ | 41.32 | 108.00 | 52.72 | 48.30 | 94.80 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 7. | 14 | 10 | 8 | 5 |

Table 45: Effect land configuration, soil conditioner and INM on Mn content (mg/kg) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|----------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 25.40 | 40.40 | 17.98 | 14.70 | 45.23 |
| L ₂ | 27.00 | 45.00 | 19.20 | 15.66 | 46.61 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G ₁ | 25.80 | 40.10 | 17.91 | 14.63 | 44.60 |
| G ₂ | 26.60 | 43.40 | 19.26 | 15.73 | 47.25 |
| C.D. at 5% | NS | NS | NS | NS | NS |

| | | | | | |
|----------------------|-------|-------|-------|-------|-------|
| F₁ | 25.42 | 39.00 | 18.00 | 14.75 | 44.00 |
| F₂ | 26.01 | 42.00 | 18.57 | 15.12 | 46.22 |
| F₃ | 27.15 | 44.25 | 19.20 | 15.67 | 47.55 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 11 | 14 | 13 | 13 | 11 |

Table 46: Effect land configuration, soil conditioner and INM on Zn content (mg/kg) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|----------------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L₁ | 15.61 | 19.38 | 25.63 | 25.92 | 36.16 |
| L₂ | 16.88 | 20.53 | 26.25 | 27.77 | 39.33 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 15.76 | 19.76 | 25.23 | 26.50 | 36.81 |
| G₂ | 16.73 | 20.15 | 26.65 | 27.20 | 37.66 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F₁ | 15.87 | 19.37 | 25.17 | 25.62 | 35.25 |
| F₂ | 16.26 | 19.62 | 25.77 | 26.46 | 36.97 |
| F₃ | 16.60 | 20.87 | 26.87 | 28.46 | 39.50 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 14 | 12 | 10 | 14 | 19 |

Table 47: Effect land configuration, soil conditioner and INM on Cu content (mg/kg) in onion plant at different growth stages

| Treatment | BI | GG | | AH | |
|--------------------|------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 9.20 | 12.00 | 25.95 | 9.65 | 32.70 |
| L ₂ | 9.68 | 12.44 | 27.23 | 10.03 | 34.00 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G ₁ | 9.38 | 11.73 | 25.66 | 9.48 | 32.33 |
| G ₂ | 9.49 | 12.70 | 27.51 | 10.20 | 34.36 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F ₁ | 8.86 | 11.47 | 25.30 | 9.30 | 32.52 |
| F ₂ | 9.48 | 12.25 | 26.50 | 9.75 | 33.40 |
| F ₃ | 9.98 | 12.93 | 37.97 | 10.47 | 34.12 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 14 | 14 | 13 | 13 | 11 |

Nutrient uptake

Periodical nutrient uptake

For knowing the nutrient uptake pattern of onion, periodical samplings at BI, GG and harvesting treatment wise five plant samples were collected and analysed for the nutrient content. Considering the concentration of N, P, K, S, Fe, Zn and Cu separately in onion bulb and leaves at different growth stages, uptake of all the nutrients was computed. As the uptake of nutrient by onion was mainly affected significantly by the

individual effects of L and G, only mean values of individual variables are interpreted here. Of course, wherever L x G interaction was turned out to be significant, separate interaction table has been furnished for that particular element and stage.

Nitrogen : The results pertaining to the N uptake by onion plant at BI stage (Table 48) revealed that the effect of land configuration, soil conditioner and INM significantly influenced the N uptake, however, their interaction effects were not significant. Between the two land configurations, L₂ (56.73 mg/plant) recorded significantly higher uptake of N as compared to L₁ (48.24 mg/plant). As far as the effect of F is concerned, significantly higher uptake of N was recorded with F₁ (59.13 mg/plant) over F₂ (46.87 mg/plant) and F₃ (51.45 mg/plant). Both F₂ and F₃ were at par with each other.

At GG stage only land configuration (L) and soil conditioner (G) could exert significant impact on N uptake in leaves (Table 48). Between the two types of land configuration raised bed (92.55 mg/plant) recorded higher N uptake than flat bed (71.76 mg/plant). This was also true for N uptake by bulb. However at GG stage, G effect was significant and G₂ level (88.47 mg/plant) recorded remarkably higher N uptake by leaves. At harvest also, L₂ recorded significantly higher N uptake by both bulb and leaves (Table 48) in comparison to L₁ level. In all the cases, first and second order interactions failed to reach the level of significance as far the N uptake in onion plant is concerned.

Table 48: Effect of land configuration, soil conditioner and INM on N uptake (mg/plant) by onion plant at various growth stages

| Treatment | BI | GG | | AH | |
|--------------------|-------|--------|-------|--------|--------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 48.24 | 71.76 | 62.51 | 40.73 | 132.85 |
| L ₂ | 56.73 | 92.55 | 82.30 | 45.60 | 162.93 |
| C.D. at 5% | 4.59 | 10.75 | 9.58 | 4.69 | 13.20 |
| G ₁ | 49.31 | 75.85 | 70.40 | 41.10 | 145.02 |
| G ₂ | 55.66 | 88.47 | 74.30 | 45.23 | 150.75 |
| C.D. at 5% | 4.49 | 10.75 | NS | NS | NS |
| F ₁ | 59.13 | 81.64 | 70.80 | 42.98 | 144.85 |
| F ₂ | 46.87 | 76.63 | 68.40 | 40.83 | 142.15 |
| F ₃ | 51.45 | 88.20 | 78.00 | 45.69 | 156.66 |
| C.D. at 5% | 5.63 | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 14 | 22 | 21 | 18 | 15 |

Phosphorus: The results presented in table 49 indicated that P uptake at BI stage was significantly affected by land configuration (L), soil conditioner (G) and fertilizers (F). However, their interaction effects did not show any significant differences in P uptake. The higher P uptake was recorded with L₂ (9.07 mg/plant) and G₂ (9.04 mg/plant) levels as compared to L₁ (7.64 mg/plant) and G₁ (7.67 mg/plant) levels. Among the various

F levels, F₁ (9.72 mg/plant) recorded significantly higher uptake over F₂ (6.92 mg/plant) and F₃ (8.42 mg/plant) levels.

Table 49: Effect of land configuration, soil conditioner and INM on P uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|--------------------|------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 7.64 | 18.66 | 33.02 | 8.11 | 28.94 |
| L ₂ | 9.07 | 24.65 | 42.89 | 9.8 | 37.10 |
| C.D. at 5% | 0.74 | 2.51 | 4.41 | 0.67 | 2.91 |
| G ₁ | 7.67 | 18.47 | 34.89 | 8.15 | 30.30 |
| G ₂ | 9.04 | 24.85 | 41.03 | 9.81 | 35.74 |
| C.D. at 5% | 0.74 | 2.51 | 4.41 | 0.67 | 2.91 |
| F ₁ | 9.72 | 21.33 | 37.76 | 8.43 | 29.28 |
| F ₂ | 6.92 | 20.16 | 35.46 | 8.67 | 33.63 |
| F ₃ | 8.42 | 23.48 | 40.65 | 9.84 | 36.16 |
| C.D. at 5% | 0.91 | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | L X G |
| C.V. (%) | 15 | 19 | 19 | 12 | 15 |

At GG stage, P uptake by both bulb and leaves of onion was significantly affected only due to land configuration

and soil conditioner (Table 49). Here also, L₂ and G₂ levels recorded the highest P uptake through both bulb and leaves of onion. However, at harvest, all the three factors *i.e.*, L, G and F significantly influenced the P uptake by bulb and leaves (Table 49). In both the cases, P uptake was found to be significantly higher with L₂, G₂ and F₃ levels than L₁, G₁ and F₁ and F₂ levels. The first order interaction *i.e.*, L x G was found to be significant as far as the uptake of P through onion bulb at harvest is concerned (Table 50). Significantly higher uptake of P was registered with L₂G₂ (38.27 mg/plant) over L₁G₁ (24.68 mg/plant) and L₁G₂ (33.20 mg/plant) but it was at par with L₂G₁ (35.92 mg/plant).

Table 50: Effect of L x G interaction on P uptake by onion bulb (mg/plant) at harvest

| Treatment | G ₁ | G ₂ |
|----------------|----------------|----------------|
| L ₁ | 24.68 | 33.20 |
| L ₂ | 35.92 | 38.27 |
| S.Em. ± | 1.43 | |
| C.D. at 5% | 4.12 | |

Potassium: An appraisal of the results presented in table 51 showed that at BI stage land configuration L₂ (65.87 mg/plant) recorded significantly higher K uptake as compared to L₁ (57.03 mg/plant). The results further revealed that application of soil conditioner registered significantly higher K uptake (66.16 mg/plant) in comparison to G₁ (56.75 mg/plant). At GG stage,

(Table 51) only land configuration had significant impact on K uptake by both bulb and leaves. In both the cases, here also L₂ maintained its superiority over L₁. However, at harvest (Table 51) land configuration and soil conditioner had significantly influenced the K uptake by bulb and leaves of onion. At this stage also, L₂ and G₂ performed better than L₁ and G₁ levels. Further, it was observed that K uptake by bulb at harvest was significantly influenced by Lx G interaction (Table 52). Significantly more uptake of K was recorded with L₂G₂ (171.99 mg/plant) but it was closely followed by L₂G₁ (166.87 mg/plant). But, L₁G₁ (124.92 mg/plant) and L₁G₂ (144.78 mg/plant) had recorded significantly lower values than rest of the combinations.

Table 51: Effect of land configuration, soil conditioner and INM on K uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|----------------|-------|--------|-------|--------|--------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 57.03 | 60.93 | 60.97 | 33.36 | 134.86 |
| L ₂ | 65.87 | 79.49 | 80.17 | 39.88 | 169.43 |
| C.D. at 5% | 5.26 | 9.51 | 8.95 | 3.01 | 7.17 |
| G ₁ | 56.75 | 65.68 | 68.03 | 33.74 | 145.90 |
| G ₂ | 66.16 | 74.74 | 73.11 | 39.50 | 158.39 |
| C.D. at 5% | 5.26 | NS | NS | 3.01 | 7.17 |
| F ₁ | 63.13 | 68.62 | 69.90 | 37.44 | 154.39 |
| F ₂ | 57.77 | 66.06 | 66.12 | 34.46 | 147.40 |
| F ₃ | 63.46 | 75.94 | 75.68 | 37.96 | 154.64 |
| C.D. at 5% | NS | NS | NS | NS | NS |

| | | | | | |
|--------------------|----|----|----|----|-------|
| Interaction | NS | NS | NS | NS | L X G |
| C.V. (%) | 14 | 23 | 21 | 14 | 8 |

Table 52 : Effect of L x G interaction on K uptake by onion bulb (mg/plant) at harvest

| <i>Treatment</i> | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 124.92 | 144.78 |
| L₂ | 166.87 | 171.99 |
| S.Em. ± | 3.52 | |
| C.D. at 5% | 10.14 | |

Sulphur: At BI stage, S uptake by onion was significantly influenced by individual effects of land configuration and soil conditioner (Table 53). Significantly more S uptake was obtained with L₂ (15.42 mg/plant) than L₁ (13.56 mg/plant). Similarly, between the two levels of soil conditioner, G₂ (15.67 mg/plant) recorded significantly higher uptake of S as compared to G₁ (13.30 mg/plant). Here, L x G interaction found to be significant on S uptake by onion plant. A combination of L₂G₂ (17.24 mg/plant) out scored rest of the combinations. The individual effect of F and remaining interactions were absent. At GG stage, S uptake by both leaves and bulb was affected significantly due to land configuration and soil conditioner (Tables 54 and 55), however, their interaction effect was found to be significant in the case of S uptake by leaves. Here, L₂ (34.39 mg/plant) registered significantly higher uptake of S by leaves as compared to L₁ (26.10 mg/plant) and between the two gypsum levels, G₂ (35.63 mg/plant) registered higher uptake in comparison to G₁

(24.86 mg/plant) in leaves. Similar trend of S uptake was also observed in case of onion bulb at GG stage. The S uptake by leaves was significantly higher with combination of L₂G₂ (41.70 mg/plant) as compared to rest of the combinations. The S uptake at harvest in leaves was affected significantly due to individual and interactive effects of land configuration (L) and soil conditioner (G). The S uptake by leaves (Table 56) at harvest was significantly more with L₂ (28.89 mg/plant) and G₂ (31.80 mg/plant) than the L₁ (24.17 mg/plant) and G₁ (21.27 mg/plant).

Table 53 : Effect of land configuration, soil conditioner and INM on S uptake (mg/plant) by plant at BI stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 12.64 | 14.73 | 13.68 | 14.09 | 17.33 | 15.71 | 14.70 |
| F ₂ | 12.96 | 13.30 | 12.87 | 12.43 | 16.27 | 14.35 | 13.62 |
| F ₃ | 13.91 | 14.29 | 14.10 | 14.25 | 18.11 | 16.18 | 15.14 |
| Mean | 13.00 | 14.10 | 13.56 | 13.59 | 17.24 | 15.42 | - |
| G. Mean | G ₁ = 13.30 | | | G ₂ = 15.67 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.40 | 0.40 | 0.49 | 0.57 | 0.70 | 0.70 | 0.99 |
| C.D. at 5% | 1.16 | 1.16 | NS | 1.64 | NS | NS | NS |

| | |
|----------|----|
| C.V. (%) | 13 |
|----------|----|

Table 54 : Effect of land configuration, soil conditioner and INM on S uptake (mg/plant) by onion leaves at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 21.35 | 29.41 | 25.37 | 27.03 | 44.05 | 35.54 | 30.46 |
| F ₂ | 20.90 | 27.23 | 24.06 | 24.60 | 38.50 | 31.55 | 27.81 |
| F ₃ | 25.70 | 32.04 | 28.86 | 29.57 | 42.56 | 36.06 | 32.47 |
| Mean | 22.64 | 29.55 | 26.10 | 27.06 | 41.70 | 34.39 | - |
| G. Mean | G ₁ = 24.86 | | | G ₂ = 35.63 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 1.209 | 1.209 | 1.481 | 1.71 | 2.094 | 2.094 | 2.962 |
| C.D. at 5% | 3.48 | 3.48 | NS | 4.92 | NS | NS | NS |
| C.V. (%) | 19 | | | | | | |

Table 55 : Effect of land configuration, soil conditioner and INM on S uptake (mg/plant) by onion bulb at GG stage

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|------------------------|----------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 31.44 | 42.50 | 36.97 | 40.31 | 54.61 | 47.45 | 42.21 |
| F ₂ | 27.94 | 38.86 | 33.40 | 38.84 | 50.20 | 44.51 | 38.96 |
| F ₃ | 33.45 | 46.19 | 39.81 | 43.65 | 55.29 | 49.46 | 44.64 |
| Mean | 30.94 | 42.51 | 36.73 | 40.92 | 53.36 | 47.15 | - |
| G. Mean | G ₁ = 35.94 | | G ₂ = 47.94 | | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 1.70 | 1.70 | 2.08 | 2.40 | 2.94 | 2.94 | 4.17 |
| C.D. at 5% | 4.89 | 4.89 | NS | NS | NS | NS | NS |
| C.V. (%) | 19 | | | | | | |

Table 56 : Effect of land configuration, soil conditioner and INM on S uptake (mg/plant) by onion leaves at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|------------------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 20.61 | 28.27 | 24.44 | 23.23 | 36.30 | 29.76 | 27.10 |
| F ₂ | 19.33 | 26.89 | 23.11 | 20.75 | 33.47 | 27.11 | 25.11 |
| F ₃ | 21.24 | 28.69 | 24.96 | 22.42 | 37.18 | 29.80 | 27.38 |
| Mean | 20.39 | 27.94 | 24.17 | 22.13 | 35.65 | 28.89 | - |
| G. Mean | G ₁ = 21.27 | | | G ₂ = 31.80 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 0.83 | 0.83 | 1.01 | 1.17 | 1.43 | 1.43 | 2.03 |
| C.D. at 5% | 2.38 | 2.38 | NS | 3.37 | NS | NS | NS |
| C.V. (%) | 15 | | | | | | |

Among the different L x G combinations, L₂G₂ (35.65 mg/plant) and L₁G₁ (20.39 mg/plant) recorded significantly maximum and minimum values, respectively. An appraisal of the results presented in table 57 revealed that at harvest S uptake by onion bulb was significantly affected only by individual effects of L and G, however, their interaction failed to reach the level of

significance. Here also, L₂ (106.47 mg/plant) and G₂ (113.30 mg/plant) recorded significantly higher S uptake over L₁ and G₁. All the first and second order interaction effects were observed to be non-significant on S uptake by onion.

Table 57: Effect of land configuration, soil conditioner and INM on S uptake (mg/plant) by onion bulb at harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|------------------------|----------------|-------|-------------------------|----------------|--------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 69.01 | 103.62 | 86.31 | 91.38 | 122.78 | 107.07 | 96.70 |
| F ₂ | 65.42 | 99.66 | 82.54 | 87.73 | 120.00 | 103.86 | 93.20 |
| F ₃ | 67.05 | 108.73 | 87.89 | 91.92 | 125.00 | 108.46 | 98.18 |
| Mean | 67.16 | 104.00 | 85.58 | 90.34 | 122.59 | 106.47 | - |
| G. Mean | G ₁ = 78.75 | | | G ₂ = 113.30 | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. ± | 1.97 | 1.97 | 2.41 | 2.78 | 3.41 | 3.41 | 4.83 |
| C.D. at 5% | 5.67 | 5.67 | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | | | | | | |

Iron: The results furnished in table 58 revealed that the Fe uptake by onion plant at BI was significantly influenced by land configuration (L) and soil conditioner (G), however their interaction effect was found to be not significant. Significantly higher uptake of Fe was recorded with G₂ (0.099 mg/plant) than L₁ (0.086 mg/plant). Similarly, gypsum level L₂ (0.099 mg/plant)

registered higher uptake than G_1 (0.086 mg/plant). At GG stage, both land configuration and soil conditioner affected Fe uptake in leaves, however in bulb, only land configuration had a significant impact on it (Table 58). In both the cases, L_2 level recorded higher Fe uptake as compared to L_1 .

Table 58: Effect of land configuration, soil conditioner and INM on Fe uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L_1 | 0.086 | 0.368 | 0.295 | 0.185 | 0.983 |
| L_2 | 0.099 | 0.503 | 0.405 | 0.227 | 1.236 |
| C.D. at 5% | 0.010 | 0.05 | 0.034 | 0.018 | 0.063 |
| G_1 | 0.086 | 0.389 | 0.335 | 0.189 | 1.056 |
| G_2 | 0.099 | 0.482 | 0.368 | 0.223 | 1.162 |
| C.D. at 5% | 0.010 | 0.05 | NS | 0.018 | 0.063 |
| F_1 | 0.096 | 0.433 | 0.360 | 0.210 | 1.134 |
| F_2 | 0.087 | 0.406 | 0.330 | 0.195 | 1.073 |
| F_3 | 0.095 | 0.467 | 0.365 | 0.213 | 1.121 |
| C.D. at 5% | NS | NS | NS | NS | NS |

| | | | | | |
|--------------------|----|----|----|-------|----|
| Interaction | NS | NS | NS | L x G | NS |
| C.V. (%) | 12 | 19 | 16 | 15 | 10 |

In case of uptake of Fe by leaves at harvest, it was significantly influenced both by L and G individually as well as their interaction. Planting of onion on raised bed and application of gypsum could enhance Fe uptake significantly as compared to flat bed planting and no application of gypsum. Among the different L x G combinations, L₂G₂ (0.253 mg/plant) recorded considerably higher uptake over rest of all the combinations (Table 59). The minimum uptake was recorded with L₁G₁ (0.177 mg/plant). In case of Fe uptake by bulb, it was significantly higher with L₂ and G₂, but all the other effects were absent.

Table 59: Effect of L x G interaction on Fe uptake by onion leaves (mg/plant) at harvest

| Treatment | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 0.177 | 0.193 |
| L₂ | 0.200 | 0.253 |
| S.Em. ± | 0.009 | |
| C.D. at 5% | 0.025 | |

Manganese: The Mn uptake by onion plant at BI stage was significantly affected by L, G, F and L x G interaction (Table 60 and 61). An application of soil conditioner (G₂) removed higher Mn than its no application (G₁). Similarly, land configuration L₂ registered significantly more Mn removal than L₁ *i.e.*, flat bed

planting. Among the fertilizer levels, F_1 and F_3 were at par with each other, but both levels were superior over F_2 . The interactive effect of L and G was also turn out to be significant and a combination L_2G_2 (0.072 mg/plant) ranked first among the different combinations.

At GG stage, Mn uptake by bulb and leaves were differed significantly due to main effect of L and G. It is seen that the INM and all the first and second order interactions did not influence the Mn uptake significantly (Table 60). The Mn uptake by leaves and bulb was much more with L_2 and G_2 than L_1 and G_1 treatments. The Mn uptake by onion leaves and bulb at harvest was significantly influenced by land configuration (L) and soil conditioner (G) only. Here also, raised bed planting registered significantly higher Mn uptake than flat bed and the G_2 level of soil conditioner recorded more Mn uptake by leaves and bulb than G_1 .

Table 60: Effect of land configuration, soil conditioner and INM on Mn uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L_1 | 0.055 | 0.152 | 0.105 | 0.060 | 0.478 |
| L_2 | 0.066 | 0.204 | 0.148 | 0.074 | 0.611 |
| C.D. at 5% | 0.004 | 0.022 | 0.011 | 0.008 | 0.041 |
| G_1 | 0.056 | 0.157 | 0.116 | 0.060 | 0.507 |
| G_2 | 0.064 | 0.198 | 0.137 | 0.074 | 0.583 |
| C.D. at 5% | 0.004 | 0.022 | 0.011 | 0.008 | 0.041 |
| F_1 | 0.062 | 0.175 | 0.129 | 0.069 | 0.541 |

| | | | | | |
|----------------------|-------|-------|-------|-------|-------|
| F₂ | 0.056 | 0.167 | 0.118 | 0.063 | 0.530 |
| F₃ | 0.062 | 0.192 | 0.132 | 0.069 | 0.563 |
| C.D. at 5% | 0.005 | NS | NS | NS | NS |
| Interaction | L x G | NS | NS | NS | NS |
| C.V. (%) | 12 | 21 | 15 | 19 | 13 |

Table 61: Effect of L x G interaction on Mn uptake by onion leaves (mg/plant) at BI stage

| Treatment | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 0.053 | 0.056 |
| L₂ | 0.059 | 0.072 |
| S.Em. ± | 0.002 | |
| C.D. at 5% | 0.006 | |

Zinc: In results of Zn uptake by onion plant at BI stage as influenced by various treatments are presented in tables 62 and 63 which revealed that it was affected significantly by individual and interactive effects of land configuration (L) and soil conditioner (G). The Zn uptake was higher with L₂ (0.041 mg/plant) type of land configuration as compared to L₁ (0.033 mg/plant). In case of soil conditioner, Zn uptake was observed to be maximum with G₂ (0.040 mg/plant). As regard the interaction effects of L x G, L₂G₂ (0.047 mg/plant) recorded significantly higher Zn uptake as compared to rest of combinations. The lowest uptake of Zn was recorded with L₁G₁ (0.033 mg/plant) which was found to be at par with L₁G₂ (0.034 mg/plant) and L₂G₁ (0.036 mg/plant).

At GG stage, significantly higher uptake of Zn by both leaves and bulb was recorded with G₂ and L₂ (Table 62). Further, it is observed that INM (F) significantly influenced the Zn uptake by onion bulb at GG stage. Among the different levels of F, the higher uptake of 0.185 mg/plant was recorded with F₃ followed by F₁ (0.180 mg/plant) but both these were significantly more than F₂ (0.165 mg/plant). As regard the uptake of Zn by leaves at harvest, it was significantly influenced individually by L and G and their interaction effect. Here also, L₂ and G₂ maintained their superiority over L₁ and G₁ levels. A combination L₂G₂ (0.151 mg/plant) recorded maximum uptake and that of minimum was registered with L₁G₁ and L₁G₂ (0.105 mg/plant) treatments (Table 64). In case of uptake of Zn by onion bulb at harvest, it was found to be significant only due to land configuration. The L₂ (0.503 mg/plant) recorded higher uptake than L₁ (0.384 mg/plant).

Table 62: Effect of land configuration, soil conditioner and INM on Zn uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|----------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 0.033 | 0.073 | 0.150 | 0.105 | 0.384 |
| L ₂ | 0.041 | 0.097 | 0.203 | 0.133 | 0.503 |
| C.D. at 5% | 0.003 | 0.010 | 0.014 | 0.015 | 0.056 |
| G ₁ | 0.034 | 0.078 | 0.164 | 0.110 | 0.420 |
| G ₂ | 0.040 | 0.092 | 0.189 | 0.129 | 0.466 |
| C.D. at 5% | 0.003 | 0.010 | 0.014 | 0.015 | NS |
| F ₁ | 0.039 | 0.087 | 0.180 | 0.121 | 0.435 |
| F ₂ | 0.035 | 0.078 | 0.165 | 0.111 | 0.425 |

| | | | | | |
|----------------------|-------|-------|-------|-------|-------|
| F₃ | 0.038 | 0.090 | 0.185 | 0.126 | 1.471 |
| C.D. at 5% | NS | NS | 0.017 | NS | NS |
| Interaction | L x G | NS | NS | L x G | NS |
| C.V. (%) | 14 | 19 | 13 | 22 | 21 |

Table 63: Effect of L x G interaction on Zn uptake by onion leaves (mg/plant) at BI

| Treatment | G ₁ | G ₂ |
|----------------------|----------------|----------------|
| L₁ | 0.033 | 0.034 |
| L₂ | 0.036 | 0.047 |
| S.Em. ± | 0.002 | |
| C.D. at 5% | 0.005 | |

Table 64: Effect of L x G interaction on Zn uptake by onion leaves (mg/plant) at harvest

| Treatment | G ₁ | G ₂ |
|----------------------|----------------|----------------|
| L₁ | 0.105 | 0.105 |
| L₂ | 0.114 | 0.151 |
| S.Em. ± | 0.008 | |
| C.D. at 5% | 0.022 | |

Copper: The results pertaining to the effect of land configuration, soil conditioner and INM on Cu uptake by onion at different growth stages are furnished in tables 65 to 67. The results indicated that at BI stage L, G and the interaction (L x G) could significantly influence the Cu uptake by onion plant. The treatment L₂ and G₂ recorded significantly higher Cu uptake as compared to L₁ and G₁. Similarly, treatment L₂G₂ (0.027 mg/plant) registered higher Cu uptake amongst the different combinations. At GG stage, only individual effect of L and G was observed to be significant on Cu uptake by both leaves and bulb. In both the cases, raised bed planting and gypsum application

enhanced the Cu uptake by leaves and bulb significantly more than flat bed and control. At harvest the individual effect of L and G were significant on Cu uptake by leaves and bulb. In both the cases, L₂ and G₂ levels showed their superiority over L₁ and G₁ levels. Similarly, the Cu uptake by leaves was also affected significantly due to interactive effect of L and G. Among the four possible combinations, L₂G₂ (0.055 mg/plant) combination proved to be the best and it was followed by L₂G₁ (0.040 mg/plant). At harvesting stage, the Cu uptake by onion bulb significantly influenced only due to individual effect of land configuration and soil conditioner. Like other elements, the Cu uptake by bulb was also significantly more with L₂ (0.446 mg/plant) and G₂ (0.424 mg/plant) than L₁ (0.346 mg/plant) and G₁ (0.369 mg/plant).

Nutrient uptake at harvest: For assessing the impact of different treatments on total uptake of nutrients by onion at harvest,

Table 65: Effect of land configuration, soil conditioner and INM on Cu uptake (mg/plant) by onion

| Treatment | BI | GG | | AH | |
|----------------|-------|--------|-------|--------|-------|
| | | Leaves | Bulb | Leaves | Bulb |
| L ₁ | 0.020 | 0.044 | 0.153 | 0.039 | 0.346 |
| L ₂ | 0.024 | 0.059 | 0.209 | 0.048 | 0.446 |
| C.D. at 5% | 0.002 | 0.005 | 0.017 | 0.005 | 0.029 |
| G ₁ | 0.020 | 0.046 | 0.169 | 0.039 | 0.369 |
| G ₂ | 0.023 | 0.058 | 0.194 | 0.048 | 0.424 |
| C.D. at 5% | 0.002 | 0.005 | 0.017 | 0.005 | 0.029 |

| | | | | | |
|----------------------|-------|-------|-------|-------|-------|
| F₁ | 0.022 | 0.052 | 0.182 | 0.044 | 0.400 |
| F₂ | 0.021 | 0.04 | 0.169 | 0.041 | 0.384 |
| F₃ | 0.023 | 0.055 | 0.192 | 0.046 | 0.405 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| Interaction | L x G | NS | NS | L x G | NS |
| C.V. (%) | 18 | 18 | 16 | 19 | 13 |

Table 66 : Effect of L x G interaction on Cu uptake (mg/plant) by onion at BI Stage

| Treatment | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 0.020 | 0.019 |
| L₂ | 0.021 | 0.027 |
| S.Em. \pm | 0.001 | |
| C.D. at 5% | 0.003 | |

Table 67 : Effect of L x G interaction on Cu uptake (mg/plant) by onion leaves at harvest

| Treatment | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 0.037 | 0.039 |
| L₂ | 0.040 | 0.055 |
| S.Em. \pm | 0.002 | |
| C.D. at 5% | 0.007 | |

content of N, P, K, S, Fe, Mn, Zn and Cu separately in onion leaves and bulb and yield of leaves and bulb were considered. The

uptake of nutrients by bulb and leaves was separately calculated on the hectare basis and the values are presented here.

Onion leaves

Macronutrients: The results pertaining of the N uptake (Table 68) by onion leaves revealed that main effect as well as all the interaction effects were absent. As regards the P uptake, it was affected significantly only due to main effect of land configuration, soil conditioner and integrated nutrient management (Table 68). Between the two land configurations, the crop planted on raised bed (2.68 kg/ha) recorded significantly higher uptake over that planted on flat bed (2.38 kg/ha). Application of gypsum @ 6 t/ha (2.73 kg/ha) showed significantly more uptake than absence of its application (2.34 kg/ha). Among different F levels, F₃ receiving 50% RD + PM @ 6 t/ha exhibited significantly higher P uptake (2.76 kg/ha) as compared to F₂ (2.48 kg/ha) and F₁ (2.37 kg/ha). However, the later two levels were at par with each other. The results of K uptake presented in table 68 revealed that only main effect of land configuration and soil conditioner could significantly influence the K uptake by onion leaves. Comparatively lower K uptake was recorded at L₁ (9.83 kg/ha) than L₂ (10.85 kg/ha). Between the two gypsum levels, G₂ (10.99 kg/ha) registered significantly higher K uptake as compared to G₁ (9.69 kg/ha). As far as the uptake of S is concerned, it was also found to be significantly affected only by

| | | | | | | | | |
|----------|----|----|----|----|----|----|----|----|
| C.V. (%) | 19 | 14 | 12 | 11 | 15 | 19 | 20 | 19 |
|----------|----|----|----|----|----|----|----|----|

land configuration and soil conditioner. In this case also, the same treatments *i.e.* L₂ and G₂ maintained their superiority over their respective levels.

Micronutrients : The results pertaining to the uptake of micronutrients revealed that uptake of all the micronutrient by onion leaves at harvest was significantly influenced by land configuration and soil conditioner. Between the two types of land configurations, crop planted on raised bed (L₂) recorded significantly more uptake of Fe, Mn, Zn and Cu (61.85 g/ha, 20.29 g/ha, 36.0 g/ha and 13.0 g/ha, respectively) than the crop planted on flat bed (L₁). Similarly, application of gypsum @ 6 t/ha as a soil conditioner (G₂) registered higher uptake of all micronutrients in comparison to G₁. In all the cases, individual effect of INM and the interaction effects were absent (Table 68).

Onion bulb

Macronutrients : The results regarding the uptake of N, P, K and S by onion bulb are furnished in table 69. The results revealed

that as observed in case of leaves, N uptake by onion bulb was also not influenced significantly by either individual effect of land configuration (L), soil conditioner (G) and INM (F) or their interaction. With respect to P uptake, main effect of L, G and F was observed to be significant. Between the two land configuration, L₂ (12.64 kg/ha) recorded higher P uptake than L₁ (11.18 kg/ha). The treatments receiving gypsum recorded significantly higher P uptake as compared to that not receiving gypsum. Similarly, the treatment

Table 69: Effect of land configuration soil conditioner and INM on nutrient uptake by onion bulb at harvest

| Treatments | Uptake (kg/ha) | | | | Uptake (g/ha) | | | |
|----------------|----------------|-------|-------|-------|---------------|-----|-----|-----|
| | N | P | K | S | Fe | Mn | Zn | Cu |
| L ₁ | 52.00 | 11.18 | 52.60 | 33.18 | 383 | 187 | 149 | 135 |
| L ₂ | 55.69 | 12.64 | 58.01 | 36.68 | 424 | 210 | 173 | 153 |
| S. Em. \pm | 2.08 | 0.34 | 1.36 | 0.97 | 11 | 7 | 7 | 5 |
| C.D. at 5% | NS | 0.97 | 3.92 | 2.80 | 32 | 21 | 21 | 15 |
| G ₁ | 52.00 | 10.79 | 52.52 | 28.22 | 380 | 183 | 152 | 132 |
| G ₂ | 55.63 | 13.03 | 58.09 | 41.64 | 427 | 214 | 170 | 156 |
| S. Em. \pm | 2.08 | 0.34 | 1.36 | 0.97 | 11 | 7 | 7 | 5 |
| C.D. at 5% | NS | 0.97 | 3.92 | 2.80 | 32 | 21 | 21 | 15 |

| | | | | | | | | |
|----------------|-------|-------|-------|-------|-----|-----|-----|-----|
| F ₁ | 53.41 | 10.67 | 56.78 | 35.67 | 418 | 200 | 160 | 148 |
| F ₂ | 51.25 | 12.12 | 53.05 | 33.52 | 385 | 191 | 153 | 138 |
| F ₃ | 56.99 | 12.94 | 56.09 | 35.61 | 408 | 205 | 170 | 147 |
| S. Em. \pm | 2.55 | 1.19 | 1.66 | 1.19 | 14 | 9 | 9 | 6 |
| C.D. at 5% | NS | NS | NS | NS | NS | NS | NS | NS |
| Interaction | NS | NS | NS | NS | NS | NS | NS | NS |
| C.V. (%) | 18 | 13 | 12 | 13 | 14 | 17 | 21 | 17 |

receiving $\frac{1}{2}$ RD + PM removed (12.94 kg/ha) significantly more P by bulb than 100 per cent RD treatment (10.67 kg/ha), but it was at par with $\frac{1}{2}$ RD + FYM treatment (12.12 kg/ha). As far as K and S uptake is concerned, only main effects of land configuration and soil conditioner could exert significant impact on their uptake. Between the two types of land configuration, L₂ recorded more uptake of both the nutrients (K: 58.01 kg/ha and S: 36.68 kg/ha) than L₁. Similarly, gypsum level G₂ recorded higher uptake of K and S over G₁ level.

Micronutrients: The results of uptake of Fe, Mn, Zn and Cu by onion bulb are given in table 68. The results revealed that only main effect of land configuration (L) and soil conditioner (G) had significant impact on uptake of all the micronutrients by onion at harvest except G effect on Zn uptake. Between the two types of

land configuration, L₂ recorded more uptake than L₁. Similarly, as compared to G₁, G₂ registered higher uptake of Fe, Mn, Zn, and Cu through onion bulbs. The values of Fe, Mn, Zn and Cu uptake with G₂ level are 427, 214, 170 and 156 g/ha, respectively. The corresponding uptake values with G₁ level are 380, 183, 152 and 132 g/ha.

4.3.5 Storage study

Under this subtitle, two aspects *viz.*, chemical quality and keeping quality parameters determined periodically during 120 days of storage are presented here. While the first aspect envisages TSS, reducing, non-reducing and total sugars, the second aspect includes losses due to physiological, sprouting and rotting.

Quality parameters

Total soluble solids: The results pertaining to the TSS as influenced by different treatments at 0, 30, 60, 90 and 120 days after storage (DAS) are presented in table 70. The results indicated that at all the sampling TSS was significantly influenced only due to INM *i.e.*, F levels. Among the F levels, at all the samplings treatment receiving ½ RD + PM recorded significantly higher TSS which was followed by F₂ and least was with F₁. The TSS values recorded with F₃ were 12.69, 12.95, 13.08, 13.31 and 13.53 per cent.

Sugars: This is one of the important quality parameters of onion. In general, with progress of time, the reducing sugar tended to

increase, while the non-reducing sugar showed declining trend. Because of this, there was not much difference in total sugar *i.e.*, reducing + non-reducing sugar with progress of time. With respect to treatment effect, almost all the factors except F failed to influence significantly the reducing and non-reducing sugar content in onion at different periods. Further, among the F levels, application $\frac{1}{2}$ RD along with PM registered significantly higher reducing and non-reducing sugars as compared to treatment receiving RD through fertilizer only. Of course, in some cases it was at par with the treatment F_2 *i.e.*, $\frac{1}{2}$ RD + FYM (Tables 71 and 72). In case of the total sugar (Table 73), with an exception of 120 DAS, at all the samplings only INM effect was found to be significant. At 120 DAS, onion planted on flat bed recorded higher total sugar compared to raised bed planted onion. At all

Table 70: Effect of land configuration, soil conditioner and INM on TSS (%) of onion bulb

| Treatment | Days after storage | | | | |
|----------------------|--------------------|-------|-------|-------|-------|
| | 0 | 30 | 60 | 90 | 120 |
| L₁ | 12.15 | 12.55 | 12.70 | 12.97 | 13.14 |
| L₂ | 12.13 | 12.45 | 12.67 | 12.85 | 13.08 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 12.20 | 12.51 | 12.79 | 12.99 | 13.09 |
| G₂ | 12.08 | 12.49 | 12.58 | 12.83 | 13.13 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F₁ | 11.50 | 11.94 | 12.27 | 12.52 | 12.72 |
| F₂ | 12.23 | 12.61 | 12.71 | 12.91 | 13.08 |
| F₃ | 12.69 | 12.95 | 13.08 | 13.31 | 13.53 |

| | | | | | |
|--------------------|------|------|------|------|------|
| C.D. at 5% | 0.32 | 0.46 | 0.40 | 0.51 | 0.52 |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 4 | 5 | 4 | 5 | 6 |

Table 71: Effect of land configuration, soil conditioner and INM on reducing sugar content (%) of onion bulb

| Treatment | Days after storage | | | | |
|----------------------|--------------------|------|------|------|------|
| | 0 | 30 | 60 | 90 | 120 |
| L₁ | 2.21 | 2.34 | 2.44 | 2.58 | 2.81 |
| L₂ | 2.35 | 2.40 | 2.58 | 2.64 | 2.70 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 2.21 | 2.35 | 2.46 | 2.56 | 2.77 |
| G₂ | 2.35 | 2.40 | 2.55 | 2.66 | 2.74 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F₁ | 2.12 | 2.28 | 2.36 | 2.50 | 2.53 |
| F₂ | 2.30 | 2.38 | 2.47 | 2.58 | 2.76 |
| F₃ | 2.42 | 2.46 | 2.69 | 2.75 | 2.98 |
| C.D. at 5% | 0.17 | 0.08 | 0.17 | 0.13 | 0.18 |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 10 | 4 | 9 | 7 | 9 |

Table 72: Effect of land configuration, soil conditioner and INM on non-reducing sugar content (%) in onion bulb

| Treatment | Days after storage | | | | |
|----------------------|--------------------|------|------|------|------|
| | 0 | 30 | 60 | 90 | 120 |
| L₁ | 7.35 | 7.23 | 7.01 | 6.69 | 6.26 |
| L₂ | 7.14 | 6.96 | 6.70 | 6.43 | 5.97 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| G₁ | 7.34 | 7.04 | 6.91 | 6.51 | 6.13 |
| G₂ | 7.16 | 7.15 | 6.80 | 6.61 | 6.11 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F₁ | 6.95 | 6.84 | 6.58 | 6.16 | 5.55 |
| F₂ | 7.32 | 7.12 | 6.93 | 6.54 | 6.11 |
| F₃ | 7.46 | 7.33 | 7.07 | 6.99 | 6.70 |
| C.D. at 5% | 0.41 | 0.36 | 0.39 | 0.31 | 0.37 |
| Interaction | NS | NS | NS | NS | NS |
| C.V. (%) | 8 | 7 | 8 | 7 | 8 |

Table 73: Effect of land configuration, soil conditioner and INM on total sugar content (%) in onion bulb

| Treatment | Days after storage | | | | |
|--------------------|--------------------|------|------|-------|------|
| | 0 | 30 | 60 | 90 | 120 |
| L ₁ | 9.56 | 9.59 | 9.46 | 9.27 | 9.08 |
| L ₂ | 9.49 | 9.36 | 9.28 | 9.08 | 8.68 |
| C.D. at 5% | NS | NS | NS | NS | 0.27 |
| G ₁ | 9.55 | 9.39 | 9.38 | 9.07 | 8.90 |
| G ₂ | 9.51 | 9.56 | 9.36 | 9.28 | 8.86 |
| C.D. at 5% | NS | NS | NS | NS | NS |
| F ₁ | 9.07 | 9.12 | 8.94 | 8.66 | 8.08 |
| F ₂ | 9.62 | 9.50 | 9.40 | 9.12 | 8.88 |
| F ₃ | 9.89 | 9.80 | 9.76 | 9.74 | 9.68 |
| C.D. at 5% | 0.39 | 0.30 | 0.32 | 0.37 | 0.34 |
| Interaction | NS | NS | NS | G x F | NS |
| C.V. (%) | 6 | 4 | 5 | 6 | 5 |

the samplings, treatment F₃ maintained its superiority over F₂ and F₁ levels. As far as interaction is concerned, at 90 DAS, G x F effect turned out to be significant on total sugar content in onion (Table 74). Here, a combination involving G₂F₃ (10.06%) recorded significantly higher value as compared to the remaining treatments.

Table 74: Effect of G x F interaction on total sugar content (%) in onion bulb at 90 days after storage

| <i>Treatment</i> | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| F₁ | 8.82 | 8.50 |
| F₂ | 8.97 | 9.28 |
| F₃ | 9.42 | 10.06 |
| S.Em. ± | 0.18 | |
| C.D. at 5% | 0.52 | |

Keeping quality parameters

The periodical storage losses *viz.*, physiological loss in weight (PLW), rotting loss (RL), sprouting loss (SL) and total loss were studied at 30, 60, 90 and 120 days after storage and the results are presented here.

Physiological loss in weight (PLW): The results of physiological loss in weight as influenced by various treatments at 30, 60 90 and 120 are presented in table 75. Irrespective of treatments, the PLW was maximum during first 30 days and at subsequently samplings the losses were almost similar. With respect to treatment effect, among all the variables only individual effects of INM was found to be significant on PLW at all the samplings. Among the F levels tested in present studies, at all the samplings, F₁ *i.e.*, RD through inorganic fertilizer alone showed maximum losses and that of minimum was recorded with F₃ treatment.

Table 75: Effect of land configuration, soil conditioner and INM on physiological weight loss (%) in onion during storage

| Treatments | Days after storage | | | |
|----------------------|--------------------|------|------|------|
| | 30 | 60 | 90 | 120 |
| L₁ | 5.24 | 2.30 | 2.40 | 2.04 |
| L₂ | 5.34 | 2.54 | 2.58 | 2.30 |
| C.D. at 5% | NS | NS | NS | NS |
| G₁ | 5.43 | 2.53 | 2.62 | 2.28 |
| G₂ | 5.15 | 2.30 | 2.36 | 2.05 |
| C.D. at 5% | NS | NS | NS | NS |
| F₁ | 6.05 | 3.17 | 2.76 | 2.79 |
| F₂ | 5.30 | 2.42 | 2.49 | 2.19 |
| F₃ | 4.53 | 1.67 | 2.22 | 1.52 |
| C.D. at 5% | 0.35 | 0.32 | 0.32 | 0.33 |
| Interaction | NS | NS | NS | NS |
| C.V. (%) | 9 | 18 | 18 | 21 |

Rooting loss: The results pertaining to the rotting loss as influenced by different treatments at various periods of storage *i.e.*, 30, 60, 90 and 120 are presented in table 76. The results revealed that effect of INM was found to be significant on RL. The soil conditioner and land configuration either alone or their interaction did not influence rotting losses at all the periods of storage. Among the different F levels, F₂ which received ½ RD + FYM @ 6 t/ha showed significantly lower losses than F₁ and F₃.

Table 76: Effect of land configuration, soil conditioner and INM on rotting loss (%) in onion during storage

| Treatments | Days after storage | | | |
|----------------------|--------------------|------|------|------|
| | 30 | 60 | 90 | 120 |
| L₁ | 1.94 | 1.76 | 0.87 | 0.72 |
| L₂ | 1.87 | 1.70 | 0.79 | 0.74 |
| C.D. at 5% | NS | NS | NS | NS |
| G₁ | 1.93 | 1.75 | 0.87 | 0.75 |
| G₂ | 1.88 | 1.71 | 0.79 | 0.71 |
| C.D. at 5% | NS | NS | NS | NS |
| F₁ | 2.12 | 1.92 | 0.98 | 0.87 |
| F₂ | 1.57 | 1.48 | 0.65 | 0.54 |
| F₃ | 2.02 | 1.79 | 0.85 | 0.78 |
| C.D. at 5% | 0.09 | 0.09 | 0.11 | 0.05 |
| Interaction | NS | NS | NS | NS |
| C.V. (%) | 7 | 8 | 19 | 10 |

Sprouting loss: During the first two periods of storage, there were no sprouting losses. However, at 90 and 120 DAS (Table 77) the sprouting losses were significantly influenced due to INM alone. Between the INM treatments *i.e.*, either FYM or PM along with ½ RD of NPK fertilizers were found equally effective and statistically at par with each other at 90 DAS. Further, it was observed that F₁ (2.62%) recorded significantly higher loss as compared to F₂ (2.31%) and F₃ (2.17%). The sprouting loss of onion bulb at 120 DAS, there was significant reduction from F₁ to F₃ level. The minimum loss was registered with F₃ where in ½ RD dose of NPK + PM @ 6 t/ha was applied.

Total loss: The results of the total loss as influenced by various treatments at different days after storage *i.e.*, 30, 60, 90 and 120 DAS are presented in tables 78 and 79. The results revealed that

Table 77: Effect of land configuration, soil conditioner and INM on sprouting loss (%) in onion during storage

| Treatments | Days after storage | | | |
|--------------------|--------------------|----|------|------|
| | 30 | 60 | 90 | 120 |
| L ₁ | - | - | 2.36 | 2.68 |
| L ₂ | - | - | 2.37 | 2.68 |
| C.D. at 5% | - | - | NS | NS |
| G ₁ | - | - | 2.42 | 2.72 |
| G ₂ | - | - | 2.31 | 2.65 |
| C.D. at 5% | - | - | NS | NS |
| F ₁ | - | - | 2.62 | 3.35 |
| F ₂ | - | - | 2.31 | 2.67 |
| F ₃ | - | - | 2.17 | 2.03 |
| C.D. at 5% | - | - | 0.23 | 0.24 |
| Interaction | - | - | NS | NS |
| C.V. (%) | - | - | 14 | 12 |

Table 78: Effect of land configuration, soil conditioner and INM on total loss (%) in onion during storage

| Treatments | Days after storage | | | |
|----------------|--------------------|------|------|------|
| | 30 | 60 | 90 | 120 |
| L ₁ | 7.18 | 4.06 | 5.64 | 5.44 |
| L ₂ | 7.21 | 4.24 | 5.75 | 5.73 |
| C.D. at 5% | NS | NS | NS | NS |
| G ₁ | 7.37 | 4.29 | 5.92 | 5.76 |
| G ₂ | 7.03 | 4.02 | 5.47 | 5.42 |

| | | | | |
|----------------------|------|------|------|-------|
| C.D. at 5% | NS | NS | NS | NS |
| F₁ | 8.18 | 5.1 | 6.37 | 7.01 |
| F₂ | 6.87 | 3.91 | 5.46 | 5.40 |
| F₃ | 6.55 | 3.46 | 5.25 | 4.34 |
| C.D. at 5% | 0.36 | 0.34 | 0.50 | 0.39 |
| Interaction | NS | NS | NS | L x G |
| C.V. (%) | 7 | 12 | 12 | 10 |

all the storage periods, INM alone and at 120 DAS L x G interaction significantly influenced the total loss of onion. In general, higher total loss was recorded with F₁ as compared to F₂ and F₃ at all the storage periods. At 30 and 90 DAS significantly more total loss was recorded with F₁ followed by F₂ and F₃, however, the latter two were found statistically at par with each other. With respect to total loss at 60 and 90 DAS, significantly higher total loss was recorded with F₁ than F₂ and F₃. As far as the total loss at 120 DAS is concerned, interactive effect of land configuration (L) and soil conditioner was observed to be significant. Among the various L x G combinations, significantly lower total loss was recorded with L₁G₂ (5.10%) than L₁G₁ (5.78%), L₂G₁ (5.74%) and L₂G₂ (5.73%).

Table 79: Effect of L x G interaction on total loss of onion at 120 DAS

| Treatment | G ₁ | G ₂ |
|----------------|----------------|----------------|
| L ₁ | 5.78 | 5.10 |
| L ₂ | 5.74 | 5.73 |
| S.Em. \pm | 0.16 | |
| C.D. at 5% | 0.45 | |

4.3.6 Soil properties

In order to study the impact of land configuration, soil conditioner and INM on soil physical properties at harvest and periodical nutrient availability status of soil, treatment wise soil samples were collected and analysed for pertinent properties.

Physical properties: For studying the effect of different treatments on physical properties of soil *viz.*, water stable aggregates (WSA) and infiltration rate (IR) were determined after harvest of onion. The results thus obtained are presented here.

Water stable aggregates (WSA): The water stable aggregate is an important physical property, which govern the water and air movement in the soils. This has more relevance in heavy textured soil. In the present study, only main effects of land configuration (L), soil conditioner (G) and INM (F) were significant on WSA of soil after harvest of onion crop (Table 80). Between the two configurations, raised bed (L₂) showed significantly better soil aggregation as compared to flat bed (L₁). In case of soil conditioner, application of gypsum @ 6 t/ha (G₂) tended to improve the soil aggregation over its no application of gypsum

(G₁). Among the different F levels, both F₂ and F₃ were equally effective in improving soil aggregation. The data further revealed that F₂ (63.00%) and F₃ (60.0%) recorded significantly higher values of soil aggregation in comparison to F₁ (56.75%).

Infiltration rate (IR): The infiltration rate is an another important physical property of soil which was determined after harvest of crop. An appraisal of the results presented in table 81 revealed that the main effects of L, G and F and interactive effects of L x G were significant on IR. Between the two land configurations, L₂ (6.25 cm/hr) enhanced IR significantly as compared to L₁ (5.53 cm/hr). As regards the soil conditioner, application of gypsum @ 6 t/ha, G₂ (6.70 cm/ha) exhibited significantly better IR than G₁ (5.07 cm/hr). As far as the INM is concerned, application of organic either FYM or PM along with ½ RD of NPK fertilizers

Table 80: Effect of land configuration, soil conditioner and INM on WSA (%) in soil after harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|----------------|----------------|-------|----------------|----------------|-------|----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 54.5 | 56.5 | 55.5 | 56.5 | 59.5 | 58.0 | 56.75 |
| F ₂ | 60.5 | 62.5 | 61.5 | 62.5 | 66.5 | 64.5 | 63.00 |
| F ₃ | 58.5 | 59.5 | 59.0 | 59.5 | 62.5 | 61.0 | 60.00 |
| Mean | 57.8 | 59.5 | 58.66 | 59.5 | 62.8 | 61.17 | - |

| | | | | | | | |
|--------------|------------------------|-------|------------------------|-------|-------|-------|-----------|
| G. Mean | G ₁ = 58.66 | | G ₂ = 61.17 | | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.869 | 0.869 | 1.065 | 1.229 | 1.506 | 1.506 | 2.13 |
| C.D. at 5% | 2.50 | 2.50 | 3.06 | NS | NS | NS | NS |
| C.V. (%) | 7 | | | | | | |

Table 81: Effect of land configuration, soil conditioner and INM on infiltration rate (cm/hr) of the soil after harvest

| Treatment | L ₁ | | | L ₂ | | | Mean (F) |
|----------------|-----------------------|----------------|-----------------------|----------------|----------------|-------|-----------|
| | G ₁ | G ₂ | Mean | G ₁ | G ₂ | Mean | |
| F ₁ | 3.66 | 5.52 | 4.59 | 4.70 | 6.20 | 5.45 | 5.02 |
| F ₂ | 5.12 | 7.21 | 6.16 | 6.19 | 7.41 | 6.80 | 6.48 |
| F ₃ | 4.88 | 6.80 | 5.84 | 5.89 | 7.10 | 6.49 | 6.17 |
| Mean | 4.55 | 6.51 | 5.53 | 5.59 | 6.90 | 6.25 | - |
| G. Mean | G ₁ = 5.07 | | G ₂ = 6.70 | | | | |
| Source | L | G | F | L x G | L x F | G x F | L x G x F |
| S. Em. \pm | 0.109 | 0.109 | 0.134 | 0.155 | 0.189 | 0.189 | 0.268 |
| C.D. at 5% | 0.31 | 0.31 | 0.38 | 0.44 | NS | NS | NS |
| C.V. (%) | 9 | | | | | | |

tended to hasten IR significantly as compared to application of RD NPK fertilizers alone. Significantly higher IR was observed with F₂ (6.48 cm/hr) and F₃ (6.17 cm/hr) than F₁ (5.02 cm/hr). In case of interactive effect of L x G, a combination L₂G₂ (6.90 cm/hr) improved the IR significantly as compared to L₂G₁ (5.59 cm/hr), L₁G₂ (6.51 cm/hr) and L₁G₁ (4.55 cm/hr).

Chemical properties: The soil chemical properties *viz.*, pH and EC as influenced by different treatments were determined at different growth stages of crop and the results are presented here.

Soil reaction: Only the main effect of soil conditioner (G) influenced significantly soil pH values at 40, 80 and 120 days after planting (DAP). Between the two levels, G₂ *i.e.*, application of gypsum @ 6 t/ha significantly depressed the pH values at all the samplings as compared to G₁ (Table 82). The individual effect of L, F and all the interactions failed to reach level of significance at all the samplings.

Electrical conductivity: The treatment wise values of EC at different periods are reported in table 83. The EC values at all the periods of sampling were significantly influenced by main effect of land configuration and soil conditioner only. The land configuration L₁ showed significantly higher values of EC than L₂ at all the samplings. Between the G levels, G₂ registered significantly higher EC values over G₁ at all the samplings.

Organic carbon: The results pertaining to the effect of land configuration, soil conditioner and INM on organic carbon

Table 82: Effect of land configuration, soil conditioner and INM on pH of the soil at different days after planting

| Treatment | Days after planting | | |
|--------------------|---------------------|------|------|
| | 40 | 80 | 120 |
| L ₁ | 7.51 | 7.64 | 7.70 |
| L ₂ | 7.20 | 7.54 | 7.54 |
| C.D. at 5% | NS | NS | NS |
| G ₁ | 7.59 | 7.78 | 7.80 |
| G ₂ | 7.30 | 7.40 | 7.43 |
| C.D. at 5% | 0.16 | 0.11 | 0.16 |
| F ₁ | 7.41 | 7.63 | 7.63 |
| F ₂ | 7.49 | 7.59 | 7.65 |
| F ₃ | 7.43 | 7.55 | 7.57 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 4 | 3 | 4 |

Table 83: Effect of land configuration, soil conditioner and INM on EC (dS/m) of soil at different days after planting

| Treatment | Days after planting | | |
|----------------|---------------------|-------|-------|
| | 40 | 80 | 120 |
| L ₁ | 0.52 | 0.48 | 0.54 |
| L ₂ | 0.44 | 0.40 | 0.47 |
| C.D. at 5% | 0.035 | 0.035 | 0.037 |
| G ₁ | 0.43 | 0.42 | 0.47 |
| G ₂ | 0.53 | 0.47 | 0.54 |

| | | | |
|----------------------|-------|-------|-------|
| C.D. at 5% | 0.035 | 0.035 | 0.037 |
| F₁ | 0.51 | 0.47 | 0.53 |
| F₂ | 0.48 | 0.45 | 0.50 |
| F₃ | 0.45 | 0.42 | 0.48 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 12 | 13 | 13 |

content in soil at different periods are given in table 84. From the results, it is revealed that only main effect of INM (F) was found to be significant on organic carbon content in soil at all the sampling. Among different F levels, F₂ showed higher organic carbon content followed by F₃. However, both F₂ and F₃ were statistically at par but significantly superior over F₁.

Soil fertility: At 40, 80 and 120 DAP treatment wise soil samples were collected and analysed for available N, P, K, S and Fe, Mn, Zn and Cu and the results are presented here.

Available N: The available N content in soil at different periods influenced by various treatments are reported in table 85. At first sampling, only main effect of INM (F) was found to be significant on available N content in soil. Among the different F levels, F₁ (272 kg/ha) recorded maximum and F₂ (248 kg/ha) recorded minimum available N content in soil. However, both F₂ and F₃ were statistically at par with each other but were significantly lower than F₁. The content of available N at second sampling did not influence significantly by various treatments. As far as the available N content in soil at harvest is concerned, it was significantly affected by INM. Here, F₃ (227 kg/ha) recorded

significantly higher N content over F₁ (203 kg/ha), however, F₂ and F₃ were statistically at par with each other. In general, at harvest application of organics along with ½ RD of NPK fertilizer enhanced the availability of N.

Available P₂O₅: The results on periodical P₂O₅ content in soil (Table 86) revealed that at first sampling soil conditioner (G) and

Table 84: Effect of land configuration, soil conditioner and INM on organic carbon (%) content in soil at different days after planting

| Treatment | Days after planting | | |
|--------------------|---------------------|------|------|
| | 40 | 80 | 120 |
| L ₁ | 0.63 | 0.52 | 0.55 |
| L ₂ | 0.58 | 0.54 | 0.58 |
| C.D. at 5% | NS | NS | NS |
| G ₁ | 0.59 | 0.53 | 0.58 |
| G ₂ | 0.62 | 0.53 | 0.55 |
| C.D. at 5% | NS | NS | NS |
| F ₁ | 0.56 | 0.46 | 0.49 |
| F ₂ | 0.64 | 0.58 | 0.63 |
| F ₃ | 0.63 | 0.55 | 0.58 |
| C.D. at 5% | 0.05 | 0.04 | 0.05 |
| Interaction | NS | NS | NS |
| C.V. (%) | 12 | 11 | 13 |

Table 85: Effect of land configuration, soil conditioner and INM on available N (kg/ha) content in soil at different days after planting

| Treatment | Days after planting | | |
|--------------------|---------------------|-----|-----|
| | 40 | 80 | 120 |
| L ₁ | 260 | 234 | 217 |
| L ₂ | 260 | 244 | 212 |
| C.D. at 5% | NS | NS | NS |
| G ₁ | 255 | 236 | 209 |
| G ₂ | 264 | 243 | 221 |
| C.D. at 5% | NS | NS | NS |
| F ₁ | 272 | 250 | 203 |
| F ₂ | 248 | 230 | 215 |
| F ₃ | 259 | 239 | 227 |
| C.D. at 5% | 11 | NS | 15 |
| Interaction | NS | NS | NS |
| C.V. (%) | 6 | 9 | 10 |

INM (F) had significant influence on P₂O₅ content in soil. An application of gypsum @ 6 t/ha (G₂) significantly increased the P₂O₅ content in soil over G₁. Among the different levels of F, an application of RD of NPK fertilizers (F₁) recorded significantly higher available P₂O₅ content in soil than F₂ and F₃. But F₂ (½ RD + FYM @ 15 t/ha) and F₃ (½ RD + PM @ 6 t/ha) were equally effective as far as the availability of P₂O₅ content in soil at this sampling is concerned. With respect to availability of P₂O₅ at second sampling, it was significantly influenced only due to main effect of soil conditioner. Between the two levels of G, G₂ (22.3 kg/ha) registered higher available P₂O₅ as compared to G₁

(20.0 kg/ha). The corresponding values of G_2 and G_1 at harvest were 20.5 and 17.4 kg/ha, respectively.

Available K_2O : The results of available K_2O content in soil at different periods as affected by various treatments are presented in table 87. The results revealed that the availability of K_2O was influenced significantly due to main effect of INM only at first sampling. Further, F_1 (450 kg/ha) recorded more available K_2O than F_2 and F_3 and the later two were statistically at par with each other. At 80 and 120 DAP all the main and their interaction effects failed to reach the level of significance on available K_2O content in soil.

Available S: The results on available S content in soil at 40, 80 and 120 DAP as affected by various treatments are presented in table 88. In general, it is seen that initially at 40 DAP availability of S was higher and towards maturity of crop tended to decline.

Table 86: Effect of land configuration, soil conditioner and INM on available P_2O_5 (kg/ha) content in soil at days after planting

| Treatment | Days after planting | | |
|------------|---------------------|------|------|
| | 40 | 80 | 120 |
| L_1 | 38.9 | 21.8 | 19.4 |
| L_2 | 40.0 | 20.5 | 18.5 |
| C.D. at 5% | NS | NS | NS |
| G_1 | 37.5 | 20.0 | 17.4 |
| G_2 | 41.5 | 22.3 | 20.5 |
| C.D. at 5% | NS | 2.17 | 1.73 |
| F_1 | 43.4 | 19.7 | 17.8 |
| F_2 | 35.8 | 20.8 | 18.8 |

| | | | |
|----------------------|------|------|------|
| F₃ | 39.3 | 22.9 | 20.4 |
| C.D. at 5% | 3.79 | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 13 | 17 | 15 |

Table 87: Effect of land configuration, soil conditioner and INM on available K₂O content (kg/ha) in soil at different days after planting

| Treatment | Days after planting | | |
|----------------------|----------------------------|-----------|------------|
| | 40 | 80 | 120 |
| L₁ | 393 | 353 | 331 |
| L₂ | 413 | 358 | 322 |
| C.D. at 5% | NS | NS | NS |
| G₁ | 392 | 353 | 320 |
| G₂ | 414 | 359 | 322 |
| C.D. at 5% | NS | NS | NS |
| F₁ | 450 | 341 | 318 |
| F₂ | 367 | 356 | 327 |
| F₃ | 392 | 371 | 334 |
| C.D. at 5% | 29 | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 10 | 9 | 8 |

The results revealed that the soil conditioner had significant impact on availability of S in soil. At all the samplings, G₂ recorded significantly more available S than G₁. The available S content of 26.4, 23.8 and 21.4 mg/kg was recorded with G₂ at 40, 80 and 120 DAP, respectively.

Micronutrients: The DTPA extractable Fe content in soil at different periods as influenced by various treatments are reported in tables 89 and 90. At 40 DAP, land configuration and soil conditioner had significant impact on the availability of Fe, in soil. Between the two land configuration, L₂ (19.25 mg/kg) showed higher available Fe over F₁ (17.89 mg/kg). With regards to soil conditioner, G₂ (19.66 mg/kg) level significantly increased the availability of Fe over G₁ (17.48 g/kg). As far as the availability of Fe at 120 DAP is concerned, it was significantly affected by the interactive effect of land configuration (L) and soil conditioner (G). Among the different combinations, L₂G₂ exhibited higher values of available Fe in soil with respect to the availability of Mn, Zn and Cu in soil at different periods, all the main and interactive effects were absent (Tables 91 to 93).

Table 88: Effect of land configuration, soil conditioner and INM on available S content (mg/kg) in soil at different days after planting

| Treatment | Days after planting | | |
|--------------------|---------------------|------|------|
| | 40 | 80 | 120 |
| L ₁ | 15.9 | 14.3 | 13.2 |
| L ₂ | 17.3 | 15.6 | 13.7 |
| C.D. at 5% | NS | NS | NS |
| G ₁ | 6.8 | 6.2 | 5.6 |
| G ₂ | 26.4 | 23.8 | 21.4 |
| C.D. at 5% | 1.63 | 1.39 | 1.40 |
| F ₁ | 17.6 | 15.8 | 14.4 |
| F ₂ | 15.9 | 14.0 | 12.8 |
| F ₃ | 16.4 | 15.1 | 13.4 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 17 | 16 | 18 |

Table 89: Effect of land configuration, soil conditioner and INM on available Fe content (mg/kg) in soil at different days after planting

| Treatment | Days after planting | | |
|----------------|---------------------|-------|-------|
| | 40 | 80 | 120 |
| L ₁ | 17.89 | 14.83 | 11.43 |
| L ₂ | 19.25 | 15.08 | 11.80 |
| C.D. at 5% | 1.35 | NS | NS |
| G ₁ | 17.48 | 14.92 | 11.36 |
| G ₂ | 19.66 | 14.99 | 11.87 |
| C.D. at 5% | 1.35 | NS | NS |
| F ₁ | 17.88 | 14.47 | 11.12 |

| | | | |
|----------------------|-------|-------|-------|
| F₂ | 18.56 | 14.91 | 11.53 |
| F₃ | 19.26 | 15.48 | 12.20 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | L x G |
| C.V. (%) | 12 | 11 | 15 |

Table 90: Effect of Lx G interaction on available Fe content (mg/kg) in soil at 120 days after planting

| Treatment | G₁ | G₂ |
|----------------------|----------------------|----------------------|
| L₁ | 11.70 | 11.17 |
| L₂ | 11.03 | 12.57 |
| S.Em. \pm | 0.50 | |
| C.D. at 5% | 1.45 | |

Table 91: Effect of land configuration, soil conditioner and INM on available Mn content in soil (mg/kg) at different days after planting

| Treatment | Days after planting | | |
|----------------------|----------------------------|-----------|------------|
| | 40 | 80 | 120 |
| L₁ | 25.38 | 16.70 | 14.67 |
| L₂ | 26.49 | 17.72 | 15.64 |
| C.D. at 5% | NS | NS | NS |
| G₁ | 25.55 | 16.80 | 14.85 |
| G₂ | 26.31 | 17.62 | 15.47 |
| C.D. at 5% | NS | NS | NS |

| | | | |
|----------------------|-------|-------|-------|
| F₁ | 25.10 | 16.67 | 14.59 |
| F₂ | 26.03 | 17.20 | 15.20 |
| F₃ | 26.67 | 17.77 | 15.69 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 12 | 13 | 14 |

Table 92: Effect of land configuration, soil conditioner and INM on available Zn content in soil (mg/kg) at different days after planting

| Treatment | Days after planting | | |
|----------------------|----------------------------|-----------|------------|
| | 40 | 80 | 120 |
| L₁ | 0.64 | 0.58 | 0.56 |
| L₂ | 0.65 | 0.63 | 0.57 |
| C.D. at 5% | NS | NS | NS |
| G₁ | 0.64 | 0.60 | 0.56 |
| G₂ | 0.65 | 0.61 | 0.58 |
| C.D. at 5% | NS | NS | NS |
| F₁ | 0.60 | 0.57 | 0.53 |
| F₂ | 0.64 | 0.60 | 0.56 |
| F₃ | 0.68 | 0.64 | 0.60 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 15 | 15 | 14 |

Table 93: Effect of land configuration, soil conditioner and INM on available Cu content in soil (mg/kg) at different days after planting

| Treatment | Days after planting | | |
|----------------------|---------------------|------|------|
| | 40 | 80 | 120 |
| L₁ | 2.34 | 2.25 | 1.84 |
| L₂ | 2.36 | 2.27 | 1.86 |
| C.D. at 5% | NS | NS | NS |
| G₁ | 2.32 | 2.21 | 1.83 |
| G₂ | 2.37 | 2.32 | 1.88 |
| C.D. at 5% | NS | NS | NS |
| F₁ | 2.26 | 2.21 | 1.75 |
| F₂ | 2.37 | 2.27 | 1.89 |
| F₃ | 2.42 | 2.31 | 1.92 |
| C.D. at 5% | NS | NS | NS |
| Interaction | NS | NS | NS |
| C.V. (%) | 13 | 14 | 14 |

V DISCUSSION

An investigation entitled “Management of Clay Soils of South Gujarat for Improving Yield and Quality of Onion” comprising survey, incubation and field experiment was carried out during the year 2003-04. In survey, through personal interview of onion growers of South Gujarat using standard questionnaire, an attempt was made to obtain views of the farmers regarding cultural practices being followed for onion crop. Similarly, an incubation study for assessing the periodical availability of the nutrients as influenced by INM in presence and absence of soil conditioner (gypsum) was carried out. In addition, a field experiment with 12 treatment combinations consisting of 2 land configurations (L_1 = flat bed, L_2 = raised bed), 2 soil conditioners (G_1 = no gypsum, G_2 = gypsum @ 6 t/ha) and 3 INM (F_1 = RD through inorganic fertilizers, F_2 = $\frac{1}{2}$ RD + FYM 15 t/ha, F_3 = $\frac{1}{2}$ RD + PM @ 6 t/ha) was conducted in FRBD with four replications during *rabi* season of 2003-04. The observations/parameters recorded/determined during the course of all 3 studies have been interpreted with the help of statistical yardsticks in preceding chapter. Here, an attempt has been made to discuss the results obtained in the present investigation in the context of earlier work done with proper scientific reasoning. For brevity, whole discussion is divided in to three parts.

5.1 Survey

5.2 Incubation study

5.3 Field experiment

5.1 Survey

For this purpose, total of 31 onion growers were selected from the Navsari and Surat districts of South Gujarat. These farmers grow onion crop during *rabi* season preceded by *kharif* paddy. The survey results revealed that majority of the farmers are grouped in to small class (52%) of land holding who allocate their 50 per cent of the land holding to onion crop. Though, most of the farmers (74%) grow improved variety of onion, yet appropriate land preparation is not done by them. This is evident from the data depicted in fig.4, as 90 per cent farmers are planting onion in flat bed. This seems to be the main reason for the low productivity of onion under South Gujarat conditions wherein soils are clayey (> 45%) in texture and their physical properties (particularly aggregation) are deteriorated due to puddling followed in preceding *kharif* paddy. This aspect become more significant, as onion is bulbous crop, which requires friable soil condition for better bulb development and consequently higher yield. In order to improve the physical conditions of soil particularly aggregation, use of soil conditioner like gypsum is essential. In this regard, a question related to use of gypsum was addressed to the farmers and out of 31 farmers only 5 are using gypsum in onion crop (Fig.5). With respect to nutrient

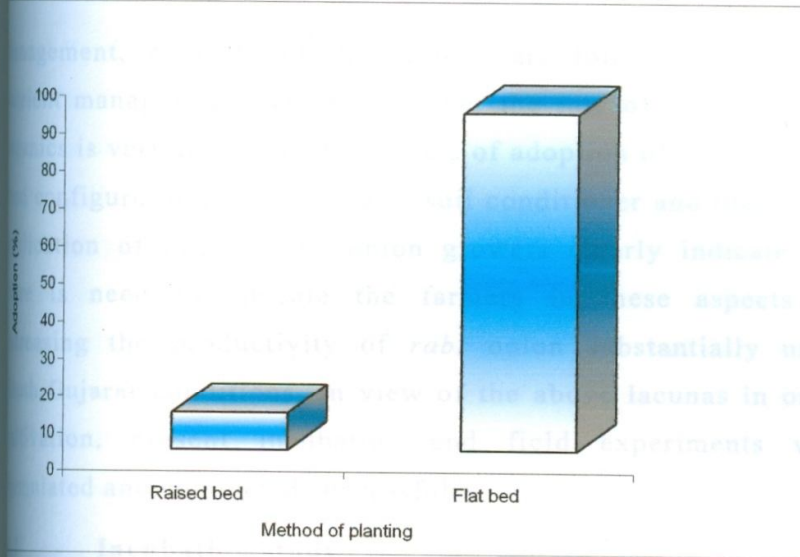


Fig. 4: Adoption of method of planting by onion growers

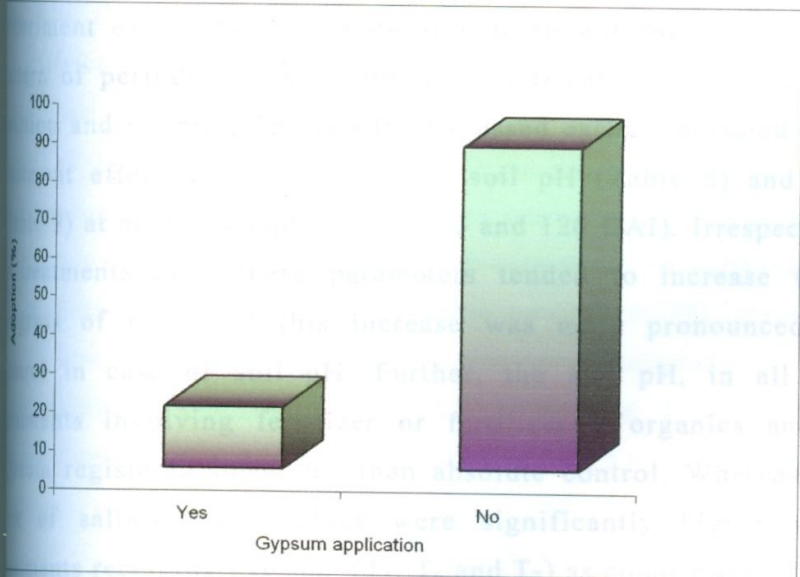


Fig. 5: Use of gypsum as soil conditioner by onion growers

management, majority of the farmers are following integrated nutrient management system, however the rate of application of organics is very low. The above facts of adoption of inappropriate land configuration, seldom use of soil conditioner and inadequate application of organics by onion growers clearly indicate that there is need to educate the farmers in these aspects for increasing the productivity of *rabi* onion substantially under South Gujarat conditions. In view of the above lacunas in onion cultivation, present incubation and field experiments were formulated and conducted successfully.

5.2 Incubation study

In present investigation, an incubation study was taken up with the same set of treatments as was tested in field experiment except land configuration treatment for judging the pattern of periodically availability of nutrients along with soil reaction and salinity. The results discussed earlier indicated that treatment effect was significant on soil pH (Table 8) and EC (Table 9) at all the samplings (40, 80 and 120 DAI). Irrespective of treatments both these parameters tended to increase with progress of time and this increase was more pronounced in control in case of soil pH. Further, the soil pH, in all the treatments involving fertilizer or fertilizer + organics and/or gypsum registered lower pH than absolute control. Whereas, in case of salinity, EC values were significantly higher with treatments receiving gypsum (T₅, T₆ and T₇) as compared to T₂,

T₃ and T₄ treatments as well as control (Fig.6). An increase in soluble salt (EC) and decrease in pH of soil seems to be due to solubilization of applied gypsum and release of soluble salts due to mineralization of FYM/PM. The solubilization of sparingly soluble gypsum might have increased further in presence of organic acids owing to liberation of organics during their decomposition. Similar results of increase in EC and decrease in pH were reported by Satyanarayana *et al.* (1975); Mathur *et al.*, (1983); Raikhy *et al.*, (1985) and Anand Swarup, (1991).

With respect to soil fertility, the organic C content in soil irrespective of treatments showed declining trend with increase in period of incubation. At all the samplings, treatment effect was significant on organic C content in soil (Table 10). In almost all the cases, treatments receiving ½ RD + either FYM or PM in absence or presence of gypsum (T₃, T₄, T₆ and T₇) recorded significantly higher organic C content in soil as compared to control (T₁) as well as treatment, receiving RD alone (Fig. 7). It is rather logical that wherever organics were applied it increased the organic C content in soils. This increase could be attributed to the congenial conditions like moisture content at FC, aeration, temperature *etc.*, provided under present set of incubation might have improved the decomposition of FYM and PM. The results of present incubation are in close agreement with those reported by Shantaram *et al.* (1975) and Rao (1998).

The availability of N, P and K was improved considerably due to different INM and gypsum treatments as

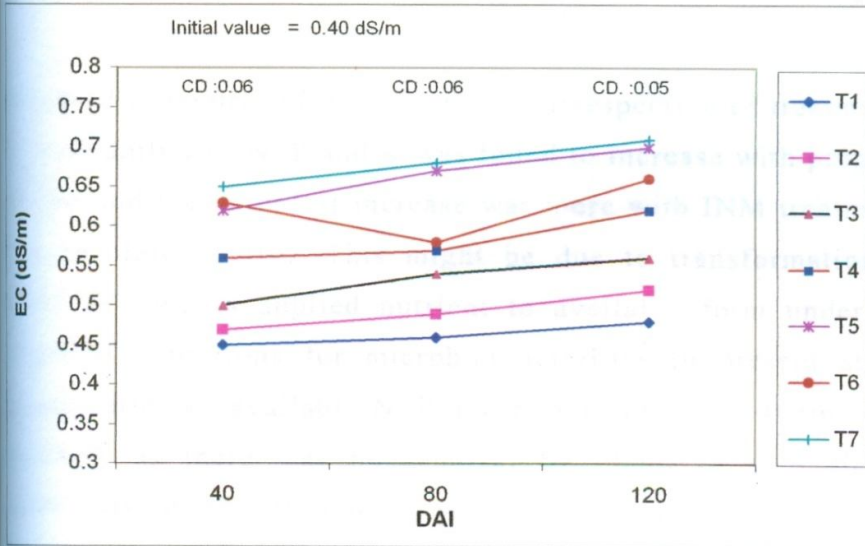


Fig. 6: Effect of soil conditioner and INM on soil EC at different periods of incubation

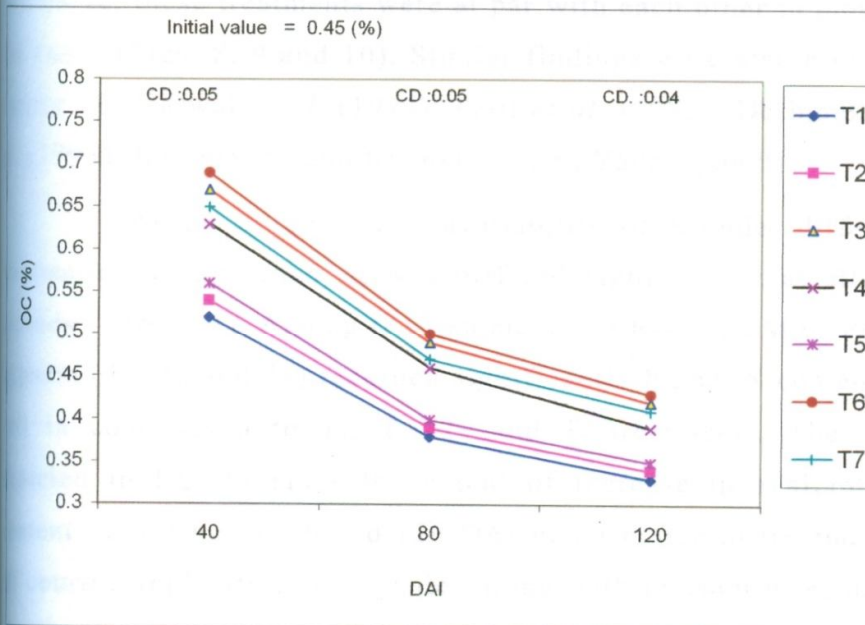


Fig. 7: Effect of soil conditioner and INM on organic carbon content at different periods of incubation

compared to control (Tables 11 to 13). Irrespective of treatments, the availability of N, P and K was found to increase with progress of time and the extent of increase was more with INM treatments than absolute control. This might be due to transformation of native as well as applied nutrient to available form under the congenial conditions for microbial activities in present study. Accumulation of available N, P and K with progress of time was expected, as there was no removal by plant. In general, the availability of N, P and K was bit slower initially in the treatments receiving organics than application of fertilizer alone. At subsequent samplings, these treatments recorded higher available N as compared to only fertilizer treatments (T₂ and T₃). Of course, these treatments were at par with each other in most of the cases (Figs. 8, 9 and 10). Similar findings were also reported earlier by Narwal *et al.* (1993); Patil *et al.* (1993); Deshmukh *et al.* (1993); Rao (1998) and Khankhane and Yadav (2000).

As far as periodical availability of S under different treatments is concerned, it was differed significantly at all the periods (Table 14). Among the treatments, ½ RD + FYM or PM + gypsum (T₅, T₆ and T₇) recorded significantly higher S content in soil in comparison to T₁, T₂, T₃ and T₅ treatments. The data depicted in fig. 11 show the extent of increase in available S content in soil at 40, 80 and 120 DAI under different treatments. Of course, application of organics along with gypsum marginally improved the S availability in comparison to application of gypsum alone. It was expected that gypsum application will

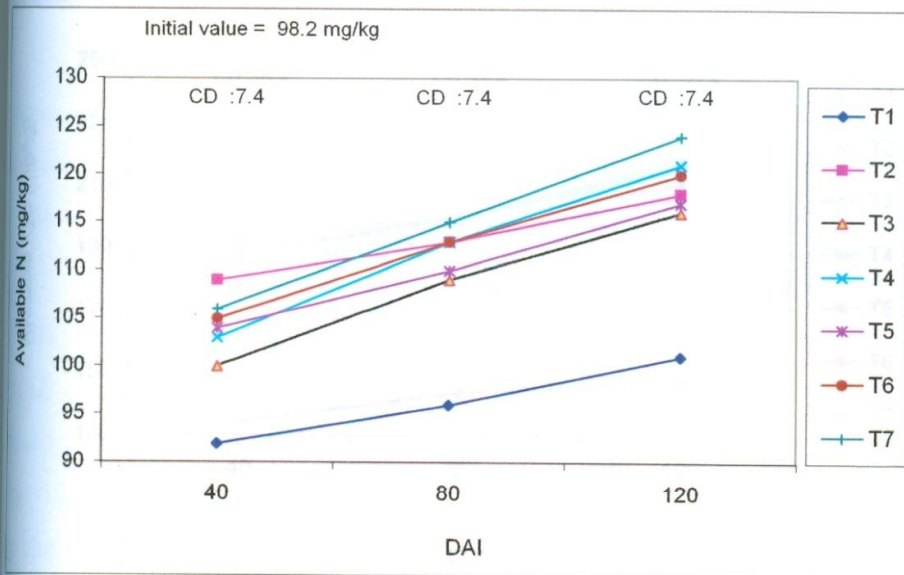


Fig. 8 : Effect of soil conditioner and INM on available N content in soil at different periods of incubation

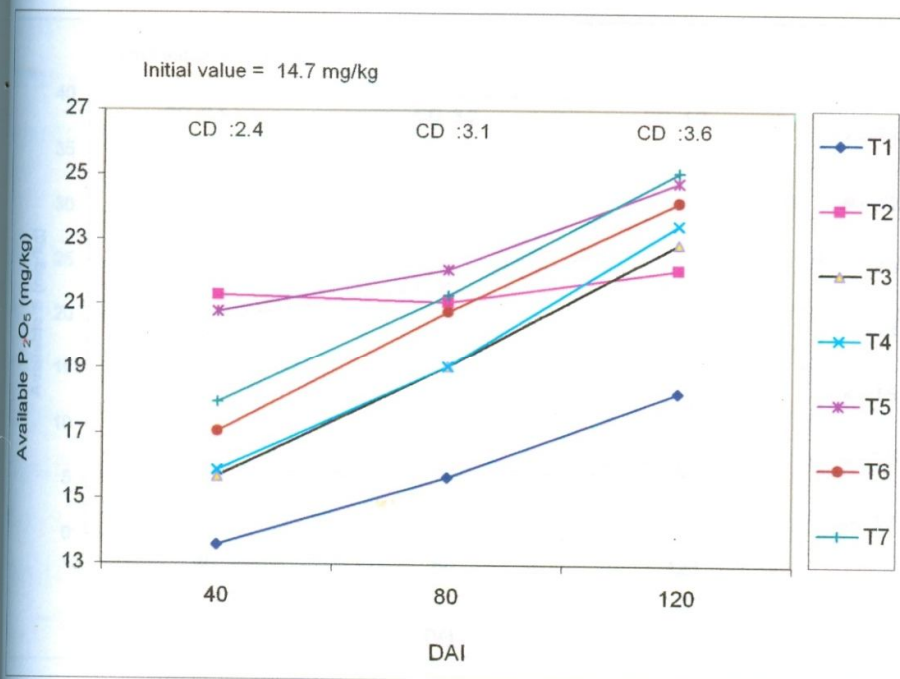


Fig. 9 : Effect of soil conditioner and INM on available P₂O₅ content in soil at different periods of incubation

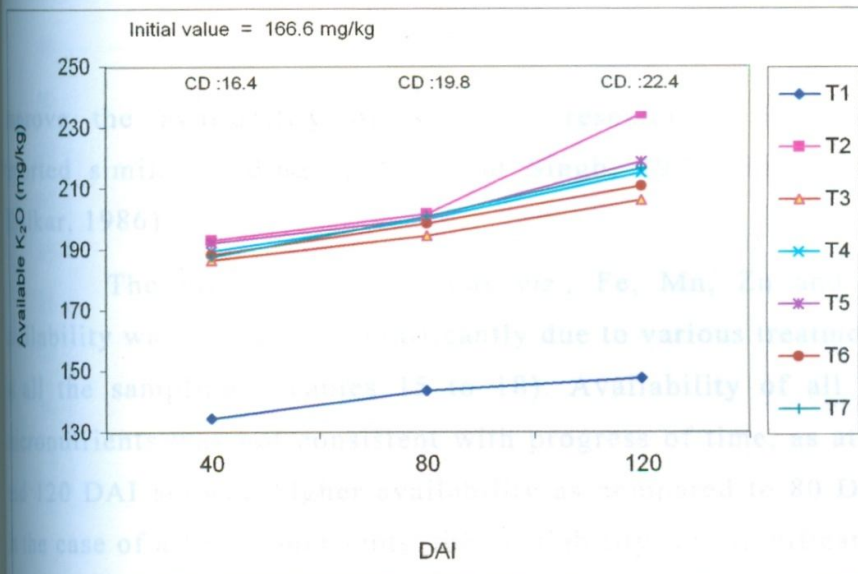


Fig.10 : Effect of soil conditioner and INM on available K₂O content in soil at different periods of incubation

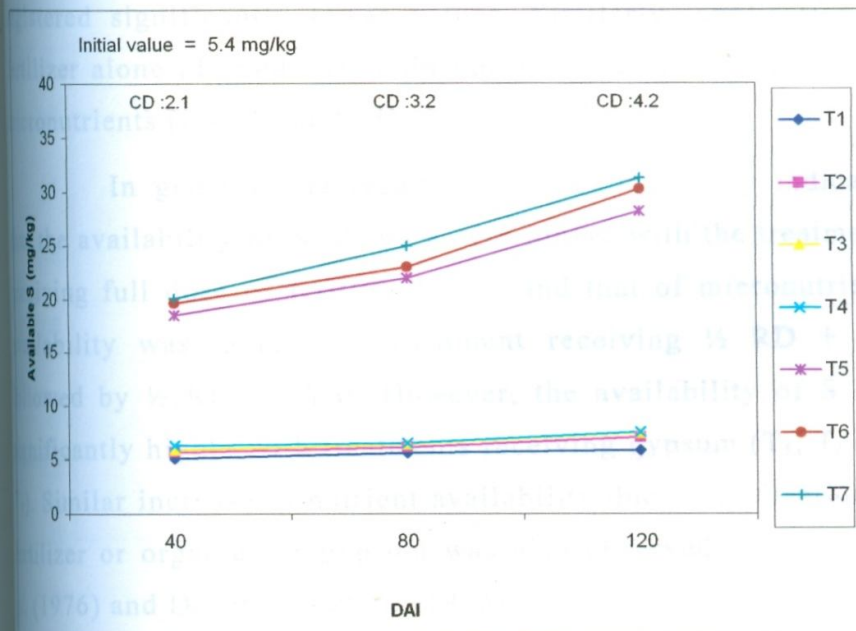


Fig.11 : Effect of soil conditioner and INM on available S content in soil at different periods of incubation

improve the availability of S. Some researchers have also reported similar findings (Singh and Singh, 1975; Sagare and Bhalkar, 1986).

The micronutrient cations *viz.*, Fe, Mn, Zn and Cu availability was influenced significantly due to various treatments at all the samplings (Tables 15 to 18). Availability of all the micronutrients was not consistent with progress of time, as at 40 and 120 DAI showed higher availability as compared to 80 DAI. In the case of all micronutrients, the availability was significantly higher with the treatments T₄ (½ RD + PM), T₇ (½ RD + PM + gypsum) and it was followed by the treatments receiving FYM (T₃ and T₆) at 40, 80 and 120 DAI. At all the samplings, control registered significantly lower values. Similarly, application of fertilizer alone (T₂ and T₅) could not enhance the availability of micronutrients (Fig. 12 and 13).

In general, the results of incubation study indicated that the availability of N, P and K was higher with the treatments receiving full dose of fertilizer alone and that of micronutrients availability was more with treatment receiving ½ RD + PM followed by ½ RD + FYM. However, the availability of S was significantly higher with treatments receiving gypsum (T₅, T₆ and T₇). Similar increase in nutrient availability due to application of fertilizer or organics or gypsum was also observed by Prasad *et al.* (1976) and Deshmukh *et al.* (1993).

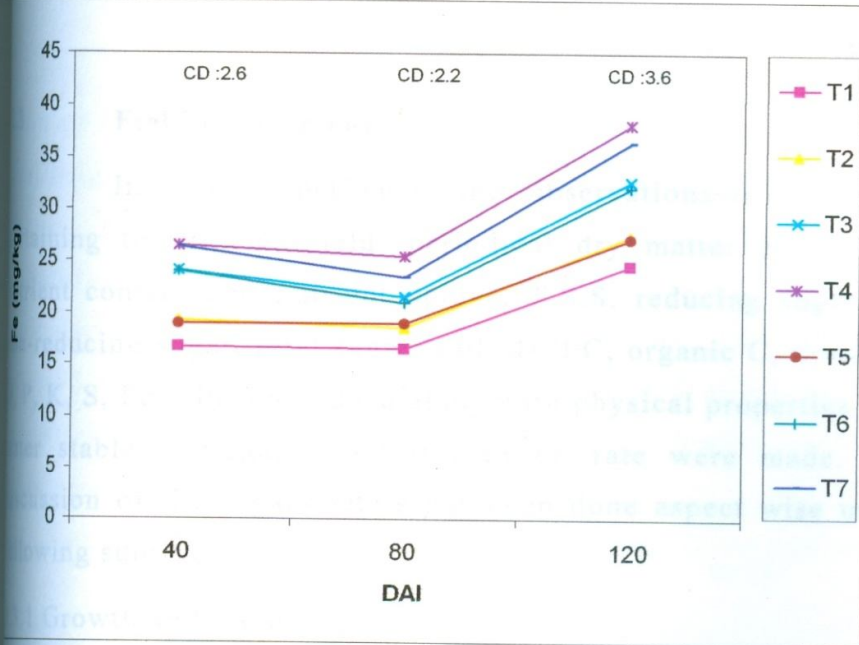


Fig. 12: Effect of soil conditioner and INM on DTPA extractable Fe content in soil at different periods of incubation

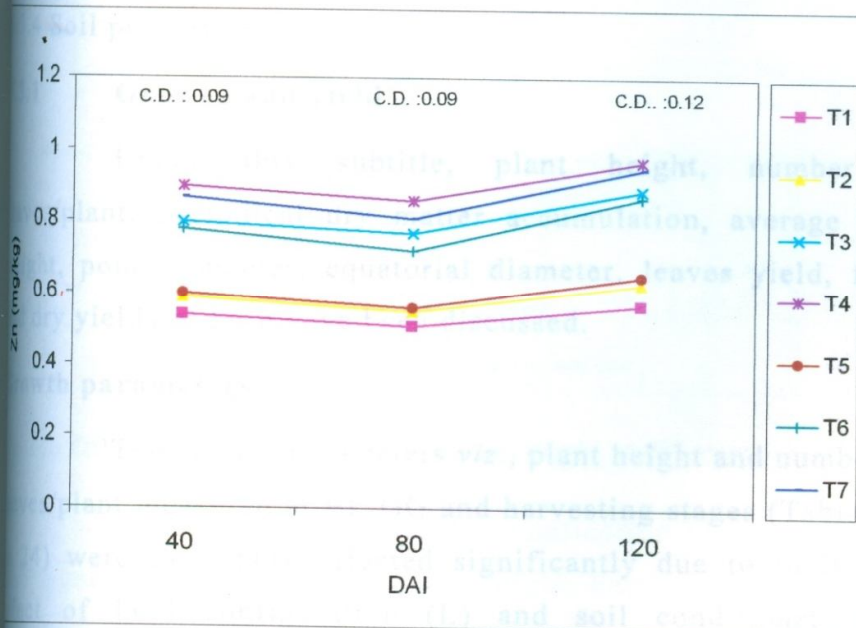


Fig. 13: Effect of soil conditioner and INM on DTPA extractable Zn content in soil at different periods of incubation

5.3 Field experiment

In field experiment, the observations/determination pertaining to growth, yield, periodical dry matter production, nutrient content and nutrient uptake, T.S.S, reducing sugar and non-reducing sugar, total sugar, soil pH, EC, organic C, available N, P, K, S, Fe, Mn, Zn and Cu along with physical properties *viz.*, water stable aggregates and infiltration rate were made. The discussion of these parameters has been done aspect wise under following subtitles.

5.3.1 Growth and yield

5.3.2 Nutrient content and uptake

5.3.3 Storage study

5.3.4 Soil properties

5.3.1 Growth and yield

Under this subtitle, plant height, number of leaves/plant, periodical dry matter accumulation, average bulb weight, polar diameter, equatorial diameter, leaves yield, fresh and dry yields of bulb have been discussed.

Growth parameters

The growth parameters *viz.*, plant height and number of leaves/plant measured at BI, GG and harvesting stages (Tables 19 to 24) were invariably affected significantly due to individual effect of land configuration (L) and soil conditioners (G). Similarly, the plant height was also affected due to interactive

effect of L x G at all the three samplings (Fig. 14). The better plant height and number of leaves/plant recorded with raised bed planting (L_2) could be attributed to the improved nutrient availability owing to adequate air and water movement particularly under puddled clay soil conditions. This was also reflected on the dry matter production recorded at BI, GG and harvesting stages which was significantly higher with L_2 configuration (Fig. 15).

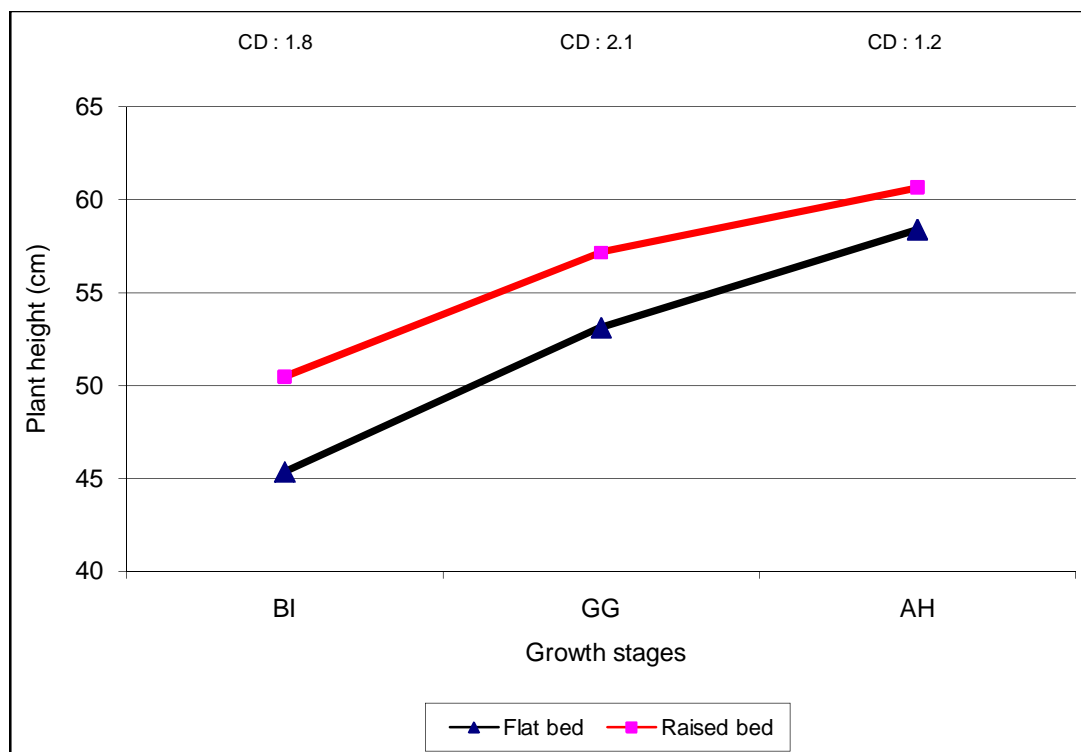


Fig. 14 : Effect of land configuration on plant height at different growth stages

As like land configuration application of gypsum could also favourably influence the plant height, number of leaves/plant and dry matter production at all the growth stages of onion (Fig. 16). It is well known fact that gypsum application improves

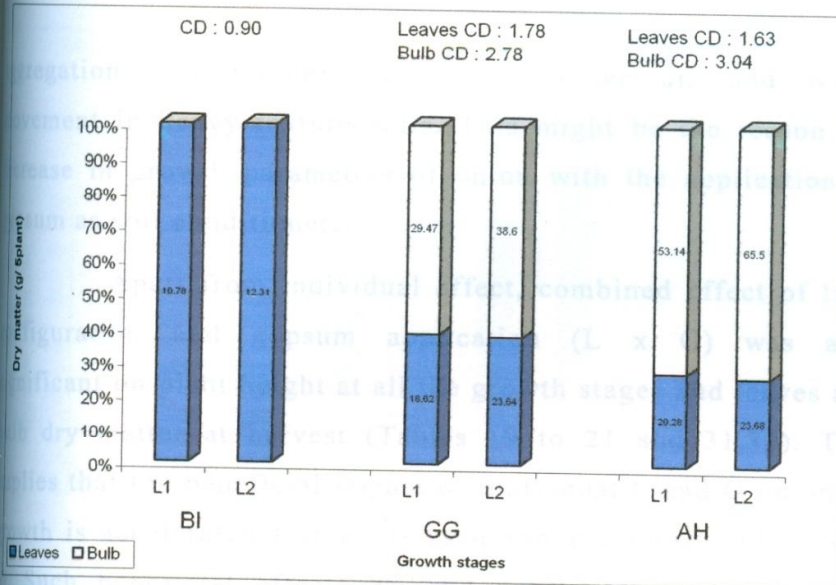


Fig. 15 : Effect of land configuration on periodical partitioning of onion dry matter

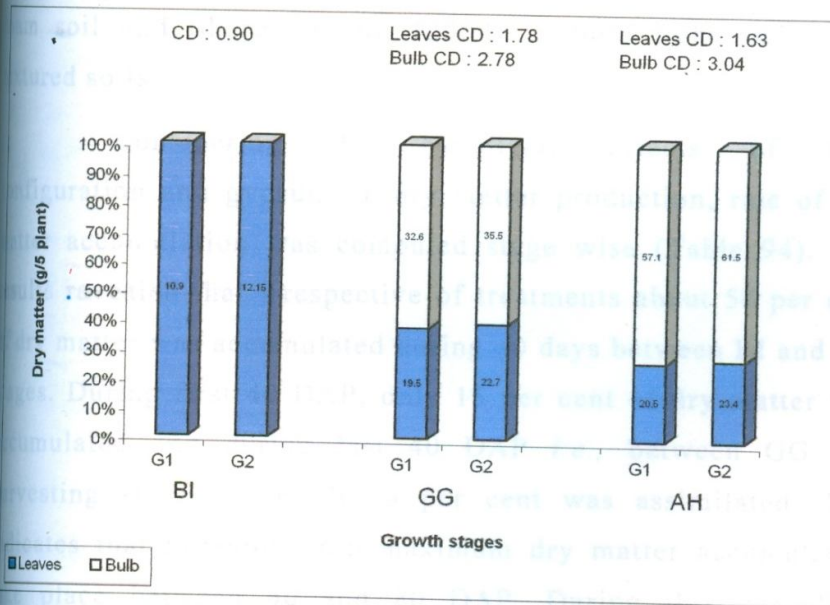


Fig. 16 : Effect of gypsum levels on periodical partitioning of onion dry matter

aggregation and thereby facilitating better air and water movement in heavy texture soils. This might be the reason for increase in growth parameters of onion with the application of gypsum as soil conditioner.

Apart from individual effect, combined effect of land configuration and gypsum application (L x G) was also significant on plant height at all the growth stages and leaves and bulb dry matter at harvest (Tables 19 to 21 and 31,32). This implies that the beneficial impact of individual L and G on onion growth is accelerated further, if used simultaneously (Fig. 17 a, b). Such beneficial effects of land configuration and gypsum application at lower rate have also been reported by Kar and Tiwari (1993) in sandy loam soil; Jana and Kabir (1990) in sandy loam soil and Sharma *et al.* (2002) in both light and heavy textured soils.

Considering the beneficial effects of land configuration and gypsum on dry matter production, rate of dry matter accumulation was computed stage wise (Table 94). The results revealed that irrespective of treatments about 50 per cent of dry matter was accumulated during 40 days between BI and GG stages. During first 40 DAP, only 15 per cent of dry matter was accumulated and during last 40 DAP *i.e.*, between GG and harvesting stages about 30-34 per cent was assimilated. This indicates that in onion crop maximum dry matter accumulation take place between 40 and 80 DAP. During this period L₂ configuration accumulated (56%) more dry matter than L₁ (51%).

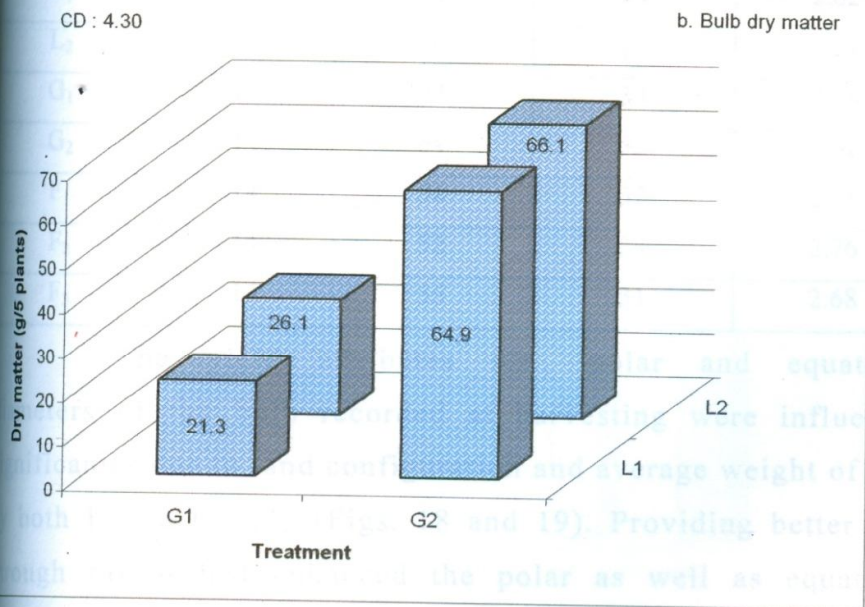
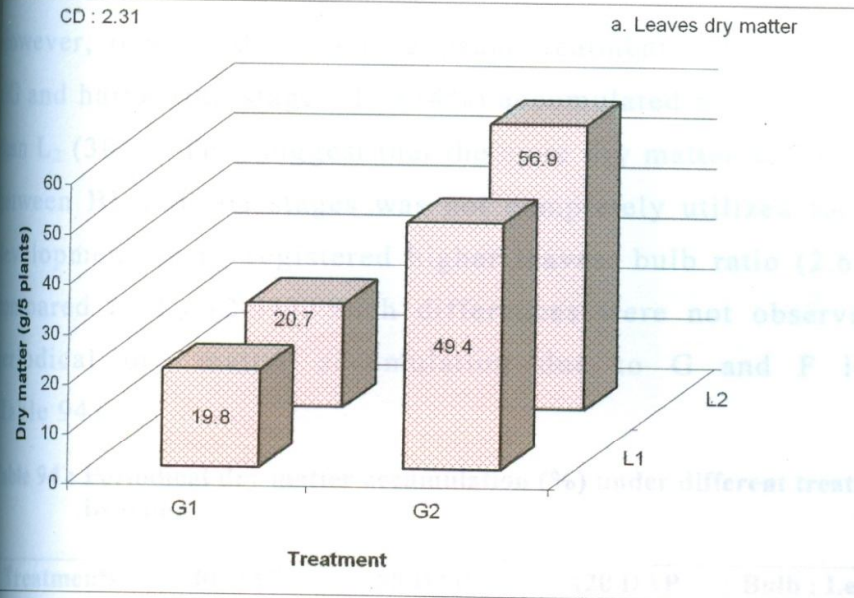


Fig. 17 : Interaction effect of L x G on dry matter production at harvest

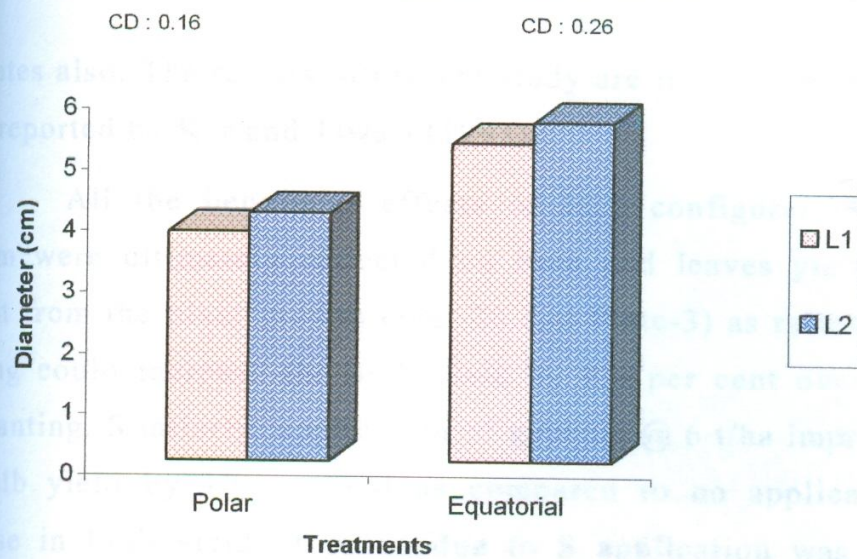
However, it was not so with gypsum treatments. While between GG and harvesting stages, L₁ (34%) accumulated more dry matter than L₂ (30%). This suggest that the more dry matter accumulated between BI and GG stages was not completely utilized for bulb development as L₁ registered higher leaves: bulb ratio (2.62) as compared to L₂ (2.51). Such differences were not observed in periodical dry matter accumulation due to G and F levels (Table 94).

Table 94 : Periodical dry matter accumulation (%) under different treatments by onion

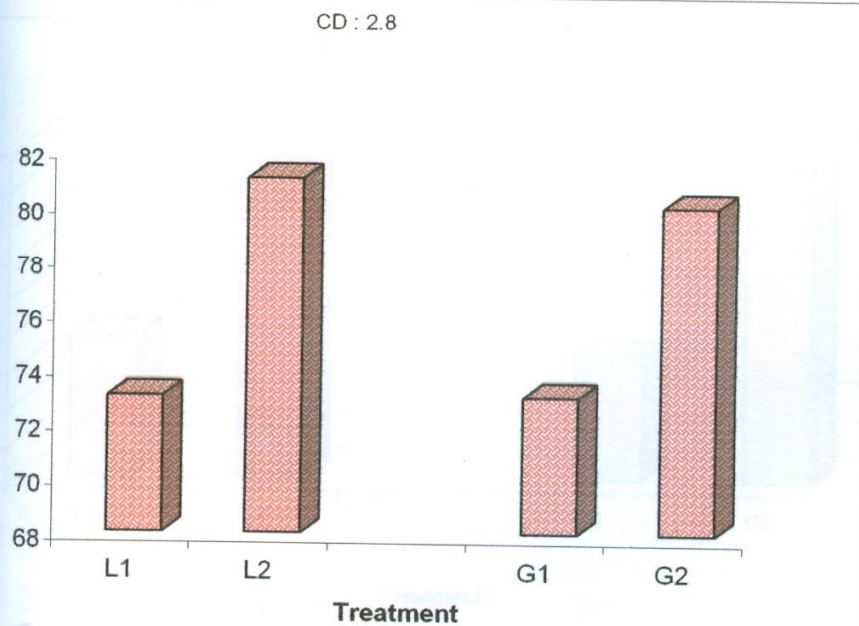
| Treatments | 40 DAP | 80 DAP | 120 DAP | Bulb : Leaves ratio |
|----------------|--------|--------|---------|---------------------|
| L ₁ | 15 | 51 | 34 | 2.62 |
| L ₂ | 14 | 56 | 30 | 2.51 |
| G ₁ | 14 | 53 | 33 | 2.78 |
| G ₂ | 14 | 54 | 32 | 2.62 |
| F ₁ | 14 | 54 | 32 | 2.65 |
| F ₂ | 14 | 52 | 34 | 2.76 |
| F ₃ | 14 | 55 | 31 | 2.68 |

The yield attributes *viz.*, polar and equatorial diameters of the bulb recorded at harvesting were influenced significantly due to land configuration and average weight of bulb by both L and G only (Figs. 18 and 19). Providing better tilth

through raised bed enhanced the polar as well as equatorial diameter and ultimately the average bulb weight significantly as compared to flat bed planting. The reason for improvement in dry matter production and growth parameters are tenable for yield



18 : Effect of land configuration on polar and equatorial diameters of onion



19 : Effect of land configuration and soil conditioner on average bulb weight

attributes also. The results of present study are in agreement with those reported by Kar and Tiwari (1993).

All the beneficial effects of land configuration and gypsum were ultimately reflected on bulb and leaves yields as evident from the plant growth (Fig. 20 and Plate-3) as raised bed planting could increase the bulb yield by 8.5 per cent over flat bed planting. Similarly, application of gypsum @ 6 t/ha improved the bulb yield by 10 per cent as compared to no application. Increase in bulb yield of onion due to S application was also reported by Kar and Tiwari (1993); Bhattacharya *et al.* (1997); Gupta and Dubey (1998); Nagaich *et al.* (1999); Sharma *et al.* (2002) and Nasreen and Huq (2005).

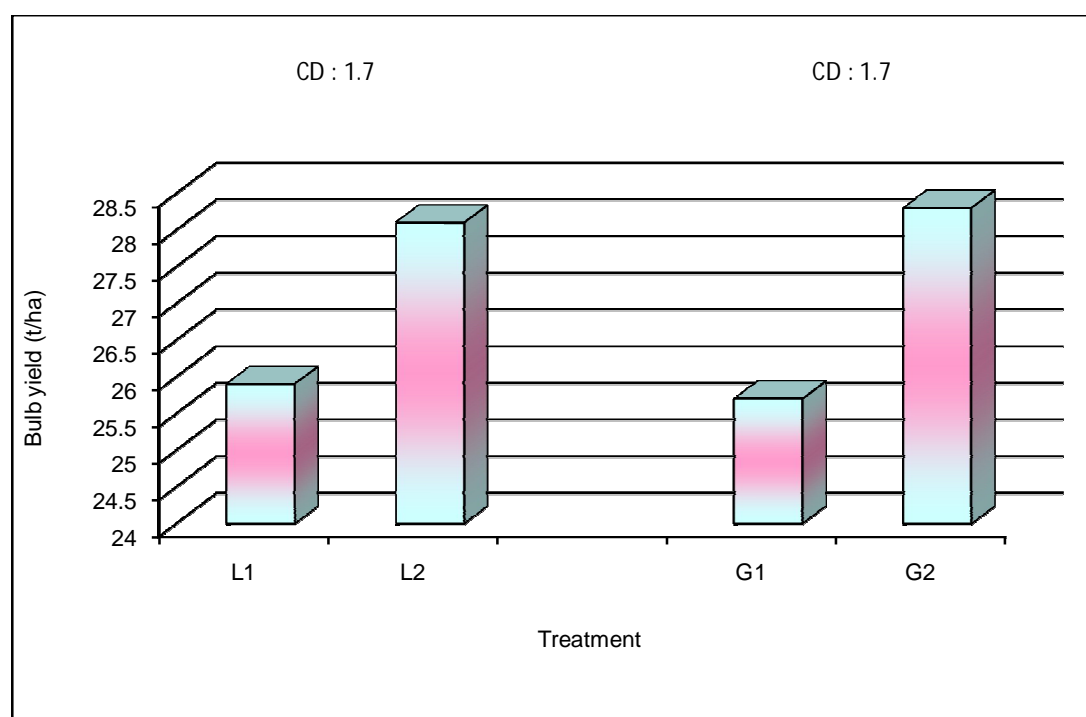


Fig. 20 : Effect of land configuration and soil conditioner on bulb yield



Plate-III : Onion crop condition with L₁G₁F₃ and L₂G₂F₃ treatments

5.3.2 Nutrient content and uptake

Hitherto, only growth parameters and yield have been discussed. Under this subtitle, the extent of periodical nutrient removed by different parts of onion as influenced by the treatments L, G and F are discussed. As the treatment effects on periodical nutrient content in leaves and bulb were not significant in most of the cases, here only periodical nutrient uptake has been discussed. As far as treatment effect on periodical nutrient uptake is concerned, it was almost identical to that observed with dry matter production (Tables 48 to 66). It implies that the pattern of dry matter production under different treatments dictated the extent nutrient removal by onion crop. In order to understand the periodical nutrient removal pattern by onion, the proportion of nutrients removed through leaves and bulb at different growth stages were worked out for N, K, S, Fe and Zn and the results are depicted in Figs 21 to 25.

With respect to N uptake at BI stage, there was no variation, but at GG stage L₂ was removed more N than L₁ and reverse was true at harvesting stage. This clearly suggest that N requirement of onion is increasing up to GG stage (80 DAP) and decline there after. This point need to be considered while N application schedule is formulated for onion crop. Similar trend of N uptake was also noticed with soil conditioner and INM treatments. In both the cases, application of gypsum and 50% RD + FYM or PM increased the N removal at GG stage as compared to respective controls. In contrast, irrespective of treatments K

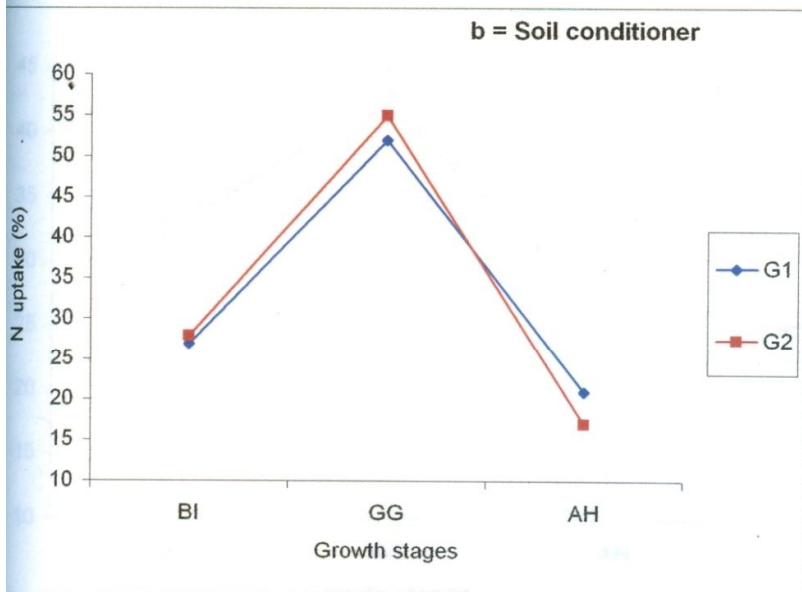
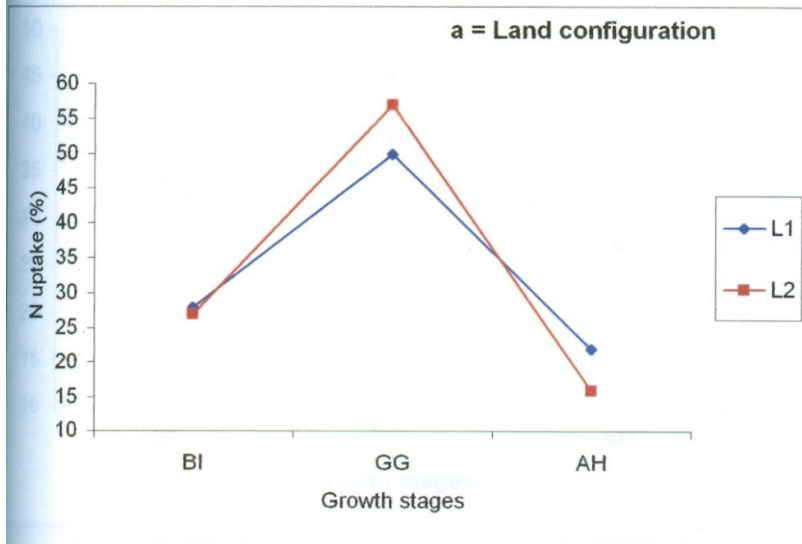


Fig. 21: Effect of land configuration and soil conditioner on pattern of N uptake during different growth stages of onion

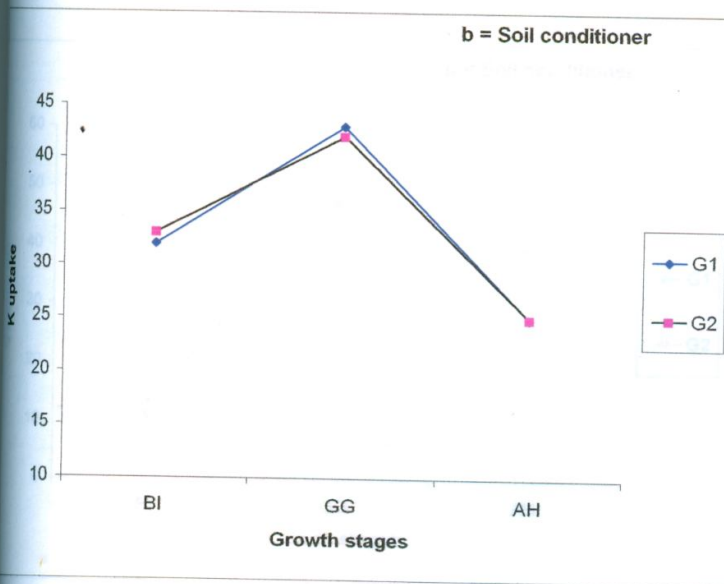
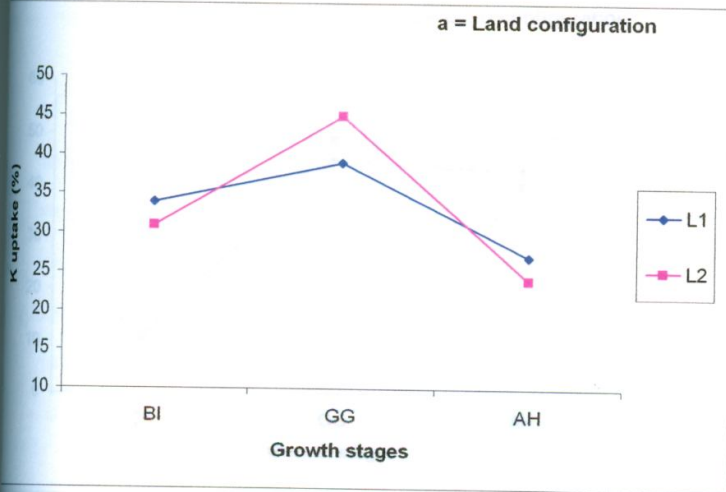


Fig. 22: Effect of land configuration and soil conditioner on pattern of K uptake during different growth stages of onion

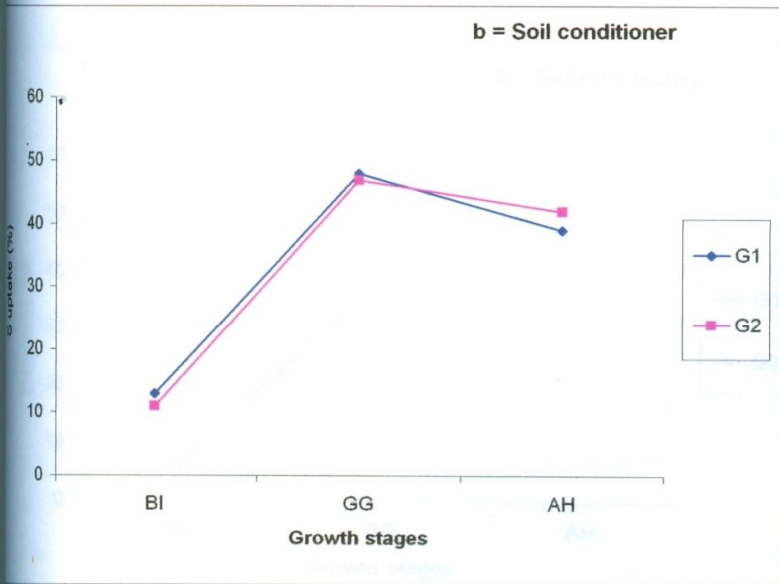
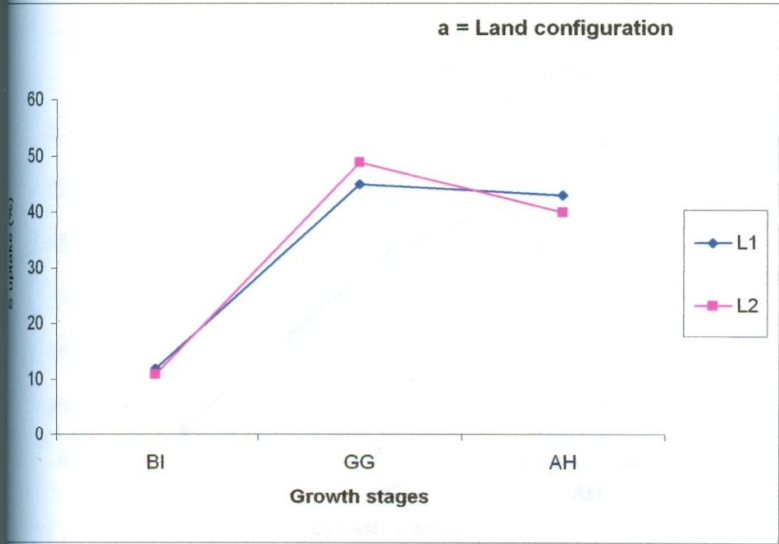


Fig. 23: Effect of land configuration and soil conditioner on pattern of S uptake during different growth stages of onion

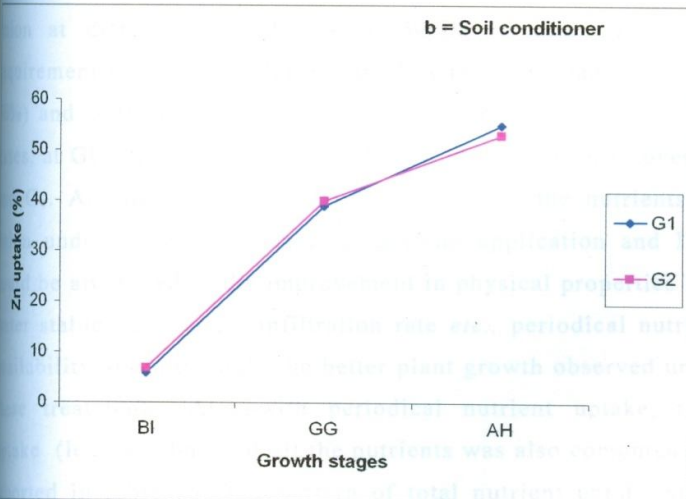
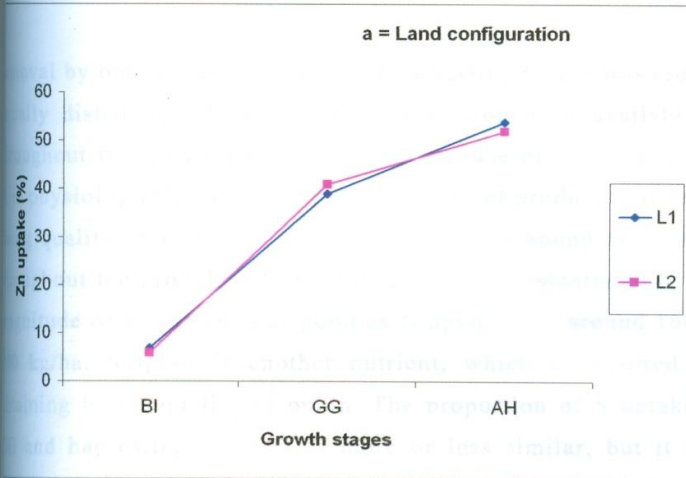


Fig. 25: Effect of land configuration and soil conditioner on pattern of Zn uptake during different growth stages of onion

removal by onion during BI, GG and harvesting stages was almost equally distributed. It means that onion crop need available K throughout its growth periods. This is because of the reason that K is physiologically associated with quality of produce and onion being quality related crop, its K requirement is bound to be there throughout the growth period. This is further substantiated by the magnitude of K uptake is as good as N uptake *i.e.*, around 160 to 200 kg/ha. Sulphur is another nutrient, which is required for obtaining better quality of onion. The proportion of S uptake at GG and harvesting stages was more or less similar, but it was very less at BI stage *i.e.* S requirement of onion during first 40 DAP is account only 20 per cent of total S uptake. Almost similar pattern of treatment effect was also observed on Fe uptake by onion at different growth stages. While in case of Zn, its requirement is maximum during 80-120 days after planting (about 40%) and only 6 to 7 per cent during first 40 DAP. In all the cases, at GG stage L₂ and G₂ maintained their superiority over L₁ and G₁. An increase in utilization of most of the nutrients by onion under raised bed planting, gypsum application and INM could be attributed to the improvement in physical properties like water stable aggregates, infiltration rate *etc.*, periodical nutrient availability and ultimately the better plant growth observed under these treatments. Alongwith periodical nutrient uptake, total uptake (leaves + bulb) of all the nutrients was also computed and reported in table 95. The pattern of total nutrient uptake under different treatments was identical to that observed with bulb and

Table 95 : Total nutrient uptake by onion plant

| Treatments | Uptake (kg/ha) | | | | Uptake (g/ha) | | | |
|---------------------------|----------------|-------|-------|-------|---------------|-----|-----|-----|
| | N | P | K | S | Fe | Mn | Zn | Cu |
| Land configuration | | | | | | | | |
| L ₁ | 64 | 13.56 | 62.43 | 40.24 | 442 | 205 | 180 | 146 |
| L ₂ | 68 | 15.32 | 68.86 | 44.50 | 459 | 231 | 209 | 166 |
| Soil conditioner | | | | | | | | |
| G ₁ | 64 | 13.13 | 62.21 | 34.32 | 434 | 200 | 183 | 143 |
| G ₂ | 68 | 18.76 | 69.08 | 50.51 | 489 | 235 | 205 | 169 |
| INM | | | | | | | | |
| F ₁ | 65 | 13.04 | 67.30 | 41.24 | 477 | 219 | 194 | 160 |
| F ₂ | 63 | 14.60 | 62.93 | 38.65 | 441 | 209 | 185 | 150 |
| F ₃ | 70 | 15.70 | 66.71 | 42.86 | 468 | 224 | 205 | 160 |

leaves yields of onion. Among the treatments, planting on raised bed, application of gypsum and conjunctive use of organics and fertilizer maintained their superiority over their respective controls. Among the major nutrients, N and K requirement was around 65 kg/ha which was followed by S (around 40 kg/ha) and P uptake was minimum (around 14 kg/ha). The extent of uptake of micronutrient was of the order of Fe > Mn > Zn > Cu. Such beneficial effect of land configuration, gypsum and INM on nutrient removal by onion was also observed by Patel *et al.* (1992); Singh and Pandey (1995); Yengade *et al.* (1995); Meena and Singh (1998); Nagaich *et al.* (1999); Sarode *et al.* (2001); Singh *et al.* (2002) and Sharma *et al.* (2003).

Storage study

In the present days of quality consciousness, increase in productivity of any crop should be coupled with quality improvement. Otherwise, farmers will not get an appropriate price and there by less net profit or in extreme case may face financial loss. Hence, in present study, chemical quality and keeping quality parameters were also studied periodically (Table 96). As far as periodical chemical quality parameters *viz.* TSS, reducing sugar, non-reducing sugar and total sugar are concerned, TSS and reducing sugar tended to increase with storage time and non-reducing sugar as well as total sugar showed declining trend. An increase in reducing sugar observed in present study seems to be due to conversion of non-reducing sugar to reducing sugar by the action of enzyme invertase (Bacon, 1957). This reduction was

Table 96 : Mean values of reducing, non-reducing, total sugars and total soluble solids

| Treatment | 0 DAS | 30 DAS | 60 DAS | 90 DAS | 120 DAS |
|--------------------------|-------------|-------------|-------------|-------------|-------------|
| Reducing sugar (%) | | | | | |
| F ₁ | 2.12 | 2.28 | 2.36 | 2.50 | 2.53 |
| F ₂ | 2.30 | 2.38 | 2.47 | 2.58 | 2.76 |
| F ₃ | 2.42 | 2.46 | 2.69 | 2.75 | 2.98 |
| Non-reducing sugar (%) | | | | | |
| F ₁ | 6.95 | 6.84 | 6.58 | 6.16 | 5.55 |
| F ₂ | 7.32 | 7.12 | 6.93 | 6.54 | 6.11 |
| F ₃ | 7.46 | 7.33 | 7.07 | 6.99 | 6.70 |
| Total sugar (%) | | | | | |
| F ₁ | 9.07 | 9.12 | 8.94 | 8.66 | 8.08 |
| F ₂ | 9.62 | 9.50 | 9.40 | 9.12 | 8.88 |
| F ₃ | 9.89 | 9.80 | 9.76 | 9.74 | 9.68 |
| Total soluble solids (%) | | | | | |

| | | | | | |
|----------------|--------------|--------------|--------------|--------------|--------------|
| F ₁ | 10.50 | 11.94 | 12.27 | 12.52 | 12.72 |
| F ₂ | 12.23 | 12.61 | 12.71 | 12.91 | 13.08 |
| F ₃ | 12.69 | 12.95 | 13.08 | 13.31 | 13.53 |

also reflected on the concomitant decline with storage time in the content of non-reducing sugar. Here only INM effect was significant on all quality parameters. Among the INM treatments application of 50% RD + PM showed superiority in all the quality parameters at all the samplings over rest of the treatments, but it was at par with treatment receiving 50% RD + FYM.

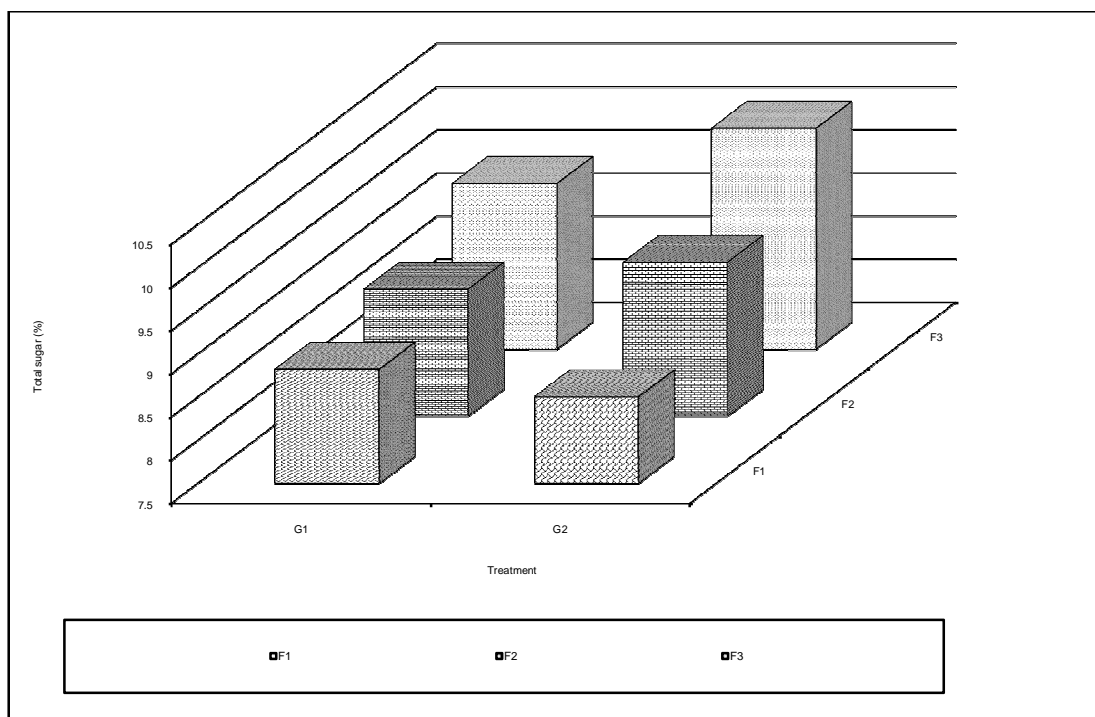


Fig. 26: Effect of G x F interaction on total sugar content in onion bulb at 90 DAS

However, application of fertilizer alone invariably recorded significantly lower values of all the chemical quality parameters at all the samplings. At 90 days after storage, the interactive effect of G x F was found to be significant on total sugar content in onion bulb (Fig. 26). A combination of G₂F₃ registered significantly higher value of total sugar (10.06%) as compared to remaining combinations. An improvement in the quality parameters due to INM in comparison to fertilizer alone could be attributed to the inadvertent beneficial effects of organics on the physical and biological properties of the soil. Similar increase in reducing sugar and TSS with storage time was also reported by Singh and Dhankar (1992) with different varieties and MH sprays under ambient storage conditions.

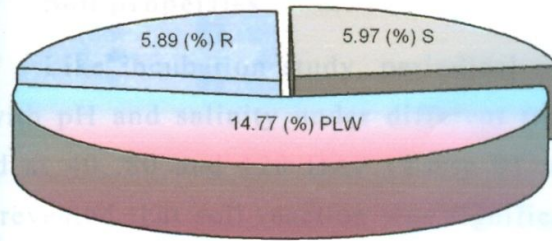
Apart from chemical quality parameters, the storage losses *viz.*, physiological loss in weight, rotting loss and sprouting loss were also determined and the total loss during storage time was also calculated (Tables 74 to 78). Here also, INM treatment could exert significant impact on the

different type of losses at all the samplings except that of sprouting loss which was affected only at last two samplings. In earlier chapter, sampling wise individual losses have been interpreted and hence, only cumulative losses are discussed here. At all the samplings, physiological loss in weight, sprouting loss and total loss were significantly lower with F₃ than F₁ but it was at par with F₂ treatments at 30 and 60 DAS. Whereas, rotting loss was found to be minimum with F₂ at all the samplings (Table 97). Application of organics with bio-fertilizer reduces storage losses as compared to fertilizer alone were also reported by Jagoda *et al.* (1972); Madan and Sandhu, (1985); Bhujbal (1989); Gopalkrishna *et al.* (1990) and Kale *et al.* (1992). With respect to total loss at the last sampling (120 DAS), it was minimum with F₃ (19.74%) which was followed by F₂ (21.66%) and maximum was with F₁ (26.66%). This has practical implication, as use of fertilizer alone could lead to about 25 per cent loss of onion during storage period of 120 days which can be reduced by about 7 per cent with the combined application of fertilizer and PM. (Fig. 27). It is interesting to note that, among the losses, physiological loss in weight contributed more than 50 per cent of the total losses. The similar magnitude of physiological loss in weight has been also reported by Warade *et al.* (1995); Warade *et al.*, (1996) and Shinde *et al.* (2001). The reason assigned by these workers for physiological loss in weight are prevalence of higher temperature and low humidity during initial period (April, May and June) causing enhanced respiration and more water loss. These reasons are equally applicable for explaining the results of present study.

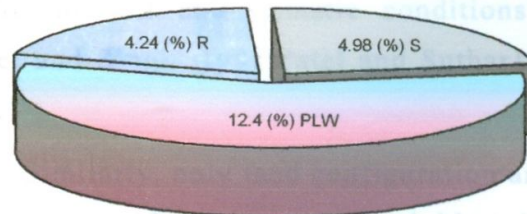
Table 97 : Cumulative loss of onion during storage

| | 30 DAS | | | | 60 DAS | | | |
|----------------------|--------|---|------|------|--------|---|------|-------|
| | PLW | S | R | T | PLW | S | R | T |
| F₁ | 6.05 | - | 2.12 | 8.18 | 9.22 | - | 4.05 | 13.27 |
| F₂ | 5.30 | - | 1.57 | 6.87 | 7.72 | - | 3.06 | 10.78 |
| F₃ | 4.53 | - | 2.02 | 6.55 | 6.20 | - | 3.82 | 10.02 |

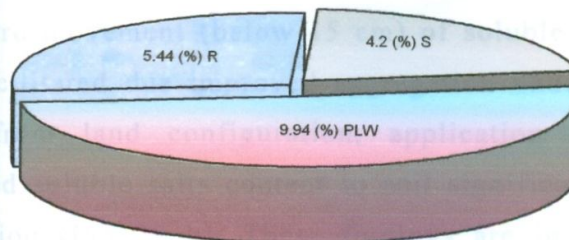
| Treatments | 90 DAS | | | | 120 DAS | | | |
|----------------|--------|------|------|-------|---------|------|------|-------|
| | PLW | S | R | T | PLW | S | R | T |
| F ₁ | 11.98 | 2.62 | 5.03 | 16.92 | 14.77 | 5.97 | 5.91 | 26.66 |
| F ₂ | 10.22 | 2.31 | 3.71 | 16.25 | 12.42 | 4.98 | 4.25 | 21.66 |
| F ₃ | 8.43 | 2.17 | 4.67 | 15.40 | 10.12 | 4.20 | 5.45 | 19.74 |



F1



F2



F3

Fig. 27 : Effect of INM on different storage losses of onion at 120 DAS

5.3.4 Soil properties

Like incubation study, periodical nutrient availability along with pH and salinity under different treatments were also assessed at 40, 80 and 120 DAP (Table 81 to 92). The results clearly revealed that soil reaction was significantly reduced only due to application of gypsum. Though, gypsum was applied as soil conditioner *i.e.*, @ 6 t/ha, formation of H₂SO₄ due to release of SO₄ by dissolution of gypsum might have helped in decreasing the soil pH. Similar results were also reported by earlier workers under different soil and climatic conditions (Anand Swarup, 1991; Patel and Singh, 1991; Patel and Suthar 1993 and Raman *et al.*, 1996).

Similarly, only land configuration and soil conditioner treatments had significant impact on soluble salt content in soil at all the samplings. Here, raised bed configuration registered conspicuously lower EC values than flat bed at all the samplings (Fig. 28 a). It seems that due to raised bed configuration downward movement (below 15 cm) of soluble salts might have been facilitated due improved aggregation under this treatment. Apart from land configuration, application of gypsum also increased soluble salts content in soil significantly owing to its dissolution (Fig 28 b). These findings are in accordance with those reported by Raman *et al.*, 1996 and Anon., 2003. As the experimental soil is non saline, in spite increase in EC, higher yield of onion has been obtained with treatment receiving gypsum.

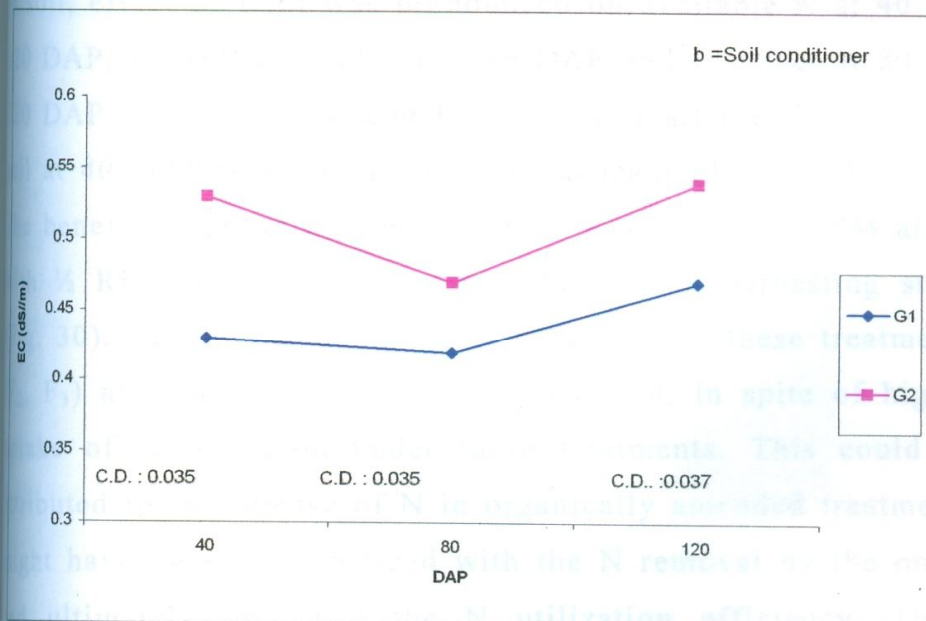
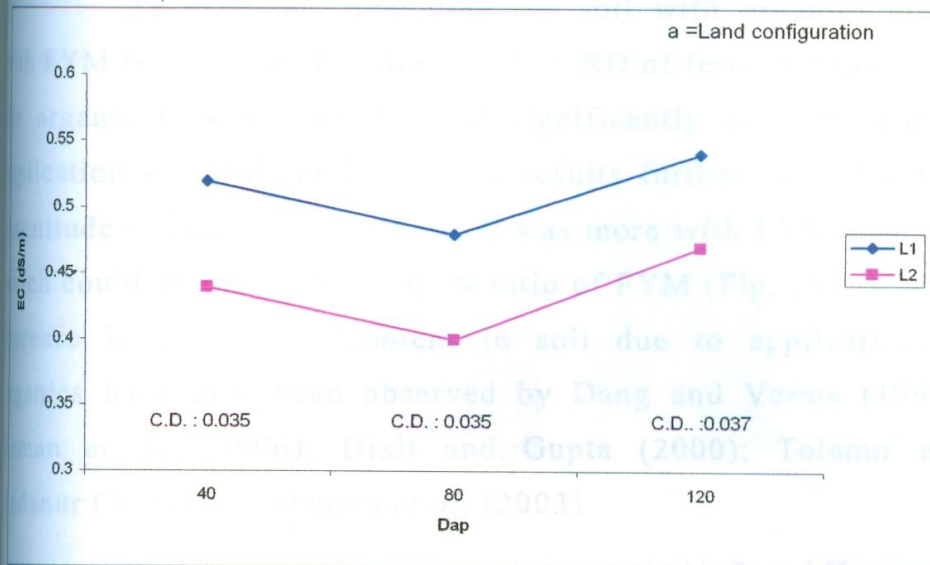
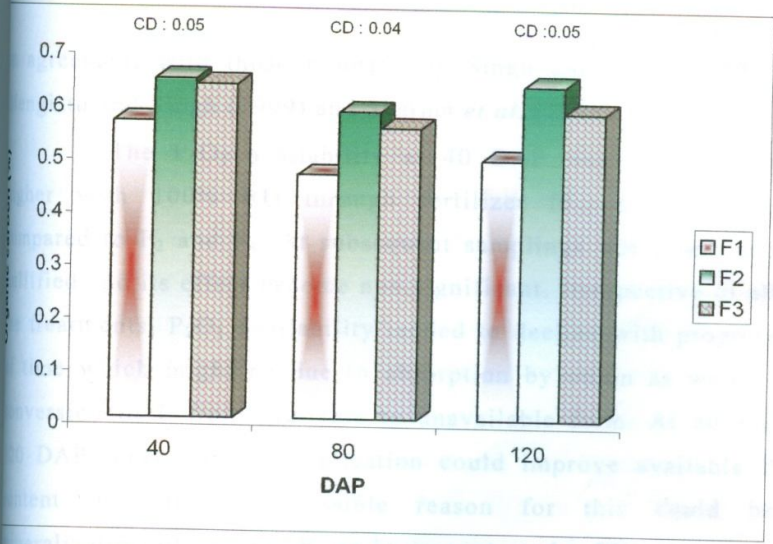


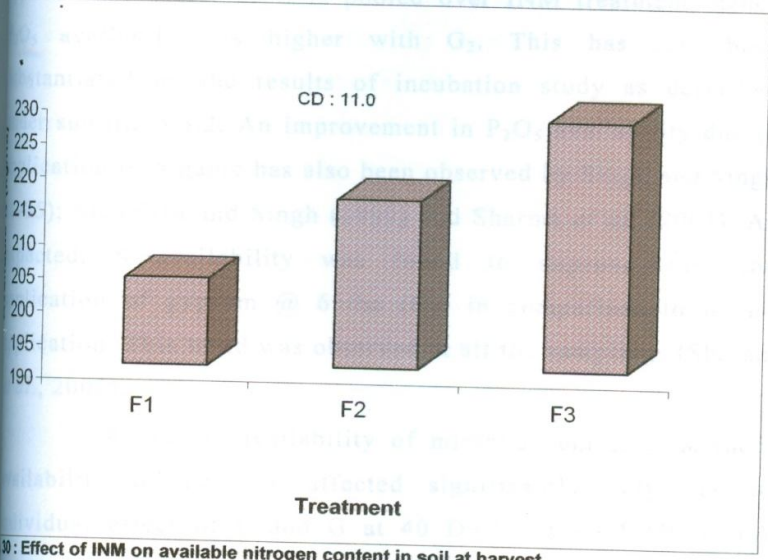
Fig. 28 : Effect of land configuration and soil conditioner on soluble salt content in soil (EC) at different DAP

As expected, amending the soil with organics either with FYM (F₂) or PM (F₃) along with ½ RD of fertilizer improved the organic C status of the soil significantly as compared to application of fertilizer alone. The results further indicated that magnitude of increase in organic C was more with FYM than PM which could be due to wider C: N ratio of FYM (Fig. 29). Similar increase in organic C content in soil due to application of organics have also been observed by Dang and Verma (1996); Raman *et al.* (1996); Dixit and Gupta (2000); Tolanur and Badanur (2003) and Sharma *et al.* (2003).

With respect to periodical available N, P and K content in soil, effect of INM was pronounced on available N at 40 and 120 DAP, as well as F effect at 40 DAP and G effect at 80 and 120 DAP on available P and F effect on available K content in soil at 40 DAP were found to be significant (Tables 84 to 86). The beneficial effect of application of either FYM or PM along with ½ RD through fertilizer persisted up to harvesting stage (Fig. 30). The higher available N content with these treatments (F₂, F₃) after harvest of crop was observed, in spite of higher uptake of N by onion under these treatments. This could be attributed to the release of N in organically amended treatments might have been synchronized with the N removal by the onion and ultimately improved the N utilization efficiency. These results also corroborate with the incubation study though in absence of crop wherein F₂ and F₃ showed their superiority over F₁ with respect to available N content in soil. These findings are in agreement with those reported by Singh and Singh (1995); Mengistu and Singh (1999) and Sharma *et al.* (2003).



29 : Effect of INM on organic carbon content in soil at different DAP



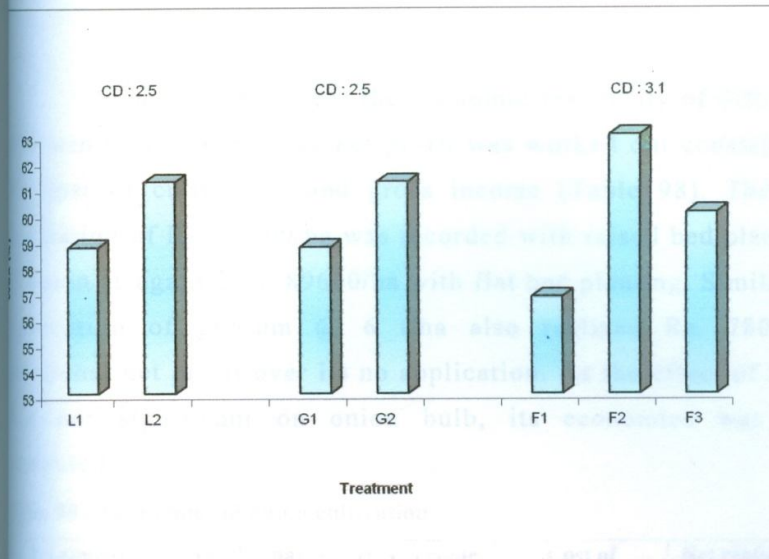
30 : Effect of INM on available nitrogen content in soil at harvest

The P_2O_5 availability at 40 DAP was significantly higher with 100% RD through fertilizer (F_1) treatment as compared to F_2 and F_3 . At subsequent samplings this effect was nullified and its effect become non significant. Irrespective of all the treatments, P_2O_5 availability tended to decline with progress of time which might be due to absorption by onion as well as conversion of P from available to unavailable form. At 80 and 120 DAP, only gypsum application could improve available P content in soil. The possible reason for this could be mineralization of organic P, as in present study, FYM/PM were applied. The effect of G is pooled over INM treatment, hence P_2O_5 availability is higher with G_2 . This has also been substantiated by the results of incubation study as described under subtitle 5.3.2. An improvement in P_2O_5 availability due to application of organic has also been observed by Singh and Singh (1995); Mengistu and Singh (1999) and Sharma *et al.* (2003). As expected, S availability was found to improve with the application of gypsum @ 6 /ha (G_2) in comparison to its no application. This trend was observed at all the samplings (Sharma *et al.*, 2002).

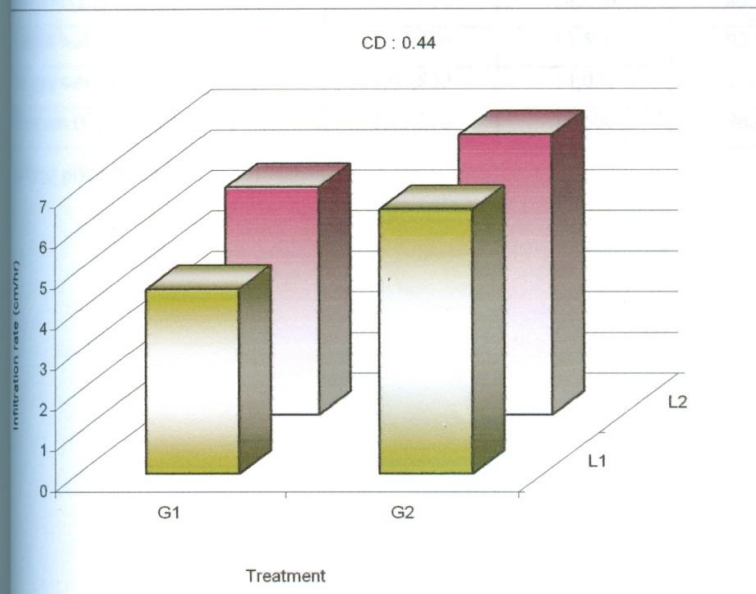
As far as availability of micronutrient is concerned, availability of Fe was affected significantly only due to individual effect of L and G at 40 DAP. At 40 DAP, DTPA extractable Fe was significantly higher with L_2 and G_2 as compared to L_1 and G_1 levels. At 80 DAP though L_2G_2 combination recorded higher available Fe content in soil than rest of L x G combinations but the differences were found non significant. At subsequent sampling *i.e.*, 120 DAP, a combination of L_2G_2 recorded significantly higher available Fe content in soil but it was at par with L_1G_1 and L_1G_2 combinations. An increase in available Fe content in soil under present set of experiment seem to be due to indirect addition Fe through gypsum and organics.

Onion being bulbous crop, physical properties *viz.*, water stable aggregates and infiltration rate were also determined after harvesting of crop (Tables 79 to 80). In both the cases, individual effect of L, G and F was found to be significant as well as L x G interaction effect on infiltration rate. Adoption of raised bed configuration had significantly improved the aggregation which could be attributed to better air and water

movement under this treatment might have enhanced the microbial activities and thereby aggregation (Fig 31). Because of improvement of WSA under L₂, might have improved the IR (Fig. 32). This effect was more pronounced on IR under land configuration and gypsum application is put together. Because gypsum application also alter the aggregation favourably. Similar beneficial effects of gypsum on WSA and IR have been reported by Raman *et al.* (1996) and (Anon., 2003). The results of present study have empathetically proved that raised bed configuration, application of gypsum and organics (FYM/PM) have improved the aggregation of high clay containing soil and ultimately the IR as well.



31 : Effect of land configuration, soil conditioner and INM on water stable aggregates (> 1mm)



32 : Interaction effect of L x G on infiltration rate of soil

In order to assess the economic feasibility of different treatments, treatment-wise net profit was worked out considering the cost of cultivation and gross income (Table 98). The net realization of Rs. 95900/ha was recorded with raised bed planting of onion as against Rs. 89600/ha with flat bed planting. Similarly, application of gypsum @ 6 t/ha also realized Rs. 7800/ha additional net profit over its no application. As the effect of INM was not significant on onion bulb, its economics was not computed.

Table 98 : Economics of onion cultivation

| Treatment | Yield (t/ha) | Gross income (Rs/ha) | Cost of cultivation (Rs/ha) | Net realization (Rs/ha) |
|------------------------------|--------------|----------------------|-----------------------------|-------------------------|
| Flat bed (L ₁) | 25.9 | 1,03,600 | 14,000 | 89,600 |
| Raised bed (L ₂) | 28.1 | 1,12,400 | 16,500 | 95,900 |
| No gypsum (G ₁) | 25.7 | 1,02,800 | 14,000 | 88,800 |
| Gypsum (G ₂) | 28.3 | 1,13,200 | 16,600 | 96,600 |

Selling price Rs. 4/kg

VI SUMMARY AND CONCLUSIONS

An investigation entitled “Management of Clay Soils of South Gujarat for Improving Yield and Quality of Onion” comprising survey, incubation study and field experiment was carried out. In survey, with the help of standard questionnaire personal interview of randomly selected onion growers was undertaken. Similarly, incubation study was also carried out for assessing periodical nutrient availability as influenced by integrated nutrient management (INM) in presence and absence of soil conditioner. In addition, a field experiment was conducted at Soil and Water Management Farm, Navsari Agricultural University (erstwhile G.A.U.), Navsari during *rabi* season of 2003-04 with 12 treatment combinations consisting of 2 land configurations (L_1 = flat bed, L_2 = raised bed), 2 soil conditioner (G_1 = no gypsum, G_2 = gypsum @ 6 t/ha) and 3 INM (F_1 = RD through inorganic fertilizer, F_2 = $\frac{1}{2}$ RD + FYM @ 15 t/ha, F_3 = $\frac{1}{2}$ RD + PM @ 6 t/ha). The treatment effect on biometrics, yields and nutrient uptake by onion along with soil properties, storage quality and losses during storage were studied. The data were analysed statistically by CRD and FRBD. The results are presented and discussed in the preceding chapters. The summary of the results is given here.

6.1 Survey

- (i) Majority of the farmers of South Gujarat are growing onion crop on flat

bed (95%) during *rabi* season preceded by *kharif* paddy.

(ii) Most of the farmers (84%) do not apply gypsum as soil conditioner, which is necessary to improve physical conditions of soil.

(iii) Majority of the farmers are adopting integrated nutrient management system, yet the rate of application was found to be very low.

6.2 Incubation study

(i) The soil pH in all the treatments involving fertilizer alone or fertilizer + organics and /or gypsum registered lower pH than absolute control.

(ii) The soluble salt content in soil was significantly higher with treatments receiving gypsum (T₅, T₆ and T₇) as compared to treatments without gypsum (T₂, T₃ and T₄) as well as control.

(iii) Organic carbon content in soil showed declining trend with progress of time. In almost all the cases, treatments receiving 50% RD + either FYM or PM in absence or presence of gypsum (T₃, T₄, T₆ and T₇) recorded significantly higher organic C content in soil as compared to control (T₁) as well as treatments receiving RD alone (T₂ and T₅).

(iii) The availability of N, P and K was found to increase with progress of time and the extent of increase was more with INM treatments than absolute control.

(iv) Application of 50% RD + FYM or PM + gypsum (T₅, T₆ and T₇) recorded significantly higher available S content in soil in comparison to rest of the treatments.

(v) Availability of all the micronutrients was significantly higher with treatments T₄ (½ RD + PM) and T₇ (1/2 RD + PM + gypsum) at all the samplings i.e., 40, 80 and 120 DAI as compared to control.

6.3 Field experiment

6.3.1. Crop growth and yield

(i) Significantly higher plant height of onion was recorded in raised planting method than flat bed planting at all the growth stages.

(ii) Application of gypsum favourably influenced the plant height, number of leaves per plant and dry matter production at all the growth stages of onion.

- (iii) Among the different treatment combinations, L₂G₂ showed superiority over rest of the combinations as it recorded significantly higher plant height of 52.4, 60.0 and 63.1 cm, at BI, GG and AH, respectively as compared to rest of the combinations.
- (iv) At harvest, significantly higher bulb dry matter per five plant was recorded with L₂G₂ (66.15g) than L₁G₁ (49.40) and L₁G₂ (56.88 g).
- (v) Application of soil conditioner and using raised bed for planting, improved the average weight of bulb significantly.
- (vi) At harvest, raised bed planting (L₂) enhanced the polar and equatorial diameters as well as average bulb weight of onion by 8.3, 6.5 and 10.5 per cent, respectively, in comparison to flat bed planting.
- (vii) The rate of dry matter production was found to be maximum between BI and GG stage (50%) followed by GG and AH (35%) and minimum was during first 40 DAP.
- (viii) Adoption of raised bed planting along with incorporation of gypsum as soil conditioner enhanced the onion bulb yield by 10.0 and 8.5 per cent, respectively, over flat bed planting without gypsum application.

6.3.2. Nutrient content and uptake

- (i) The N requirement of onion was found to increase up to GG stage (80 DAP) and declining thereafter.
- (ii) At GG, the removal of N by onion with treatment L₂ was more by 30.37 per cent than L₁ but reverse was true at harvesting stage.
- (iii) Irrespective of treatments, K removal by onion crop during BI, GG and at harvesting stages was almost equal.
- (iv) At BI stage, among the different INM treatments F₃ (2.76 mg/plant) removed significantly higher P than F₂ (2.48 mg/plant) and F₁ (2.37 mg/plant)
- (v) The proportion of S uptake at GG and harvesting stages was more or less similar, but it was very less during BI stage.
- (vi) The uptake of Fe, Mn and Cu by onion plant was observed to be higher with L₂ (raised bed) land configuration and G₂ (gypsum @ 6 t/ha) soil conditioner level than their respective control *i.e.*, L₁ and G₁.
- (vii) Zinc requirement was maximum during 80-120 DAP (about 53%) followed by GG (40%) and only 6 to 7 per cent during first 40 DAP.

- (viii) At harvest, effect of L x G interaction on Fe uptake through leaves was found to be significant. Among the various L x G combinations, L₂G₂ (0.253 mg/plant) showed significantly more uptake over rest of the combinations.
- (ix) The uptake of Mn by onion plant at BI stage was significantly higher with treatment L₂G₂ (0.072 mg/plant) as compared to L₁G₁ (0.053 mg/plant), L₁G₂ (0.056 mg/plant) and L₂G₁ (0.059 mg/plant).
- (x) The treatment L₂G₂ recorded significantly higher uptake of Zn by leaves at BI stage (0.047 mg/plant) and harvesting stages (0.151 mg/plant) of onion.
- (xi) At harvesting, raised bed planting showed relatively more total uptake (leaves + bulb) of N (6.2%), P (13.0%), K (12.3%), S (10.6%), Fe (3.8%), Mn (12.7%), Zn (16.1%) and Cu (13.7%) than flat bed planting.
- (xii) Application of gypsum as soil conditioner (G₂) recorded significantly higher uptake of P (18.76 kg/ha), K (69.08 kg/ha), S (50.51 kg/ha), Fe (489 g/ha), Mn (235 g/ha), Zn (205 g/ha) and Cu (169 g/ha) in comparison to its no application.
- (xiii) Except P uptake in leaves, INM levels did not influence uptake of macro and micronutrients. Among the different F levels, F₃ (2.76 kg/ha) recorded significantly higher P uptake by leaves at harvest.

6.3.3 Storage study

- (i) Total soluble solids and reducing sugar tended to increase with storage time and non-reducing sugar as well as total sugar showed declining trend.
- (ii) Among the INM treatments, application of 50% RD + PM @ 6 t/ha showed superiority in all quality parameters *i.e.*, T.S.S, reducing sugar and non-reducing sugar over application of fertilizer alone. An extent of increase in T.S.S, RS and NRS with INM treatments was of the order of 4.60, 13.4 and 15.3 per cent respectively, over application of fertilizer alone.
- (iii) At all the samplings *i.e.*, 30, 60, 90 and 120 DAS, physiological loss in weight, rotting loss and total losses were significantly lower with F₃ than F₁. At the end of storage study (120 DAS), F₃ recorded 30 per cent less total loss than application of fertilizer alone (F₁), while F₂ (½ RD + FYM @ 15 t/ha) showed 38 per cent less rotting loss than F₁.

6.3.4 Soil properties

- (i) After harvest of onion crop, application of gypsum could reduce the soil pH by 4.7 per cent as compared to its no application.
- (ii) Raised bed configuration registered conspicuously lower EC values than flat bed at all the samplings. The values recorded at harvest were 0.47 and 0.54 dS/m with L₂ and L₁ respectively.
- (iii) After harvest of crop, an application of gypsum increased the soluble salt content in soil by 15 per cent as compared to its no application.
- (iv) Amending the soil with either FYM (F₂) or PM (F₃) along with ½ RD of fertilizer improved the organic C status of soil significantly as compared to fertilizer alone. The magnitude of increase in organic C content in soil with INM treatments at harvest was ranging from 18 to 29 per cent as compared to fertilizer alone.
- (v) Irrespective of all the treatments, P availability tended to decline with progress of time. An application of gypsum could improve available P content in soil at harvest of crop by 17.8 per cent as compared to its no application.
- (vi) Between the two land configurations, raised bed (L₂) recorded 11.1 per cent higher IR than flat bed (L₁). Application of soil conditioner @ 6 t/ha (G₂) showed 32.1 per cent more IR than its no application (G₁). By adopting INM approach 24.9 per cent higher IR was observed as compared to application of fertilizer alone. Among the different L x G combinations, L₂G₂ showed significantly higher IR (6.90 cm/hr) over rest of the combinations.
- (vii) Raised bed land configuration (L₂) and application of soil conditioner (G₂) showed 4.3 per cent better soil aggregation than flat bed and no application of soil conditioner. When INM approach was adopted, the WSA was tended to increase by 8% over application of fertilizer alone.

Conclusions

Based on the results of present studies, following inferences can be drawn.

For enhancing the productivity of onion grown after *kharif* paddy under South Gujarat conditions, adoption of raised bed planting along with application of gypsum @ 6 t/ha and 50 per cent recommended dose of fertilizer + either FYM @ 15 t/ha or press mud @ 6 t/ha was found to be essential. This package of practices was also found to improve the quality of onion and soil properties.

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