INTEGRATED NUTRIENT MANAGEMENT IN ONION *(Allium cepa* L.) cv. N-53

l;kt ¼,fy;e lhik ,y-½ fdLe ,u- 53 e lefUor ik"kd rRo icU/ku

SHANKAR LAL MEENA

Thesis

Master of Science in Agriculture

(Horticulture)

2015

Department of Horticulture

RAJASTHAN COLLEGE OF AGRICULTURE MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY,

UDAIPUR-313001 (RAJ.)

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Thesis

Submitted to the

Maharana Pratap University of Agriculture and Technology, Udaipur

In partial fulfillment of the requirements for the Degree of

Master of Science in Agriculture

(HORTICULTURE)

By

SHANKAR LAL MEENA

2015

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLOGY, UDAIPUR
RAJASTHAN COLLEGE OF AGRICULTURE, UDAIPUR

CERTIFICATE-I

Dated / /2015

This is to certify that **Mr. Shankar Lal Meena** has successfully completed the comprehensive examination held on June 23, 2015 as required by the regulation for degree of **Master of Science in Agriculture (Horticulture).**

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CERTIFICATE-II

Dated: /   / 2015

This is to certify that the thesis entitled **"Integrated Nutrient Management in Onion *(Allium cepa* L.) cv-N53"** submitted for the degree of **Master of Science in Agriculture** in the subject of **Horticulture,** embodies bonafied research work carried out by **Mr. Shankar Lal Meena** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The draft of this thesis was also approved by the advisory committee on   /   /2015.

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CERTIFICATE-III

Dated: / / 2015

This is to certify that the thesis entitled **"Integrated Nutrient Management in Onion *(Allium cepa* L.) cv-N53"** submitted by **Mr. Shankar Lal Meena** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the subject of **Horticulture** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory; we therefore, recommended that the thesis should be approved.

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CERTIFICATE-IV

Dated: / /2015

This is to certify that **Mr. Shankar lal Meena** of the Department of **Horticulture,** Rajasthan College of Agriculture, Udaipur has made all corrections and modifications in the thesis entitled **"Integrated Nutrient Management in Onion *(Allium cepa* L.) cv-N53"** which were suggested by the external examiner and the advisory committee in the oral examination held on 04 /06 /2015. The final copies of the thesis duly bound and corrected were submitted on / /2015 are enclosed here with for approval.

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Enclosed one original and two copies of bound thesis forwarded to the Director, Resident Instruction, MPUAT, Udaipur, through the Dean, Rajasthan College of Agriculture, Udaipur.

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Integrated Nutrient Management in onion *(Allium cepa* L.) cv-N53

Shankar Lal Meena* **Dr. H. L. Bairwa**** **(Research Scholar)** **(Major Advisor)**

ABSTRACT

A field experiment entitled "**Integrated Nutrient Management in onion *(Allium cepa* L.) cv. N-53**" was conducted during the *rabi* season in 2014-15 at the Horticulture cum Instructional Farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, Rajasthan. The objectives of experimentation were to assess the effect of inorganics, organic sources, bio-fertilizers with reduced level of inorganic fertilizers on growth, yield and quality of onion and economics of the treatments and NPKS status of soil befor and after completion of crop. The experiment consisted of thirteen treatments.

The results were revealed that the application of 60 per cent recommended dose of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + *PSB* (T_{12}) recorded significantly maximum growth parameters in terms of plant height at 30, 60 and 90 DAP (19.24 , 29.71 and 41.94 cm) respectively, number of leaves per plant (3.27, 5.33, 7.60) and minimum bolting percent (2.25%) at 90 DAP followed treatment T_{13} by 40 percent recommended dose of NPKS + NC 9 q ha^{-1} + VC 30 q ha $^{-1}$ + *Azotobacter* + PSB.

Similarly, the yield components of onion viz., bulb diameter (5.20), fresh weight of bulb (52.32 g), yield per plot of bulb (16.05 kg) and yield per hectare (27.17 t) followed by treatment T_{13} with the application of 40 percent recommended dose of NPKS + NC 9 q ha^{-1} + VC 30 q ha $^{-1}$ + *Azotobacter* + PSB. The bulb yield of onion was increased 16.45 per cent over recommended dose of 100 % NPKS (120:60:60:40 kg/ha) through inorganic fertilizers.

The quality parameters were reaveled that the maximum value of TSS (15.19%), chlorophyll content of leaves at 90 DAP (0.76 mg), carbohydrate content

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(8.82%) dry matter content (16.39%), ascorbic acid (13.01 mg), protein content (6.10%), sugar content (6.70%) and pyruvic acid content (2.73 umol/100g) was achieved by combined application of 60 percent recommended dose of fertilizer of NPKS + NC (6q/ha) + VC (20q/ha) + *Azotobacter* + PSB (T_{12}). However, treatments $T_{4,}$ T_8 and T_9 were at par with each other in respect to quality parameters.

Similarly, the maximum uptake of NPKS (233.53 kg ha^{-1}, 52.78 kg ha^{-1}, 297.99 kg ha^{-1} and 238.03 kg ha^{-1}) was recorded in the treatment T_{12} (60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB), followed (229.51 kg ha^{-1}, 52.78 kg ha^{-1}, 290.14 kg ha^{-1} and 221.26 kg ha^{-1}) by T_{13} (60 percent recommended dose of fertilizer of NPKS + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB) in comparison of T_1 treatment (100 % RDF of NPKS 120:60:60:40 kg ha^{-1} through chemical fertilizers).

After final harvesting of onion, the maximum available nitrogen NPKS (195.21 kg ha^{-1}, 28.24 kg ha^{-1}, 265.90 kg ha^{-1} and 15.68 kg ha^{-1}), were resulted with the application of T_{12} treatment in comparison T_1. The application of integrated nutrients also improved the post harvest fertility status of the soil after harvest of the crop.

As far as economics is concerned, maximum net return of ₹ 325507 ha^{-1} and benefit cost ratio 3.97 was also recorded by the application of 60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB over recommended dose of NPKS (120:60:60:40 kg ha^{-1}) through chemical fertilizers.

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1. INTRODUCTION

Onion (*Allium cepa L.*) belongs to family Alliaceae, having chromosome 2n=16. Onion is the fore most widely cultivated bulb crop. It is an erect annual herb that can reach a height of 75-90 cm and grown during winter season.

Onion bulb is strongly contracted subterranean shoot with thickened, fleshy leaves as food organs and bulb is composed of carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and energy (38 cal). Biseds, vitamins like vitamin 'A' (0.012 mg), vitamin 'C' (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg), and minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) are also recorded per 100 g material (Anon, 1978). Onions have wider use in manufacture of soaps, ketchups, onion flakes (dehydrated) and food seasoning besides being used as salad and pickle. The smell and pungency is due to the oil known as "Allyal propyl disulphide". Extracts of onion are being used in the prevention of 'atherosclerosis' and 'coronary heart disease' as they can inhibit the aggregation of human blood platelets to form the clots, which have the potential for arterial blocking. It has properties of lowering blood sugar and lipid with good coagulation efficiency. The bulb is useful as diuretic and heart stimulant.

The primary centre of origin of onion lies in Central Asia. The Near East and the Mediterranean are the secondary centers of origin. It is an ancient crop have been utilized in medicine, rituals and as a food in Egypt and in India since 600 B.C. References of onion as food were also found in Bible and Quran. The genus Allium is very large with more than 500 species, which are perennial and mostly bulbous plants. Out of these, only seven species are in cultivation. However, *Allium cepa* (onion) and *Allium sativum* (garlic) are the two major cultivated species grown all over the world.

In India, onion occupies about 12.17 lakh hectare areas under cultivation with total production of 192.99 lakh MT (Anonymous 2014). Maharashtra is the leading producer of onions, contributing 31.6 per cent of the area and 32.9 per cent of the total country production followed by Gujarat and Karnataka. Other states growing onion are Orissa, Andhra Pradesh, Tamil Nadu and Madhya Pradesh .

In Rajasthan, Alwar is the leading producer of onion followed by Jhalawar, Bharatpur, Bheelwara, Jaipur, Tonk, Chitorgarh, Jhunjunu, Sikar etc.

Onion, being a nutrient loving crop, responds well to added fertilizers. The uses of inorganic fertilizer help in achieving maximum yield of onion. Among the major nutrients, nitrogen, phosphorus and potash play an important role in nutrition of onion plants in relation to growth, yield and quality of bulb. This might be due to beneficial role played by nitrogen in synthesis of protein through amino acid. Phosphorus play role in process of photosynthesis which ultimately leads to the accumulation of large amount of carbohydrates. Potash activates numerous enzymes affecting metabolic events and carbohydrates movement.

However, improper use of chemical fertilizers causing nutritional imbalance in the soil and lead to instability in productivity and causing hidden hunger besides depleting the nutritional quality of the vegetables. To maintain sustainability in quality production through integrated nutrient management can help to maintain the fertility of the soil (Palaniappan and Annadurai, 2000). Only alternative is an organic farming that avoids depletion of soil organic matter and plant nutrients besides suppression of certain insect-pests and diseases (Gaur, 2001). Organic manures not only balance the nutrient supply but also improve the physical and chemical properties of soil (Nair and Peter, 1990).

Organic farming is not new in India and is being followed from ancient times. It is a method of farming system which primarily aimed at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal, farm wastes and aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco-friendly, pollution free environment.

The plants absorb all the nutrients in the ionic forms irrespective of the sources through which they are supplied. The nutrients from the organic and inorganic sources differ only in their relative availability for crop. The nutrients release by organic manures are gradual, slow and would become available for longer duration due to its slow decomposition rate. It is true that the quality of the agricultural produces, particularly of vegetables, fruits etc. improve when the nutrients are supplied through organic manures than chemical fertilizers. This is because of the supply of enzymes, hormones and growth regulators from the organic source

Biofertilizers, which are eco-friendly and more economical can play an important role in reducing the dependence on chemical fertilizers. They activate beneficial microorganisms present in the soil, utilize atmospheric nitrogen for fixation in the soil and improve the availability and uptake of existing nutrients besides exerting other beneficial effects (Singh and Kalloo, 2000). Nevertheless, in the present situation of Indian agriculture, particularly looking at the availability of the organic manures and existing gap between the demand and supply of vegetables, organic farming could not be taken as a complete substitute for chemical fertilizers and pesticides. Rather organic sources should be used only as a supplement for partial replacement of the chemical fertilizer. Thus, an integrated nutrient management strategy for judicious combination of both organic and inorganic sources is the demand of the present era. It will be more economically viable and also help in attaining sustainability in production and maintaining soil health and eco-friendly environment.

Therefore, keeping in view the present investigation entitled "**Integrated Nutrient Management in Onion (*Allium cepa)* cv. N-53**'' was conducted with the following objectives:

(i) To find out the most effective treatment combinations for growth, yield and quality of onion.

(ii) To evaluate the efficacy of organic manure in combination with biofertilizers and inorganic fertilizers on growth, yield and quality of onion.

(iii) To evaluate the economic feasibility of different treatments.

2. REVIEW OF LITERATURE

A brief review of literature on important aspects pertaining to present study entitled "**Integrated Nutrient Management in Onion (*Allium cepa)* cv. N-53**" is presented in this chapter. An attempt has been made to cite all available literature on onion but due to paucity of adequate published information, research work on other crops has also been reviewed.

2.1 Application of organics

2.1.1 Growth parameters

Lal *et al.* (2002) reported that FYM @ 100 t ha^{-1} was found beneficial than other FYM levels and produced taller plant (49.4cm) with more leaves per plant (9.1) in onion.

Reddy and Reddy (2005) studied the effects of different levels of vermicompost (0, 10, 20 and 30 t ha^{-1}) on growth of onion (cv. N-53). The plant height, number of leaves per plant and leaf area increased significantly with increasing levels of vermicompost from 10 to 30 t per ha.

Kore *et al.* (2006) reported that plant height and number of leaves per plant in garlic were found maximum in the plants receiving nutrients @ 10 t FYM + 3 kg *Azotobactor* + 3 kg PSB + 75 per cent RDF ha^{-1}.

Patil *et al. (*2007) reported that the significantly higher plant height, number of seed stalks per plant in onion was recorded with the application of FYM @ 10, 15 and 20 t per ha than 5 t per ha.

Ngullie *et al.* (2009) recorded the higher plant height of onion with FYM @ 30 tonnes/ha (30.3-45.2 cm) compared to FYM @ 30 tonnes/ha + Azotobacter (26.3-41.7 cm) or pig manure @ 20 tonnes/ha (25.0-41.7 cm).

Jawadagi *et al*. (2012) reported that organic sources of nutrients, significantly increased plant height (29.05, 39.52, 48.06 and 50.83 cm) and leaf length (24.03, 28.06, 34.75 and 36.38 cm respectively at 30, 60, 90 DAT and at harvest) was recorded with 50 per cent FYM (12.5 t ha-1) + 50 per cent VC (2 t ha-1) +

biofertilizers as compared to 50 per cent FYM (12.5 t ha-1) + 50 per cent VC (2 t ha-1) + biofertilizers in onion cv. Bellary Red.

Kaswan *et al.* (2013) recorded the maximum plant height of onion with the application of 60 t FYM ha-$^{1.}$

Umrao *et al.* (2013) revealed that after 150 Days of sowing (DAS) maximum plant growth of garlic was observed with the application of FYM 2.9 kg per plot (66.08 cm) followed by combination of 50 per cent FYM + 50 per cent vermicompost (66.0 cm) in open conditions.

2.1.2 Yield and yield attributes

Jayathilake *et al.* (2003) obtained highest onion bulb yield (22.4%) with the application of *Azospirillum* + vermicompost + chemical fertilizers. A significant yield reduction was also observed when vermicompost was substituted with FYM in the same integrated nutrient management system.

Sharma *et al.* (2003) reported that application of FYM @ 10 and 20 t ha^{-1} increased onion bulb yield by 9 and 19 per cent over 100 per cent NPK alone, respectively.

Chander *et al.* (2005) recorded the highest yield of okra in the treatment comprising 100 per cent recommended NPK + vermicompost @ 10.0, 11.10 and 11.63 t ha^{-1} and maximum yield (14.67 t ha^{-1}) of onion was observed in plot receiving 100 per cent recommended dose of NPK + 25 t vermicompost.

Shashidhar *et al.* (2005) conducted an experiment at Belgaum district in Karnataka during 2002-03 to determine the effect of different organic manures (FYM, vermicompost, poultry manure, pressmud, sheep manure, Gliricidia and Sunnhemp) on the yield of garlic cv. BLG-1. The yield per hectare (73.48, 68.15 and 70.82 q ha^{-1}, respectively, during *kharif, rabi* and over two season) was maximum with the application of sunnhemp at 20 t ha^{-1}. However, it was at par with the application of poultry manure (2.5 t ha^{-1}) and vermicompost (5 t ha^{-1}).

Patil *et al.* (2007) reported that the combined application of 25 per cent RDF with 75 per cent N through FYM @ 20 t ha^{-1} gave higher marketable garlic bulb yield of 19.34 t ha^{-1} as compared to other treatments which were statistically at par with 100 per cent RDF (18.53 t ha^{-1}) and 50 per cent RDF + 50 per cent N supplied as FYM (18.94 t ha^{-1}).

Hari *et al.* (2009) recorded significantly higher onion (Arka Kalyan) bulb yield (202.85q ha-1) with the application of vermicompost @ 7 t ha^{-1} coupled with 75 per cent of recommended nitrogenous fertilizers.

The FYM application showed synergistic interaction effect on the uptake of S and ultimately on the bulb yield of garlic. Maximum bulb yield was obtained in the treatment where S was applied @ 40 kg ha^{-1} with 20 t FYM ha^{-1}.(Singh *et al.,* 2009).

Reddy *et al.* (2010) reported that the application of 10 t vermicompost ha^{-1} + 120 kg N ha^{-1} recorded significantly highest fresh onion bulb yields (24.45 t ha^{-1}).

2.1.3 Quality parameters

Sankar *et al*. (2005) reported that the organic treatment combination consisting of 3 per cent panchagavya + 50 per cent FYM + 50 per cent poultry manure registered the lowest postharvest loss (30.57%) in onion at 120 days after storage over onion grown with 100 per cent NPK (39.84%).

Bybordi and Malakouti (2007) obtained the highest ascorbic acid content 13.5 mg/100g) and protein content 1.49% in onion bulb with application of 6 t ha^{-1} vermicompost.

The total soluble solids, S and N contents in onion bulb were found significantly higher in 100 kg N + 20 t ha^{-1} FYM during both years and in pooled analysis compared to the rest of the treatments (Patel *et al*., 2008).

Hari *et al.* (2009) recorded the highest TSS (%) with application of VC @ 7 t ha^{-1} + 75 per cent RNF followed by application of NC @ 20 t ha^{-1} + 75 per cent RNF in onion cv. Arka kalyan.

Mohd *et al.* (2011) reported that 25 per cent RDF + 75 per cent through FYM showed maximum TSS and ascorbic acid content in garlic cv. GG-1 compared to other treatments.

Jamir *et al*. (2013) recorded the maximum TSS (13.18 °brix) and dry matter in onion (15.89%) with 50 per cent NPK + 50 per cent FYM. The same

treatment also produced the highest net return of Rs 1,29,260 ha^{-1} with cost-benefit ratio of 1:3.5.

Jawadagi *et al.* (2013) reported that application of 50 per cent FYM (12.50 t ha^{-1}) + 50 per cent VC (2 t ha^{-1}) + biofertilizers (*Azospirillum* and *PSB* @ 5 kg ha^{-1} each) with 15 cm x 10 cm spacing recorded maximum values 13.27, 13.36 and 49.28 per cent of TSS, dry matter and marketable bulbs in onion at 120 DAS.

Fresh weight of bulb, diameter of bulb, volume of bulb, bulb yield, TSS and pungency in onion were found maximum with the application of FYM@ 40 t ha^{-1} (Kaswan *et al.*, 2013).

2.2 Application of Inorganics

2.2.1 Growth parameters

Abdel-Fattah *et al.* (2002) reported that application of potassium chloride and potassium sulphate at 0, 48, 72 and 96 kg/feddan on garlic cv. Side-40 performance was evaluated in Egypt during 2000-01 and 2001-02. Potassium sulphate showed better effect than potassium chloride in improving plant height, neck diameter and leaf dry weight of garlic. The growth parameters increased with increasing fertilizer concentration.

Kumar *et al.* (2002) reported that growth of garlic was significantly increased with increasing level of N (0, 50, 100 and 150 kg ha^{-1}), P (0, 40 and 80 kg ha^{-1}) and K (0 and 60 kg ha^{-1}) during the *Rabi* season at Faizabad conditions. All the treatment significantly improved the growth of garlic compared with the control.

Abbey and Kanton (2003) reported plant height and bulb diameter were maximum with the application of NPK fertilizers in onion cv. Bawku Red.

Shrawan Singh *et al.* (2004) recorded the maximum plant height at harvest (152 cm), leaf length (29 cm), fresh weight of leaves (24.60 g) with application of 120 kg K per ha in onion cv-Pusa Red.

Maximum plant height and number of leaves per bulb were recorded in 120-75-75 kg ha^{-1} N P K in garlic cv. Baffa (Abbas *et al.*, 2006)

Combination of *AZT* + *PSB* +75 per cent RDF significantly increased plant height and leaf number of garlic (Gaiki *et al.*, 2006)

Gowda *et al.* (2007) recorded significantly higher plant height, more number of leaves and girth in garlic cv. G-282 with the application of 100 per cent NPK + biofertilizer + vermicompost and which was at par with the treatment combination of 100 per cent NPK + biofertilizer + farmyard manure.

Farooqui *et al.* (2009) observed that application of 200 kg nitrogen ha^{-1} significantly increased the plant height (cm), number of leaves per plant and neck thickness (cm) in garlic.

Chuda *et al.* (2009) revealed that application of 50 per cent NPK+50 per cent FYM recorded significantly higher plant height (45.45 cm), number of leaves per plant (12.67) and neck thickness (2.95 cm) in onion.

Bagali *et al.* (2012) reported that higher level of inorganics *viz.*, 162:32:148 kg NPK per ha significantly increased growth components like plant height (61.35 cm), number of leaves (8.11), leaf area (424.47sq.cm) and leaf area index (3.77) per plant in onion compared to other levels.

Bhandari *et al.* (2012) reported that maximum plant height (59.67cm), number of leaves per plant (8.96) and diameter of stem (1.52cm) in garlic was recorded with the application of 100:40:60 kg ha^{-1} NPK + 100 kg N ha^{-1} + *Azotobacter* + *PSB*.

Nori *et al.* (2012) observed the highest leaf length and number in garlic with 300 kg N ha^{-1}, while the lowest was with 100 kg N ha^{-1}.

The growth in terms plant height, number of leaves per plant, length and width of leaf, fresh and dry weight of plant and leaf area index were significantly superior under the treatment 75 per cent RDF + 5 t FYM/ha + *Azotobacter* + PSB over rest of the treatments in garlic (Pratap *et al.*, 2012).

2.2.2 Yield and yield attributes.

Tiwari *et al*. (2002) revealed that the application of 75 kg N ha^{-1} gave better yield than 100 kg N ha^{-1} in onion cv- Pusa Red.

Yadav *et al.* (2002) observed that application of 100 kg N and 150 kg k_2O ha^{-1} was ideal for obtaining higher bulb production of *kharif* onion when sets were planted at 22.5× 10 cm spacing in semi arid condition of Rajasthan.

Naik and Hosamani (2003) reported that application of 150 kg N ha^{-1} was optimum for enhancing yield (169.02 q ha^{-1}) of onion.

Jilani *et al.* (2004) recorded that maximum leaf length, cull percentage, individual bulb weight and total yield were highly significant at different levels of nitrogen in all three varieties of onion whereas, 120 kg N per ha proved to be the best for all the parameters studied.

Jahangir *et al.* (2005) reported that highest bulb weight (21.6 g) and yield in garlic (4.9 t/ha) were recorded with 100 kg N + 75 kg K ha^{-1}.

Singh and Singh (2005) reported that yield of garlic increased with increasing phosphorus levels upto 120 kg ha^{-1}, however, no significant difference was noted between 80 and 120 kg P_2O_5 ha^{-1}.

Kun *et al.* (2006) reported that pigment content, net photosynthesis rate, fresh and dry weight of garlic increased with K concentrations.

Chattoo *et al.* (2007) reported that application of 100 kg N + 60 kg P/ha enhanced yield attributes in garlic. The effects were much more pronounced when *Azotobacter* + *phosphobacteria* was applied in conjuction with 75 kg N + 45 kg P ha^{-1}, resulting in a fertilizer savings of 25 per cent without affecting the crop yield.

Nasreen *et al.* (2007) found that the highest yield of onion and the maximum uptake of N and S were recorded by the combined application of 120 kg N and 40 kg S ha^{-1} with a blanket dose of 90 kg P_2O_5, 90 kg K_2O, and 5 kg Zn ha^{-1} + 5 t ha^{-1} cowdung.

Yadav *et al.* (2007) recorded significantly highest bulb yield of garlic with the combined application of 150 kg N and 150 kg of K_2O ha^{-1} (the bulb yield increased 6.9 t ha^{-1} with this treatment over control).

The highest bulb yield of onion (34.70 t ha^{-1}), dry matter yield (5.46 t ha^{-1}) and protein content (6.95%) was obtained with 100 per cent NPK + 10 t ha^{-1} FYM. The uptake of N, P and K was highest under 100 per cent NPK + 10 t ha^{-1} FYM. The available N, P, K, S and Zn status of the soil decreased appreciably in the control. The application of farmyard manure and chemical fertilizers individually and in combination increased the available N by 21.6 - 88.3 kg ha^{-1} over the control. The soil available P increased by 2.6-10.0 kg ha^{-1}. Similarly, soil available K recorded an increase of 24.1-66.1 kg ha^{-1} (Singh *et al.,* 2008).

Trani *et al.* (2008) reported that maximum total yield 8689 kg ha^{-1} in garlic was obtained with 107 kg N ha^{-1}.

Adagale *et al.* (2010) recorded higher yield contributing characters under the application of 150 per cent RDF (150:75:75kg/ha) + FYM (20 t/ha) + biofertilizer in onion cv. Phule Samarth.

Singh *et al.* (2012) reported that 50 per cent RDF + 25 t FYM ha^{-1} was found superior with respect to bulb yield, quality and benefit cost ratio for the garlic var. Yamuna Safed-2 (G-50) under Allahabad agro-climatic condition

Kumar *et al.* (2013) reported that 25 per cent RDF organic + 75 percent RDF inorganic recorded higher number of cloves, length of largest clove (cm), diameter of bulb (cm), bulb yield and nutrient uptake of NPK as compared to other treatments in garlic.

Shinde *et al*. (2013) reported that plant receiving 110:40:60:40 kg NPKS+7.5 t FYM + 2.5 t poultry manure + 2.5 t vermicompost + biofertilizer (5 kg each of *Azospirillum* + *Posphobacteria*) ha^{-1} recorded the highest bulb yield of onion (57.61 t ha^{-1}) compared to control (35.82 t ha-1).

2.2.3 Quality parameters

Naruka *et al.* (2002) observed maximum values for moisture, protein, nitrogen, potassium, sulphur, ascorbic acid and volatile oil contents in garlic bulb with the application of 200 kg N ha^{-1}.

Pant *et al.* (2012) recorded that the N fertilization decreased bulb dry matter content about 4% over the control and pungency measured as pyruvate concentration improved with increase in the rate of N application and reached the highest value of 2.72 µmol ml^{-1} at the rate of 138 kg N ha^{-1} but the highest level of N or P fertilizer caused the highest cumulative weight loss. It was also observed that bulb sprouting percentage of 63 and 53% were recorded from treatments that received 69 and 40 kg P.

Rizk *et al*. (2012) significantly recorded the highest values of minerals and protein content of onion, when supplied with nitrogen + phosphorus at a higher rate of 90 + 45 kg ha^{-1}.

Shiferaw *et al*. (2014) reported that combined applications of 92 kg N + 40 kg P + 30 kg S ha^{-1} and 138 kg N + 40 kg P + 60 kg S ha^{-1} prooved to optimum quality attributes of garlic bulb on Andosol and Vertisol, respectively. However, the application of 92 kg N + 40 kg P + 30 kg S ha^{-1} was found to be economical.

2.3 Application of Organics and Inorganics

2.3.1 Effect on Growth Parameters

Devi and Limi Ado (2005) studied that the combination of *Azospirillum*@ 2 kg $ha\text{-}^{1}$ and *phosphatika* @ 2 kg $ha\text{-}^{1}$ with 75 kg N and 45 kg P_2O_5 per ha resulted in the maximum leaf area index (1.91), net assimilation rate (0.166 g per cm), dry matter (11.07%), growth efficiency rate (50.9) at 60 days after planting in onion crop.

Mahanthesh *et al.* (2008) found that the plants provided with *Azospirillum* + 100 per cent N + PK (125:50:125 kg ha^{-1}) recorded the greatest plant height, highest number of leaves, neck thickness, bulb diameter under irrigated conditions during both *kharif* and *rabi* seasons in onion cv. Bellary Red.

Sridevi and Ramakrishnan *et. al.* (2010) found that the two beneficial microbes (*Arbuscular mycorrhizae* and *Azospirillum*) played a vital role in supplying N and P to the onion and enhanced the growth and yield over the untreated control.

2.3.2 Effect on Yield parameters

Gunjan *et al.* (2005) observed that the treatment combination of 100 kg N + *Azotobacter* as seedling dip gave the highest bulb yield and fresh weight of bulb in onion cv. Puna Red.

Yadav *et al.* (2005) reported that the maximum bulb yield was found with the treatment combination of 75 per cent recommended P_2O_5 + *Azospirillum* biofertilizer application.

Gowda *et al.* (2007) reported that the maximum fresh weight and dry weight of the bulb, and bulb yield in the garlic with the application of 100 per cent NPK + *Azospirillum* + *PSB* + *Trichoderma viridae* + vermicompost (6.25 t ha^{-1}).

Yadav *et al.* (2007) concluded that 75% recommended dose of nitrogen alongwith Azospirillum application gave significantly highest of onion bulb yield (328.4 q ha^{-1}) and net return of Rs. 31,287 ha^{-1} with a B:C ratio of 1:10.

Mahanthesh *et al.* (2008) reported that plants inoculated with *Azospirillum* + 100 per cent N + P K (125:50:125 kg ha^{-1}) recorded that the highest bulb weight and yield (250.29 and 330.02 q ha^{-1}, respectively) under irrigated conditions during both *kharif* and *rabi* seasons in onion cv. Bellary Red.

Singh and Singh (2009) recorded that the individual bulb weight and bulb yield were significantly higher with FYM at 30 t ha^{-1} (40.0 g per bulb and 140.0 t ha^{-1}) compared to rest of the treatments (24.5-34.9 g per bulb and 85.7-122.1 t ha^{-1}) and control (19.9 g per bulb and 69.8 t ha^{-1}).

Basavaraj *et. al.* (2012) recorded that the highest bulb weight, bulb yield as well as net returns and B : C ratio with the application of RDF (125:50:125 NPK kg ha^{-1}) + FYM (30 t ha^{-1}) followed by the application of 50% FYM (12.50 t ha^{-1}) + 50% VC (2 t ha^{-1})+Bio fertilizers in both *rabi* and *kharif*.

2.3.3 Effect on Quality parameters

Maximum TSS (4.3 Brix), vitamin-C (24.93 mg 100 g^{-1}) and nutrient uptake (134.3 N kg ha^{-1}, 17.59 P kg ha^{-1} and 232.59 K kg ha^{-1}) were recorded with 50 per cent NPK + 50 per cent FYM + biofertilizers in radish as compare to 100 per cent NPK under the foothill condition of Nagaland (Sentiyangla *et al.* 2010).

Chumyani *et al.* (2012) reported maximum fruit yield (486.89 q ha^{-1}), vitamin C (56.73 mg 100^{-1} g of fruit) and TSS (5.07 Brix) with 50 per cent NPK + 50 per cent FYM + biofertilizers in tomato.

Yogita Ram and R. B. (2012) found maximum ascorbic acid, reducing sugar and total sugars with the application of (100 kg N + 50 kg P + 70 kg K ha^{-1} + 2 kg ha^{-1} *Azotobacter* + 2 kg ha^{-1} *Phosphobacteria*) in onion.

Nitrobeine as a single or as mixture with bio fertilizers resulted in an increase in plant growth, yield and its components. Other benefits of these treatments include reduction in cost of chemical fertilizers, and reduced contamination with nitrate content in onion (Abo-Sedera *et. al*. 2012).

The quality parameters viz. TSS (7.00 Brix), total sugars (2.627 g), reducing sugar (0.470 g) and Vitamin-C (22.77 mg per 100 g) were recorded under 25 per cent RDF + 75 per cent Neem cake in tomato (Kashyap *et al.*, 2014).

After going through the review of literature it becomes clear that the use of manure and inorganic fertilizers particularly N, P, K, FYM and vermicompost along with neem cake improving the growth, yield and quality of various vegetable crops have been attempted by several research workers in the different part of the country and abroad. However, the beneficial effect of organic manures and fertilizers on growth, yield and quality of onion has not yet been fully exploited on the commercial scale.

3. MATERIALS AND METHODS

The present investigation on **"**Integrated Nutrient Management in Onion (*Allium cepa*) cv-N53" was carried out during the year 2014 and 2015 in the experimental field of department of Horticuture, at RCA, MPUAT Udaipur, (Rajasthan) India. The details of the experiment performed, materials used and techniques employed for studies have been described briefly.

3.1 EXPERIMENTAL SITE:

The experiment was laid out at Hortculture farm, Department of Horticulture, Rajasthan College of Agriculture, Udaipur, which is situated at $24^0$34 N latitude and $73^0$42 E longitudes at an elevation of 585.5 meters above mean sea level. The region falls under agro climatic Zone IV A (Sub-humid Southern Plain and Aravali Hills), of Rajasthan. The field had fairly leveled topography and clay loam texture.

3.2 CLIMATE AND WEATHER CONDITIONS

The climate of this zone is typically semi-arid and subtropical, characterized by mild winter and moderate summers associated with high relative humidity during the month of July to September.

The average rainfall of this tract ranges from 650 mm to 750 mm, out of which 90 per cent is received during July to September and sometimes scanty showers during winter months.

Weather, the non-monetary input influences the growth, yield and quality of crops as well as biotic phase of soil during the growing season; hence, it is important to present climatic variables in this context. The weather parameters were weekly recorded during the crop period at the meteorological observatory, presented in Table 3.1 and depicted in Fig. 3.1. The maximum temperature ranged between 21^0C to 37.9^0C while minimum temperature ranged between 4.8^0C to 22.2^0C during onion crop season (October to April) 2014-15. The minimum and maximum relative humidity varied between 14.4 to 91.3 per cent and total rainfall received during the crop season (October to April) 2014-15 was 65.8 mm.

Table 3.1 Mean weekly meteorological observations during experimental period (Oct. 2014 to Apr, 2015)

Standard Meteoro-logical week	Period	Temperature (^{0}C)			Relative Humidity (%)			Rainfall (mm)
		Max.	Min.	Mean	Morning	Evening	Mean	
42	15 Oct-21 Oct	32.5	17.6	25.05	75.6	32.4	54	0.0
43	22 Oct- 28 Oct	33.2	16.6	24.9	69.6	22.4	46	0.0
44	29 Oct- 4 Nov	31.4	18.4	24.9	71.4	31.9	51.65	0.0
45	5 Nov-11 Nov	31.5	15.6	23.55	76.6	31.4	54	0.0
46	12 Nov-18 Nov	29.5	15.4	22.45	74.4	36.7	55.55	11.0
47	19 Nov-25 Nov	29.7	12.1	20.9	76.3	27.0	51.65	0.0
48	26 Nov-2 Dec	30.7	12.3	21.5	79.3	23.9	51.6	0.0
49	3 Dec-9 Dec	27.2	10.4	18.8	75.4	25.9	50.65	0.0
50	10 Dec-16 Dec	24.6	7.6	16.1	79.9	29.0	54.45	0.0
51	17 Dec-23 Dec	22.6	5.0	13.8	86.9	31.4	59.15	0.0
52	24 Dec-31Dec	22.9	4.8	13.85	84.1	26.9	55.5	0.0
1	1 Jan.- 7Jan	21.8	8.8	15.3	90.4	43.4	66.9	3.2
2	8 Jan.-14 Jan	27.4	7.7	17.55	85.7	25.1	55.4	0.0
3	15 Jan - 21 Jan	22.8	6.9	14.85	91.3	36.0	63.65	6.0
4	22 Jan - 28 Jan	21.0	9.1	15.05	88.1	52.4	70.25	6.2
5	29 Jan - 4 Feb	25.2	6.9	16.05	86.9	28.6	57.75	0.0
6	5 Feb -11 Feb	25.3	8.6	16.95	87.9	36.6	62.25	0.0
7	12 Feb - 18 Feb	29.8	10.6	20.2	78.9	30.7	54.8	0.0
8	19 Feb -25 Feb	32.5	13.7	23.1	78.4	30.6	54.5	0.0
9	26 Feb - 4 Mar	25.0	10.3	17.65	76.9	33.0	54.95	13.2
0	5 Mar -11 Mar	28.0	11.3	19.65	76.7	27.6	52.15	0.0
11	12 Mar - 18 Mar	28.6	14.0	21.3	79.4	30.4	54.9	10.6
12	19 Mar - 25 Mar	33.8	15.9	24.85	68.6	24.7	46.65	0.0
13	26 Mar - 1 Apr	36.3	19.5	27.9	66.1	19.4	42.75	0.0
14	2 Apr- 8 Apr	34.1	21.7	27.9	53.9	25.7	39.8	0.0
15	9 Apr- 15 Apr	32.6	18.5	25.55	60.9	30.9	45.9	15.6
16	16 Apr -22 Apr	37.9	22.2	30.03	37.0	14.4	25.7	0.0

3.3 CROPPING PERIOD

The experiment was started in *Rabi* season October 2014 and completed in April 2015.

3.4 SOIL CHARACTERISTICS OF THE EXPERIMENTAL FIELD

In order to determine the physical and chemical properties and fertility of experimental soil, the soil samples were taken randomly from different spots in the field at the depth of 0-30 cm before experimentation. A representative soil sample was prepared and subjected to mechanical, physical and chemical analysis. The results of soil analysis along with methods used for determination are presented in Table 3.2.

The result of the analysis showed that the soil of the experimental field was clay loam in texture, slightly alkaline in reaction, medium in organic carbon, low in available nitrogen and medium in available phosphorus and potassium.

Table 3.2 Physico-chemical properties of the experimental soils

Characteristics of the soil	*Method of analysis*	**Reference**
A. Mechanical (i) Coarse sand (%) (ii) Fine sand (%) (iii) Silt (%) (iv) Clay (%)	International pipette method	Piper (1950)
B. Physical		
(i) Bulk density (mgm^{-3})	Core sampler	Piper (1950)
(ii) Particle density (mgm^{-3})	Core sampler	Black (1965)
(iii) Porosity (%)	Core sampler	Black (1965)
C. Chemical		
(i) Available nitrogen ($kg\ ha^{-1}$)	Alkaline $KMnO_4$ method	Subbiah and Asija (1956)
(ii) Available phosphorus ($kg\ ha^{-1}$)	Olsen's method	Olsen *et al.* (1954)
(iii) Available potassium ($kg\ ha^{-1}$)	**FLAME PHOTOMETER METHOD**	**JACKSON (1973)**
(iv) Available sulphur ($kg\ ha^{-1}$)	Turbidimetric method	Tabatabi (1970)
(v) pH (1:2 Soil water ratio)	Blackman's pH method	
D. Bulb analysis		
(i) Total nitrogen ($kg\ ha^{-1}$)	Micro Kjeldhal's method	**JACKSON (1973)**
(ii) Total phosphorus ($kg\ ha^{-1}$)	Vanadomolybdate phosphoric acid yellow colour method	**JACKSON (1973)**
(iii) Total potassium($kg\ ha^{-1}$)	Flame photometer method	**JACKSON (1973)**
(iv) Total sulphur ($kg\ ha^{-1}$)	Turbidimetric method	Tabatabi (1970)

Table 3.3 Treatments detail with their symbol.

S.No.	Treatment combination	Notation
1.	100%RDF(NPKS 120:60:60:40 Kg/ ha^{-1})	T_1
2.	NC (6q/ha) + VC (30q/ha) + *Azotobacter* + PSB (sole organic)	T_2
3.	NC(6q/ha) + VC (30q/ha)	T_3
4.	60% RDF of NPKS + NC(6q/ha)	T_4
5.	40% RDF of NPKS + NC (9q/ha)	T_5
6.	60% RDF of NPKS + VC (20q/ha)	T_6
7.	40% RDF of NPKS + VC (30q/ha)	T_7
8.	60% RDF of NPKS + NC(6q/ha) + VC (20q/ha)	T_8
9.	40% RDF of NPKS + NC (9q/ha) + VC (30q/ha)	T_9
10.	60% RDF of NP&100%KS + *Azotobacter* + PSB	T_{10}
11.	40% RDF of NP&100%KS + *Azotobacter* + PSB	T_{11}
12.	60% RDF of NPKS + NC(6q/ha) + VC (20q/ha) + *Azotobacter* + PSB	T_{12}
13.	40% RDF of NPKS + NC (9q/ha) + VC (30q/ha) + *Azotobacter* + PSB	T_{13}

* RDF- Recommended Doses of Fertilizer through inorganic fertilizer

* VC- Vermicompost

* NC- Neem cake

3.5 TREATMENTS DETAILS:

The experiment consisted of 13 treatments in combinations of recommended dose of fertilizers and organic manures along with biofertilizers. The various treatments with their symbols are presented in Table 3.3

3.6 EXPERIMENTAL DESIGN AND LAYOUT

The experiment was laid out in randomized block design with three replications. The treatments were randomly allotted to different plots using random number table of Fisher and Yates (1963).

	Crop	:	Onion
1.	Variety	:	N-53

2.	Spacing (R X P)	:	15 × 10 cm.
3.	Treatments	:	13
4.	Site of experiment	:	Horticulture Farm, RCA Campus
6.	Experimental design	:	Randomized Block Design
7.	Plot size	:	3 × 2 m. (6 m^2)
8.	Planting time	:	October, 2014
9.	Replications	:	3

3.7 RAISING OF THE EXPERIMENTAL CROP

The schedules of different pre and post sowing operation carried out during the crop season and details of crop raising are described as under :

3.7.1 Field preparation

The experimental field was thoroughly ploughed and cross-ploughed with the help of mould board plough and cross harrowing was done with tractor and the soil was brought to a good tilth. The beds of 3 x 2 m^2 size were prepared, paths and channels were also prepared as per layout.

3.7.2 Nursery raising

For raising a crop for bulb production, onion seeds were sown on nursery beds to raise seedlings for transplanting in the main field. Raised beds of about 3 meter long, 1 meter width and 15cm above the ground level were prepared. The nursery beds were well manured with farmyard manure @ 20 kg per bed. Seeds were sown on well prepared beds in lines with a spacing of 10 cm apart and covered with soil. Seed beds were irrigated regularly with the help of watering can. Seed sowing was taken in October 2014 *(rabi)*. The seedlings were ready within eight weeks for transplanting.

3.7.3 TRANSPLANTING

The field was well prepared and manured with the incorporation of vermicompost and neemcake as per the individual treatment at the time of transplanting. At transplanting, the main field was marked and made furrows 15 cm in row to row and 10 cm in plant to plant. Eight weeks old healthy seedlings were dipped in bio fertilizers *Azotobacter* @ 2 kg per ha and P-solubilizing bacteria @ 2 kg per ha and transplanted in main field on 3rd December 2014.

3.7.4 Treatment application

(i) Inorganic fertilizers

The recommended dose of NPKS for onion in this zone (Sub-Humid Southern Plain and Aravali Hills IV-A) is 120:60:60:40 kg ha^{-1}. As per treatment combination nitrogen was applied through urea. Phosphorus and potash was applied through single super phosphate and muriate of potash respectively. Full dose of phosphorus, potassium and sulphur and half dose of nitrogen were applied as basal dose just before sowing and rest half dose of nitrogen was applied as top dressing in two split doses as per treatment.

(ii) Organic mannure

The dose of NPKS through vermicompost and neem cake was supplemented as basal dose before transplanting of onion seedling as per treatments. The nutrient composition of used organic manures were as follows. .

S. No.	**Source**	**Nutrient composition**		
		% N	**% P**	**% K**
1.	Neem cake	3.0	1.0	1.0
2.	Vermicompost	0.70	0.60	0.75

(iii) Biofertilizers

The biofertilizers, Azotobacter and PSB powder were treated with onion seedling and after that transplanting is done as per treatment. The inoculants population used biofertilisers were as follows.

S.N.	Biofertilizers	Inoculant Population
1.	*Azotobacter chroococcum*	4.5 $X10^{8}$ (colony forming unit/g)
2.	PSB	51.75 X 10^{8}(colony forming unit/g

3.8 CULTURAL DETAILS

3.8.1 Irrigation, weeding and hoeing

For the establishment of the crop, first light irrigation was given just after planting of seedling than subsequent irrigations were given at 10 days interval and irrigation was withheld before 10 days of harvesting. Onion is a shallow rooted crop, therefore shallow hoeing was done twice or thrice for weed control. Hand weeding was also done as and when required. Earthing up was done immediately after bulb planting and 35 days after bulb planting as required by the crop.

3.8.2 Plant protection measures

In order to protect the crop from insect pest and diseases standard methods of plant protection were followed whenever needed.

3.8.3 Harvesting

Harvesting was done manually by hand digger when the top turned yellow or brownish and exhibited sings of drying up and bend over. The harvested bulb along with tops were weighed and subjected to other observations**.**

3.9 CHARACTERS STUDIED AND TECHNIQUES OF STUDY

3.9.1 Vegetative growth attributes

(i) Plant height (cm) at 30, 60 and 90 DAP

Five plants were selected randomly in each plot and tagged. Plant height was measured from the ground level to the top of the highest leaf at 30, 60 and 90 DAP. The meter scale was used to measure the height.

(ii) Number of leaves per plant at 30, 60 and 90 DAP

Five plants were selected randomly in each plot and tagged. Total number of leaves was counted from selected and tagged plants at 30, 60 and 90 days after planting.

(iii) Crop maturity (days)

When top of the onion plants turned yellow and fully dried, date was recorded in every plot and days to maturity were counted from the date of sowing.

(iv) Bolting (%)

It is the ratio of bolted plant to the total number of the plant which was worked out by following formula and expressed in percentage.

$$\text{Bolting (\%)} = \frac{\text{Bolted plant / plot}}{\text{Total no of the plant/plot}} \times 100$$

3.9.2 Yield attributes

(iii) Bulb length (cm)

Length of bulb was measured with the help of vernier calipers from five randomly selected plants and average length was measured in centimeter.

(ii) Bulb diameter (cm)

Diameter of bulb was measured with the help of vernier calipers from five randomly selected plants and average diameter was measured in centimeter.

(iii) Bulb weight (g)

Weight of five randomly selected bulbs recorded in 'g' by weighing in double pan balance. Average fresh weight was calculated.

(iv) Bulb yield per plot (kg)

The bulbs harvested from each plot were weighed separately and recorded in kilogram (kg).

3.9.3 Quality attributes

(i) TSS (^{o}Brix)

The total soluble solids (TSS) content of bulb was measured by the digital Zeiess Hand Refrectometer (0-50) and value obtained was corrected at 20^{0}C (A.O.A.C., 1984).

(ii) Protein content (%)

Estimation of nitrogen was done by colorimetric method as suggested by Snell and Snell (1949) using the Spectronic-20 (Model SL-177). The details of procedure followed are mentioned here as under:

- Take 0.1 g well ground and dried sample and transfer into a 100 ml dry Kjeldahl flask carefully so that it should not stick to the neck.
- Add 5ml concentrated H_2SO_4 to the Kjeldahl flask. Place on the digestion assembly and heat it till the plant material is digested.

- Cool the flask and add 0.5ml (10 drops) of 30% H_2O_2 and again heat the content of flask. If it does not become colourless then again add 3-4 drops of H_2O_2 and heat it. Repeat this till it becomes clear and colourless.
- Transfer the digested content of the kjeldahl flask into a 100 ml volumetric flask by washing it 2-3 times with distilled water and make the volume.
- Take 5 ml of digested solution into a 50 ml volumetric flask and few ml of water. Then add 2ml of 10% NaOH and 1 ml of 10% sodium silicate solution and then add some water. Mix the content and add 1.6 ml Nessler's reagent to the flask while shaking. After this, make it volume.
- Take the reading of standard working solution using blue filter or adjusting the spectrophotometer at a wave length of 420 nm. Plot the concentration of N on X- axis and the colorimeter reading on Y- axis and prepare a standard curve
- Now take the reading of plant sample and calculate the ppm N with the help of standard curve.

Concentration of N present in bulb sample is calculated by this formula:

Dilution factor = 100/0.1 × 50/5 = 10,000

Concentration of N in ppm = ppm N from standard curve (R) × 10,000

Weight of bulb sample = 0.1 g

Volume of digested material = 100 ml

Volume of extract taken = 5 ml

Final volume prepared = 50 ml

The amount of crude protein in bulb was calculated in per cent. The formula used for calculating the protein is as under:

Protein % = Nitrogen % × 6.25*

*This is based on the assumption that plant protein contains 16 per cent nitrogen.

(iii) Total sugars

Total sugars content was determined by using anthrone reagents method. To 1 ml of diluted sample (100 times), 4 ml of anthrone reagent was added, then heated for 10 to 15 minutes on a water bath, cooled to room temperature and absorbance was measured at 630 nm on spectrophotometer (Double beam SL 210 UV Visible Spectrophotometer, Ellico, Hyderabad, India). The amount of sugars present in the sample was plotted against standard curve prepared from glucose. The value was expressed in terms of percentage.

(iv) Chlorophyll content of leaves (mg / g fresh weight)

Chlorophyll content was measured as per method suggested by Sadasivam and Manickam (1997). The details of procedure followed are mentioned here as under:

(a) 1 g of fresh cut leaves of onion was weighed and ground using 20 ml volume of acetone into a clean mortar with pestle.

(b) The sample was centrifuged at 5000 rpm for 5 min. and the supernatant was transferred to a100 ml volumetric flask.

(c) The process of centrifuging was repeated until the appearance of colourless residue. The mortar and pestle were washed thoroughly with 80 per cent acetone to get the clear extract of leaves.

(d) The volume was made up 100 ml with 80 per cent acetone.

(e) The absorbance of the solution was read at 645, 663 and 652 nm against the blank solution of 80 per cent acetone with the help of Spectrophotometer (Model: Double Beam UV-VIS spectrophotometer UV5704SS)

(f) The amount of chlorophyll present in the extract was calculated using the following equations:

Chlorophyll (a) mg/g tissue = 12.7(A663) – 2.69 (A645) x V/1000 x W

Chlorophyll (b) mg/g tissue = 22.9(A645) – 4.68(A663) x V/1000 x W

Total Chlorophyll mg/g tissue = 20.2(A645) + 8.02 (A663) x V/1000 x W

Where-

A = Absorbance at specific wave length

V = Final volume of chlorophyll extract in 80 per cent acetone

W = Fresh weight of tissue extracted

(v) Physiological loss in weight (%) during storage

The weight of the bulbs was recorded on 10, 20, and 30 days after storage (DAS) using an electronic balance. The cumulative loss in weight of the bulbs was calculated and expressed as per cent physiological loss of weight using the formula given below.

$$\text{PLW (\%)} = \frac{P_0 - P_1 \text{ or } P_2 \text{ or } P_3}{P_0} \times 100$$

Where,

P0 = Initial weight

P1 = Weight after 10 days

P2 = Weight after 20 days

P3 = Weight after 30 days

(vi) Nutrient uptake by bulb

The bulb samples collected at harvest were cut into pieces, after air drying, the samples were oven dried at 70°C and ground in a Wiley mill to pass through two mm sieve. The sieved samples were preserved in polythene bags and used for the estimation of nitrogen, phosphorus potash and sulphur uptake by the bulbs.

Analysis of bulb samples

The predigested samples were treated to determine the nitrogen content in plant samples, 0.5 g of plant sample was treated with concentrated sulphuric acid and digested with digestion mixture ($CuSO_4$ + K_2SO_4 + Selenium powder). After complete digestion, contents were transferred to volumetric flask and volume was made up to 100 ml. A known amount of aliquot was transferred to distillation unit (microkjeldhal) 40 per cent NaOH was added to make the contents alkaline. The liberated ammonia was trapped in boric acid-mixed indicator solution, which was treated against standard acid. For phosphorus and potassium determination, powdered samples were treated with HNO3 for pre-digestion diacid (HNO_3 : $HCLO_4$; 10:4 ratio) mixture and digested on a Tecator digestion unit. After the completion of digestion, the tubes were cooled and volume was made up to 100 ml using 6 N HCl. The methods followed for the estimation of N, P, K, and S is presented in Table 3.2.

(vii) Drymatter content (%)

Dry matter content was calculated by the given formula.

$$\text{Dry matter content (\%)} = \frac{\text{Weight of bulb after oven drying}}{\text{Fresh weight of bulb}} \times 100$$

(viii) Pyruate content (μ mol/100g)

The pyruvate content was estimated by Schwimmer and Weston method (1961). It was simple and widely used, the determination of pyruvic acid by reaction with DNPH has problems. Onions were sliced in half longitudinally and the outer skin and ends were removed. One half of the onion was homogenised for 1 min in a Waring blender at a ratio of 1 ml of added water per gram of onion. The homogenate was allowed to stand for 10 min at room temperature, then filtered through two layers of cheesecloth. An aliquot of this filtrate was transferred to a 1.5 ml centrifuge tube and clarified by centrifugation at 10000 × g for 5 min. We have subsequently determined that this centrifugation step can be omitted if the sample is to be analysed by the colorimetric procedures described below. The other half of the onion was placed in a plastic bag and microwaved (microwave power equal to 1200 W) for 1 s per gram of onion weight. After standing for about 20 min to allow the sample to cool, the onion half was transferred to a blender and water was added to bring the total weight to twice the original fresh weight and after that 25 ml of the clarified onion filtrate was added to 1.0 ml of water in a 13 mm × 100 mm test tube with a Drummond positive displacement pipetter. To this was added 1.0 ml of 0.25 g l^{-1} DNPH in 1 M HCl and the samples were placed in a 37 ◦C water bath. After 10 min the samples were removed from the water bath and 1.0 ml of 1.5 M NaOH was added. The absorbance at 515 nm was then determined. A blank and standards were prepared by adding 25 μl of sodium pyruvate solutions, ranging in concentration from 0 to 8 mm, instead of the onion sample.

(xi) Ascorbic acid (mg/100g)

Ascorbic acid content of onion was determined by diluting the known volume of crash clove juice filtered through muslin cloth and with 3 per cent appropriate volume metaphosphoric acid. 10 ml of aliquot was titrated against 2,6- dichlorophenol indophenol dye solution till a stable light pink colour appeared. The results were expressed as mg ascorbic acid/100 g bulb. For recording ascorbic acid content standardization of dye solution was done as under:

Standardization:

Standardization of 2, 6- dichlorophenol indophenol dye was done by titrating against standard ascorbic acid solution. The standard ascorbic acid solution was prepared by dissolving 100 mg of L- ascorbic acid in 3 per cent metaphosphoric acid and 1 ml was used for titration.

The ascorbic acid content of fruit was calculated using following formula:

$$\text{Ascorbic acid (mg/100 ml juice)} = \frac{\text{Titre (ml) x Dye factor x Volume made up (ml)}}{\text{Aliquat (ml) taken for estimation x Volume of pulp (ml)}} \text{ x } 100$$

3.9.4 Soil analysis

(i) Soil samples

Composite soil samples using tube auger were collected, from 0-15 cm depths, from all the plots before sowing and after final harvest of garlic crop.

Method of analysis

The available N content in the soil was determined by alkaline permanganate method (Subhiah and Asija, 1956), available phosphors by Olsen's method (Olsen *et al.*, 1954) and available potassium by Flame photometer method (Jackson, 1973),

3.10 ECONOMICS OF THE TREATMENT

The relative economics of different treatments were estimated on the basis of cost of treatment and yield per hectare. The net income was calculated by subtracting the treatment cost from gross income. It was expressed on net excess income over control.

Gross return (₹. ha^{-1}) = Return from bulb yield

Net return (₹. ha^{-1}) = Gross return-Total cost of cultivation (Rs ha^{-1})

$$\text{B:C ratio} = \frac{\text{Net return (` ha}^{-1}\text{)}}{\text{Total cost of cultivation (` ha}^{-1}\text{)}}$$

3.11 STATISTICAL ANALYSIS

To test the significance of variation in the data obtained from various growth, yield and quality characters the technique of analysis of variance was adopted as suggested by Fisher (1950) for randomized block design. Significance of difference in the treatment effect was tested through ‘F’ test at 5 % level of significance and CD (critical difference) was calculated wherever the results were significant. The analysis of Tables for all the data discussed is given (Appendix I-IX) at the end.

4. EXPERIMENTAL RESULTS

The results of the field experiment entitled "**Integrated Nutrient Management in onion *(Allium cepa* l.) cv. N-53"** conducted in winter season during 2014-15 at Instructional Cum Horticulture Farm, Rajasthan College of Agriculture, Udaipur, are presented in this chapter. The data pertaining to the effect of different treatments on growth, yield, quality parameters and soil nutrients status, economics, & storage studies were statistically analyzed for test of significance of the results. In addition to tabular presentation data, depicted through graphs has also been done for better understanding. The results of various treatments for different characters are presented in relevant tables. The analysis of variance for different characters is given in the appendices (I to XI).

4.1 VEGETATIVE GROWT CHARACTERS

The data on vegetative growth characters e.g. plant height, number of leaves per plant, days for harvesting of bulb and bolting percent were recorded and presented in Table-4.1, 4.2 and 4.3 and Fig-4.1, 4.2 and 4.3.

4.1.1 Plant height (cm)

A perusal of data (Table-4.1 and Fig-4.1) revealed that application of plant nutrients through inorganic, organic manures and bio-fertilizers showed significant variation in plant height at 30, 60 and 90 DAP in onion cv-N53.

It is evident from the data that maximum plant height at 30, 60 and 90 DAP (19.24 , 29.71 and 41.94 cm) was recorded with application of 60 per cent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + *PSB* (T_{12}), followed by (18.98, 29.68 and 41.84 cm) 40 per cent recommended dose of NPKS through inorganic fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + *PSB* (T_{13}) compared to other treatments. Respectively, minimum plant height (15.78, 26.01 and 36.00 cm) at 30, 60 and 90 DAP was recorded with the application of NC 6 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + *PSB* (T_2).

The magnitude of plant height was increased 2.23, 4.65 and 4.80 percent at 30, 60, and 90 DAP over 100 % RDF through inorganic fertilizers.

4.1.2 Leaves per plant

It is explicit from data presented in Table 4.2 and Fig 4.2 that combined application of plant nutrients through inorganic, organic and biofertilizers or their combinations significantly influenced the leaves per plant at 30, 60 and 90 DAP in onion cv. N 53. The data indicated that the leaves per plant varied “Between” 2.40 to 7.60.

The maximum leaves per plant at 30, 60 and 90 DAP (3.27, 5.33, 7.60) were achieved by combined application of 60 per cent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed by (2.93, 5.00 and 7.40) leaves per plant with the application of 40 per cent recommended dose of NPKS through inorganic fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB (T_{13}) as compared to other treatments. While, the minimum leaves per plant (2.40, 4.00 and 5.40) per plant at 30, 60 and 90 DAP were recorded with the application of NC 6 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB (T_2). The leaves per plant was increased 13.94, 6.6 and 8.57 per cent over 100 % RDF of NPKS 120:60:60:40 kg ha^{-1} through chemical fertilizers.

4.1.3 Days taken to harvesting of bulb

It is depicted from the data presented in Table 4.3 that there was non significant variation in crop maturity days with the application of plant nutrients through inorganic fertilizers, organic manure and biofertilizers or their combinations.

However, early crop maturity (138.45days) was recorded in treatment T_{12} (60 % RDF of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB) followed by T_{13} (40 % RDF of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB).

Whereas, late crop maturity (145.78 days) was recorded with the application of 100% RDF (NPKS 120:60:60:40 Kg ha^{-1}).

4.1.4 Bolting percent at 90 days

It is depicted from the data presented in Table 4.3 and fig. 4.3 that there was significant variation in bolting percent of onion crop with the application of nutrients through inorganic, organic and biofertilizers and their combinations.

Minimum bolting percent (2.25%) was recorded in treatment T_{12} (60% RDF of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB, followed (2.35%) by T_{13} treatment. Whereas, maximum bolting percent (4.33%) was recorded in the T_1 treatment with application of 100% RDF NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

The bolting percent was reduced 51.96 % as compared to over 100% RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

4.2 YIELD ATTRIBUTING CHARACTERS

The effect of organic, inorganic and biofertilizers at different doses on yield attributes of onion such as bulb length, bulb diameter, bulb weight and bulbs yield kg/plot were studied and data are presented in Table 4.4, 4.5 and depicted in Fig. 4.4, 4.5 and 4.6. The analysis of variance of these characters is given in Appendices- III to IV.

4.2.1 Bulb length (cm)

The data presented in Table-4.4 established that, different treatment exhibited non significant effect on bulb length.

However, the maximum bulb length (4.45cm) was recorded in T_{12} treatment (60 % RDF of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB) followed (4.41cm) by T_{13} (40% RDF of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha $^{-1}$ + *Azotobacter* + PSB) as compared to over 100 % RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers whereas, minimum bulb length (4.25cm) was recorded in treatments T_6, T_7 and $T_{11.}$

4.2.2 Bulb diameter (cm)

A persual of data presented in Table 4.4 and fig 4.4 clearly indicated that bulb diameter was significantly increased by applying plant nutrients through inorganic fertilizers, organic manures and biofertilizers.

The maximum bulb diameter (5.20cm) was recorded by applying 60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (4.85cm) by T_{13} treatment (40 per cent recommended dose of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha $^{-1}$ + *Azotobacter* + PSB) as compared to over 100 % RDF NPKS (120:60:60:40 kg ha^{-1}). While, minimum bulb diameter of onion (3.80cm) was recorded with the application of 40 per cent recommended dose of NP + 100 % KS through chemical fertilizers + *Azotobacter* + PSB (T_{11}).

4.2.3 Fresh weight of bulb (g)

It is from data presented in Table-4.5 and Fig.4.5 revealed that application of various plant nutrients through inorganic fertilizers, organic source and bio-fertilizers were significantly increased bulb weight.

The maximum bulb weight (52.32 g) was recorded with the application of 60 per cent recommended dose of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), closely followed by (52.21g) 40 per cent recommended dose of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB (T_{13}). While, Minimum bulb weight (34.98 g) was recorded with the application of 40 per cent recommended dose of NP + 100 % KS through chemical fertilizers + *Azotobacter* + PSB (T_{11}). However, the treatment T_6, T_8, and T_9 were at par with T_{12}.

The magnitude of average bulb weight was increased 13.41 per cent over 100% RDF of NPKS (120:60:60:40 kg ha^{-1}) through chemical fertilizers.

4.2.4 Bulb yield per plot (kg)

It is explicit from data presented in Table-4.5 that application of plant nutrients in combination through organic manures, inorganic fertilizers and bio-fertilizers significantly increase yield per plot in onion.

The highest bulb yield (16.05 kg per plot) was obtained with application of 60 per cent recommended dose of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (15.52 kg) by the application of 40 per cent recommended dose of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB (T_{13}), While, minimum bulb yield (10.51 kg) was recorded with the application of 40 % RDF of NP + 100 % KS through chemical fertilizers + *Azotobacter* + PSB Kg ha^{-1} in treatment (T_{11}). However, treatment T_8 was at par with T_{12} treatment.

The bulb yield per plot was increased 16.90 per cent over 100 % RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

4.3 QUALITY CHARACTERS

The effects of organic manure and fertilizers at different levels on quality characters of onion such as TSS, protein content, carbohydrate content, sugar content, total chlorophyll content at 90 DAP, loss in weight during storage, uptake of NPKS by bulb, dry matter content, pyruvic acid and ascorbic acid content were studied that the data are presented in Tables (4.6, 4.7, 4.8, 4.9, 4.10, and 4.11) and depicted in Fig (4.6, 4.7, 4.8, 4.9, 4.10 and 4.11).

4.3.1 TSS (^{o}Brix)

The data showed in Table 4.6 and Fig. 4.7 that application of plant nutrients through organic sources, chemical fertilizers and their integrated use significantly increased TSS content in onion.

The maximum value of TSS (15.19^{0}Brix) was achieved by the combined application of 60 per cent recommended dose of NPKS through chemical fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (13.48^{0}Brix) by 40 percent recommended dose of NPKS through chemical fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB) compared to other treatments. While, the minimum TSS (10.85 ^{o}Brix) was recorded with the application of 40% RDF of NP + 100% KS + *Azotobacter* + PSB (T_{11}). The magnitude of TSS content 19.60 per cent was increased over 100 % RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

4.3.2 Protein content (%)

It is explicit from data presented in Table 4.6 and fig. 4.8 that application of plant nutrients in combination of inorganic fertilizers, organic manures and bio-fertilizers significantly influence protein content in onion.

The maximum protein content in onion (6.10%) was recorded with the application of 60 per cent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (5.74%) by T_{13} whereas, minimum protein content (4.23%) was recorded with the application of 40 % RDF of NP + 100 % KS through inorganic fertilizers + *Azotobacter* + PSB (T_{11}). The significantly protein content 19.84 per cent was increased over 100 % RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

4.3.3 Carbohydrate content (%)

A perusal of data (Table 4.7 and Fig. 4.8) revealed that application of various nutrients by organic manures and fertilizers or their integrated use significantly influenced dry matter content in onion.

The highest carbohydrate content (8.82%) was recorded with the application of 60 percent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (8.32%) by T_{13} treatment while, the minimum carbohydrate content (6.85%) was recorded in treatment T_{11} (40% RDF of NP + 100% KS through inorganic fertilizers + *Azotobacter* + PSB). The magnitude of carbohydrate content 19.84 per cent was increased over 100% RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers.

4.3.4 Sugar content (%)

Data presented in Table 4.7 and fig 4.8 clearly indicated that significantly increase was derived in term of sugar content in bulb of onion by applying plant nutrients through inorganic fertilizers, organic manure and bio-fertilizers in onion cv-N53.

The maximum sugar content (6.70%) was recorded with application 60 percent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed by (6.48%) T_{13} with the application of 40 percent recommended dose of NPKS through inorganic fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB as compared to other treatments. While, minimum sugar content of bulb (5.36%) recorded with the application of 40 percent recommended dose of NP + 100 per cent KS through inorganic fertilizers + *Azotobacter* + PSB (T_{11}).

The sugar content was increased 12.98 percent over 100% RDF of NPKS (120:60:60:40 kg ha^{-1}) through chemical fertilizers.

4.3.5 Total chlorophyll content at 90 DAP (mg g^{-1} fw)

Data presented in Table-4.8 clearly established that total chlorophyll content at 90 DAP was significantly increased with the application of various nutrients through inorganic fertilizers, organic manures and biofertilizers.

The maximum total chlorophyll content (0.76 mg g^{-1} fw) at 90 DAS was recorded with the application of 60 percent recommended dose of NPKS through inorganic fertilizers + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed (0.73 mg g^{-1} fw) by treatment T_{13} (40% RDF of NPKS through inorganic fertilizers + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB). While, minimum Total chlorophyll content (0.55 mg g^{-1} fw) at 90 DAP was recorded with the application of 40% RDF of NP + 100 % KS through inorganic fertilizers + *Azotobacter* + PSB (T_{11}).

4.3.6 Dry matter content (%)

A perusal of data (Table 4.8 and Fig. 4.9) revealed that application of various nutrients by organic manures bio fertilizers and fertilizers or their integrated use significantly influenced dry matter content in onion.

However, the highest dry matter content (16.39%) was recorded with the application of 60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), which was at par with treatment $T_{8,}$ T_9 and T_{13} (14.92, 14.94 and 15.32%), whereas, minimum dry matter content (13.56%) was recorded in treatment T_{11} (40% RDF of NP + 100% KS through inorganic fertilizers + *Azotobacter* + PSB).

It is magnitude the dry matter content 10.82 percent was significantly increased over 100 % RDF NPKS (120:60:60:40 kg ha^{-1}) through chemical fertilizer.

4.2.7 Pyruvic acid (µ mol 100g^{-1})

It is explicit from data presented in Table-4.9 that application of plant nutrients through organic manures and fertilizers significantly increased pyruvic acid content of onion.

The maximum pyruvic acid content of onion was recorded (2.74 µ mol 100g^{-1}) with the application of 60 percent recommended dose of NPKS through chemical fertilizer + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}), followed by (2.56 µ mol 100g^{-1}) with the application of 40 percent recommended dose of NPKS through chemical fertilizer + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB (T_{13}), while, minimum pyruvic acid content (1.87 µ mol 100g^{-1}) was recorded with the application of 40 % RDF of NP + 100% KS through chemical fertilizer + *Azotobacter* + PSB (T_{11}).

4.3.8 Ascorbic acid (mg $100g^{-1}$)

Data presented in Table 4.9 and depicted in Fig 4.9 revealed that the application of organic and inorganic fertilizers improved significant ascorbic acid content in onion cv-N53.

The maximum ascorbic acid content (13.01 mg/100g) was recorded with the application of 60 percent recommended dose of NPKS through chemical fertilizer + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) which was at par with treatment T_{13} (12.98 mg/100g). While, minimum ascorbic acid content (10.60 mg/100g) was recorded with the application 40 % RDF of NP + 100 % KS through chemical fertilizer + *Azotobacter* + PSB (T_{11}).

The ascorbic acid 14.56 per cent was significanty increased over 100 per cent NPKS (120:60:60:40 kg ha^{-1}) through in organic fertilizers.

4.2.9 Nutrient uptake of NPKS

A perusal of data (Table 4.11) and fig. 4.10 revealed that application of various nutrients combination, inorganic fertilizers, organic manures and bio-fertilizers or their integrated use significantly increased uptake of nutrient.

The maximum uptake of NPKS (233.53 kg ha^{-1}, 52.78 kg ha^{-1}, 297.99 kg ha^{-1} and 238.03 kg ha^{-1}) was recorded in the treatment T_{12} (60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB), followed (229.51 kg ha^{-1}, 52.69 kg ha^{-1}, 290.14 kg ha^{-1} and 221.26 kg ha^{-1}) by T_{13} (40 percent recommended dose of fertilizer of NPKS + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB) as compared to 100 % RDF of NPKS (120:60:60:40 kg ha^{-1}). Whereas, minimum uptake of NPKS by bulb of onion (137.35 kg ha^{-1}, 30.77 kg ha^{-1}, 231.66 kg ha^{-1} and 132.00 kg ha^{-1}) was recorded in the treatment T_{11} (40 percent recommended dose of fertilizer of NP + 100 % KS + *Azotobacter* + PSB). However, the treatments $T_{1,}$ $T_{6,}$ $T_{8,}$ $T_{9,}$ and T_{13} were at par with $T_{12.}$

4.3.10 Physiological loss in weight at 10, 20, and 30 DAS

It was observed that the treatments differed non significantly in their influence on percent weight loss during storage which is depicted in Table 4.11 and fig. 4.1.1

The minimum weight loss during storage of onion (2.58, 4.10 and 5.78%) percent was recorded at 10, 20, and 30 DAS respectively in treatment T_{13} (40 percent recommended dose of fertilizer of NPKS + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB).

The maximum percent weight loss (2.81%, 4.36%, and 6.12) during storage of onion was recorded at 10, 20, and 30 DAS respectively in the treatment T_1 (100% RDF NPKS 120:60:60:40 kg ha^{-1}).

4.4 SOIL ANALYSIS AFTER HARVEST

4.4.1 Available nitrogen in soil (kg ha^{-1})

The data presented in Table-4.12 and fig. 4.11 revealed that the application of organic manure and fertilizers exhibited significant variation in nitrogen availability in soil after harvesting of onion cv-N53. The initially available nitrogen in soil before planting of onion was 181.5 kg ha^{-1}.

However, the maximum available nitrogen in soil after harvest was recorded (195.21 kg ha^{-1}), in the treatment T_{12} (60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB) followed (194.26 kg ha^{-1}) by T_{13} treatment as compared to all other treatments, whereas, minimum available nitrogen in soil after harvest (181.88 kg ha^{-1}) was recorded in treatment T_{11} (40 % RDF of NP + 100 % KS + *Azotobacter* + PSB).

4.4.2 Available phosphorus in soil (kg ha^{-1})

It is explicit from the data presented in Table 4.12 and fig. 4.11 that there was significant difference among all the nutrient treatments for available phosphorus in soil after harvest of onion cv-N53. The initially available phosphorus in soil before planting of onion was 22.50 kg ha^{-1}.

The maximum available phosphorus in soil after harvest was recorded (28.24 kg ha^{-1}) in the treatment T_{12} with the application of 60 percent recommended dose of fertilizer of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB) which was at par with the treatment T_{13} (27.28 kg ha^{-1}). While, minimum available phosphorus in soil was recorded (22.41 kg ha^{-1}) in treatment T_{11} with the application of 40 % RDF of NP + 100% KS + *Azotobacter* + PSB).

4.4.3 Available potassium in soil (kg ha^{-1})

The data presented in Table-4.12 and fig 4.11 revealed that the application of organic manure and fertilizers also exhibited significant variation in available potassium in soil after harvest of onion cv-N53. The initially available potassium in soil before planting of onion was 250 kg ha^{-1}.

However, the maximum available potassium in soil (265.90 kg ha^{-1}) was recorded in treatment T_{12} (60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB), which was at par with the values of treatments T_{13} (264.26 kg ha^{-1}) whereas, minimum available potassium in soil (245.04 kg ha^{-1}) was recorded with application of 40% RDF of NP + 100% KS + *Azotobacter* + PSB (T_{11}). Significantly marked variation was found among all the treatments.

4.4.3 Available sulphur in soil (kg ha^{-1})

The data presented in Table-4.12 revealed that the application of organic manure and fertilizers also exhibited significant variation in available potassium in soil after harvest of onion crop. The initially available sulphur in soil before planting of onion was 12.75 kg ha^{-1}.

However, the maximum available sulphur in soil (15.68 kg ha^{-1}) was recorded in treatment T_{12} (60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB), which was at par with the values of treatments T_{13} (15.48 kg ha^{-1}) whereas, minimum available sulphur in soil (12.82 kg ha^{-1}) was recorded with application of NC 6 q ha^{-1} + VC 30q ha^{-} (T_2). Significantly marked variation was found among the treatments.

4.5 ECONOMICS OF THE TREATMENTS

Economic evaluation of treatments indicated (Table 4.13) that during the experimental year application of 60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) gave the highest net return ` 325507 per hectare followed by treatment $T_{13}$ (` 311221) per hectare.

In respect of B C ratio during the year highest values (3.97%) was also obtained by 60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) followed (3.78%) by T_1 treatment.

5. DISCUSSION

During the course of presenting results of the field experiment entitled **“Integrated Nutrient Management in Onion *(Allium cepa L.)* cv. N-53”** significant variations in the criteria used for evaluation of treatments were observed due to different treatments. An attempt has been made hitherto to discuss the significant effects of these assuming a pattern in respect of vegetative growth, yield, quality characters and other related phenomenon of onion so as to establish causes and effect relationship in the light of available evidence and literature.

The results of analysis, which have a significant effect, are being discussed in this chapter.

5.1 Effect of Integrated Nutrient Management on vegetative growth parameters of onion cv. N-53

Fertilizer is one of the most important inputs for increasing onion production. But the continuous and liberal use of inorganic fertilizers alone affects soil health and thus resulting in lower yield with poor quality produce. Consequently it is felt necessary to advocate the use of the organic sources of nutrients for sustainable production. Thus, in order to combat future degradation of soil productivity or fertility, adoption of nutrient management system consisting of organic and inorganic sources as per need of crop, have been postulated (Kore *et al.*, 2006).

The effect of Integrated Nutrient Management on vegetative growth parameters showed that application of 60 percent RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB recorded significantly highest plant height (19.24 cm, 29.71 cm and 41.94 cm) and number of leaves (3.27, 5.33 and 7.60 per plant) at 30, 60 and 90 which were followed T_{13} by (40 percent RDF of NPKS + NC 9 q ha^{-1} + VC 30 q ha^{-1} + *Azotobacter* + PSB) as compared to over 100 per cent RDF of NPKS (120:60:60:40 kg ha^{-1}) through inorganic fertilizers. The lowest value of growth characters was recorded in treatment $T_{2.}$

The significant effect on these parameters, as consequence of organic manures and chemical fertilization are attributed to the increased nutritional status of soil resulting into increased growth of the crop. This may be attributed to favorable effect of organic sources on microbial activity and root proliferation in soil which caused solubilizing effect on native nitrogen, phosphorus, potassium and other nutrients. The reduced dose of chemical fertilizers supplemented with organic manures also decreases exploitation of micronutrients.

The result of combined use of fertilizers and organic manures are in close agreement with the findings of Patil *et al.* (2007) and Jawadagi *et al.* (2012) reported that combined application of organic manures and inorganic fertilizers increased organic carbon, available N, S and micro nutrients thus, improved soil fertility.

Further, the nitrogen is the most indispensable of all mineral nutrients for growth and development of the plant as it is the basis of fundamental constituents of all living matter. The biological role of nitrogen as an essential constitution of chlorophyll in harvesting solar energy, phosphorylated compound in energy transformation, nucleic acids in the transfer of genetic information and the regulation of cellular metabolism and of protein as structural units and biological catalysts is well known.

Phosphorus not only plays an important role in root development and proliferation by means of efficient translocation of growth, stimulating compounds but also enhanced the uptake of other nutrients. Improvement in the nutrient availability status resulting greater increased in photosynthetic and carbohydrate synthesis and then translocation to different parts for promoting meristamatic development in potential apical buds and intercellular meristems which ultimately increased in vigorous growth of plants. Potassium helps in the protein and chlorophyll formation ultimately they are used for better vegetative growth.

Organic manure addition also enhanced the vegetative growth of onion and also act as stimulate for supply of plant nutrient during the course of microbial decomposition and enable the crop to utilize nutrient and water more efficiently. It also releases macro and micro nutrient during the course of microbial decomposition which ultimately improves the vegetative growth.

Present results support above hypothesis that organic manure can act as a best plant growth media when conjugated with some amount of NPKS fertilizer. These finding are quite comparable to those of Gowada *et al.* (2007) in garlic and later on it was also confirm by Pratap *et al.* (2012). Similar results have been reported by Bairwa *et al.* (2009) in okra, Ngullie *et al.* (2009), Chuda *et al.* (2009) in onion, Prativa *et al.* (2011) in tomato, Nori *et al.* (2012) and Bhandari *et al.* (2012) in garlic, Bagali *et al.* (2012) in onion, Jamir *et al.*(2013), Umrao *et al.*(2013) in garlic.

5.2 Effect of Integrated Nutrient Management on yield parameters of onion cv. N-53

The application of organic manure, bio fertilizers and chemical fertilizers significantly increased the yield parameters (Table 4.4 and 4.5). The maximum values of yield attributes i.e. bulb diameter (5.20 cm), bulb weight (52.32 g), yield per plot (16..05 kg) and yield per hectare (27.17 t), were achieved by combined application of 60% RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) followed by T_{13} as compared to other treatments.

With the application of 60 percent recommended dose of fertilizer of 60 % RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) significantly higher yield was recorded 16.46 per cent over recommended dose of 100 percent NPKS (120:60:60:40 kg ha^{-1}) through chemical fertilizers.

This might be due the facts that combined application of inorganic fertilizers and organic manures helped in the expansion of leaf area and chlorophyll content which together might be have accelerated the photosynthetic rate and in turn increased the supply of carbohydrates to the plants. The application of 60 percent recommended dose of NPKS + + NC (6q/ha) + VC (20q/ha) + *Azotobacter* + PSB (T_{12}) favored the metabolic and auxin activities in plant and ultimately resulted in increased bulb weight, bulb diameter, bulb length, yield per plot (kg) and finally the total yield. Similarly, vermicompost, neem cake and biofertilizers improved physical, chemical and biological properties of soil which consequently increased the value of growth parameters, yields attributes and finally yield. Further, it is relevant to note that, organic manure and biofertlizers seems to be directly responsible in increasing crop yields either by accelerating the respiratory process by increasing cell permeability due to hormone growth action or combination of all these processes. It supplies nitrogen, phosphorus, potassium of which phosphorus involved in cell division, photosynthesis and metabolism of carbohydrates where potash regulated proper translocation of photosynthesis and stimulated enzyme activity which in turn might have increased the rate of growth and positive development in yield characters which was resulted in high bulb yield of onion. Further, it is noticed that vermicompost and neem cake increased the soil organic matter and improved the soil structure. This would have reduced the loss of nitrogen by increased cation and anion exchange capacities in soil, thereby enhancing the bulb development and yield. It also function as a source of energy for soil micro flora which brings transformation of inorganic nutrient present in soil or applied in the form of fertilizer, in readily form which can be utilized by growing plant.

Increased vegetative growth, dry matter production and translocation of photosynthesis might have resulted in increased size of bulb. The size of bulb was directly influenced by the enhanced vegetative growth of the plants and resulted in increased in height and number of leaves. This might have accumulated more carbohydrates, resulting in to increased diameter of the bulb, which is food storage organ as reported by Bhandari *et al.* (2012).

These finding are in conformity with those of Patil *et al.* (2007) and Singh *et al.* (2012) in garlic. They found that combined application of organic manure and fertilizers increased the yield attributes and finally the total yield in garlic. Later on it was also supported by the findings of Adagale *et al.* (2010) in onion, Kumar *et al.* (2012) in garlic, Shinde *et al.* (2013) in onion.

5.3 Effect of Integrated Nutrient Management on quality parameters of onion cv-N53

It is evident from the data presented in the previous chapter that different organic manures and fertilizers had significant effect on physico-chemical characteristics of onion (Table 4.6, 4.7, 4.8, 4.9, 4.10 and 4.11). The maximum value of TSS (15.19%), chlorophyll content at 90 DAP (0.76 mg), carbohydrate content (8.82%) dry matter content (16.39%), ascorbic acid (13.01 mg $100g^{-1}$), protein content (6.10%), sugar content (6.70%) and pyruvic acid content (2.73 µ mol $100g^{-1}$) was recovered by combined application of 60 percent recommended dose of fertilizer of NPKS + NC (6q/ha) + VC (20q/ha) + *Azotobacter* + PSB (T_{12}). While, the minimum value of TSS (10.85%), chlorophyll content of leaves at 90 DAP (0.55 mg), carbohydrate content (6.85%) and dry matter content (13.56%) ascorbic acid (10.60 mg), protein content (4.23%) sugar content (6.70%) and pyruvic acid content (1.87 µ mol/100g)) was achieved by combined application of 40 percent RDF of NP + 100 percent KS + *Azotobacter* + PSB (T_{10}).

Similarly, NPKS content in bulb of onion as well as its uptake increased significantly with application of NPKS fertilizers, various organic mannure, alone or in combination and with biofertilizers as cmpared to other treatment. The highest Nitrogen, Phosphorous, Potassium and Sulphur content in bulb were recorded in treatment T_{12} (60% RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB). Similarly, the maximum uptake of N (233.53 kg ha^{-1}), P (52.78 kg ha^{-1}), K (297.99kg ha^{-1}) and S (238.03 kg ha^{-1}) was recorded from treatment T_{12} (60% RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB) followed by treatment $T_{13.}$

The minimum loss of weight (2.58%, 4.10%, and 5.78%) during storage of the bulb at 10, 20 and 30 DAH in the treatments T_{12} (60 percent RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB), whereas control exhibited maximum loss of weight (%) during storage of the bulb at 10, 20 and 30 DAH with application of 100 percent RDF (NPKS 120:60:60:40 Kg ha^{-1} in the storage. Minimum physiological loss of weight (%) of bulbs in organic treatment T_{12} is due to higher and continuous uptake of potassium nutrients from organic sources throughout the crop growth and better accumulation of sulphur, phosphorus and TSS (%) which would have helped in maintaining the cell wall turgidity.

The improvement in physico-chemical properties of onion might be due to fact that organic manures and biofertilizers are capable of supply adequate macro and micro plant nutrients which play major role in quality improvement through desirable enzymatic changes taking place during growth. Response of vermicompost and neem cake in improving soil nutrition is well established fact. The effects were much more pronounced when inorganic fertilizer use with vermicompst and neem cake. Positive influences of NPKS fertilization on N content of bulb appear to be due to improved nutritional environment both in root zone and plant system.

Adequate supply of nitrogen early in the crop season resulted in greater availability of nutrients including N, P, K and S in particular in crop root zone. The increase in N and P might be due to more availability of N, P and K to plants due to application of vermicompst which might have improved chemical and biological properties of soil and enabled plant roots to proliferate resulting in better utilization of nutrients by crop. The increase in nitrogen content in bulbs resulted in higher protein content in onion bulb. These results are in close conformity with the finding of Mohd *et al.* (2011) in garlic and Jamir *et al*. (2013) and Swati *et al.* (2014) in onion. The findings of present study are in accordance with Patel *et al.* (2008) in onion, Indra *et al.* (2014) in onion and Shiferaw *et al.* (2014) in garlic.

5.4 Effect on Available NPKS in Soil

Application of organic manures and fertilizers could bring significant variation in respect to NPKs status of soil after harvest. However, Maximum available nitrogen and potassium in soil after harvest of onion crop 195.21 kg ha^{-1}, 28.24 kg ha^{-1}, 265.90 kg ha^{-1} and 15.68 kg ha^{-1} were recorded with the application of 60 per cent recommended dose of NPK NC (6 q ha^{-1}) + VC (20 q ha^{-1}) + *Azotobacter* + PSB (T_{13}). While, minimum available NPK in soil were recorded in T_{11} treatment (40% RDF of NP&100%KS + *Azotobacter* + PSB). The integration of nutrients increases the available of N, P K, and S manifolds over the chemical fertilizer.

The application of organic manures and inorganic fertilizers improved the post harvest fertility status of the soil after harvest of the crop. The organic manure acts as store house of energy for microorganisms responsible of nutrient transformation. Besides, providing favorable physical properties these also helps in the mineralization of soil nutrients leading to higher available N, P and K. The results are collaborated with the findings of Bhandari *et al.* (2012, Damse *et al*. (2014) in garlic and Jamir *et al*. (2013), Swati *et al.* (2014) in onion.

5.5 Effect on Economics of Onion

Economic evaluation of treatments indicated (Table 4.13) that during the experimental year application of 60 per cent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) gave the highest net return ` 325507 per hectare followed by treatment $T_{13}$ (` 311221) per hectare.

In respect of B:C ratio during the year highest values (3.97) was also obtained by 60 percent recommended dose of fertilizer NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (T_{12}) followed by T_8 (3.84).

The effects were much more pronounced when inorganic fertilizer use with vermicompost and neem cake. Similar results have been reported by Bairwa *et al.* (2009) in okra, Jamir *et al*. (2013) in onion, Umrao *et al.* (2013) in garlic.

6. SUMMARY

The results of the field experiment entitled "Integrated Nutrient Management in Onion *(Alium cepa* L.) cv. N-53" presented and discussed in the preceding chapters are summarized below:

6.1 GROWTH CHARACTERS

- There was no significant difference in case of days taken to harvesting of bulb of onion among all the treatments.
- The application of 60 per cent recommended dose of NPKS + VC (20 q ha^{-1}) + NC (6 q ha^{-1}) + *Azotobacter* + PSB (T_{13}) recorded significantly maximum plant height (19.24 cm, 29.71 cm and 41.94 cm) at 30, 60 and 90 DAP per plant and number of leaves (3.27, 5.33 and 7.60) at 30, 60 and 90 DAP followed by 40 percent recomended dose of fertilizer of NPKS + NC (9 q ha^{-1}) + VC (30 q ha^{-1}) + *Azotobacter* + PSB (T_{13}).
- Minimum bolting per cent (2.25%) at 90 DAP was recorded with the application of NC (6 q ha^{-1}) + VC (30 q ha^{-1}) + *Azotobacter* + PSB (T_{12}), followed by (2.35%) applying 60 percent recomended dose of fertilizer of NPKS + NC (6 q ha^{-1}) + VC (20 q ha^{-1}) + *Azotobacter* + PSB (T_{13}).

6.2 YIELD AND YIELD ATTRIBUTING CHARACTERS

- The maximum values of yield attributes i.e. bulb length (4.45cm), bulb diameter (5.20cm), bulb weight (52.32 g), yield per plot (16.05 kg) and yield per hectare (27.17 t ha^{-1}) were achieved by combined application of 60 percent recomended dose of fertilizer of NPKS + NC (6 q ha^{-1}) + VC (20 q ha^{-1}) + *Azotobacter* + PSB (T_{12}) as compared to other treatments.
- Integrated use of chemical fertilizers, organic manures and bio fertilizers (60% RDF of NPKS + NC (6 q ha^{-1}) + VC (20 q ha^{-1}) + *Azotobacter* + PSB) significantly increased bulb yield per hectare 21.67 percent over recomended dose of NPKS (120:60:60:40) through inorganic fertilizers.

6.3 QUALITY CHARACTERS

- The maximum value of TSS (15.19%), chlorophyll content of leaves (0.76 mg $100g^{-1}$) at 90 DAP, carbohydrate content (8.82%), dry matter content

(16.39%), ascorbic acid (13.01 mg/100g), sugar content (6.70%) and pyruvic acid content (2.74 µ mol 100g^{-1}) was also achieved by combined application of 60 percent recomended dose of fertilizer of NPKS + NC(6q/ha) + VC (20q/ha) + *Azotobacter* + PSB (T_{12}) followed by 40 percent recomended dose of fertilizer of NPKS + NC(9q/ha) + VC (30q/ha) + *Azotobacter* + PSB (T_{13}).

- The highest uptake of NPKS (233.53 kg ha^{-1}, 52.78 kg ha^{-1}, 297.99 kg ha^{-1} and 238.03 kg ha^{-1}) were recorded with application of 60 percent recomended dose of fertilizer of NPKS + NC (6 q ha^{-1}) + VC (20 q ha^{-1}) + *Azotobacter* + PSB (T_{12}) followed by 40 percent recomended dose of fertilizer of NPKS + NC (9 q ha^{-1}) + VC (30 q ha^{-1}) + *Azotobacter* + PSB (T_{13}) as compared to other treatments.

6.4 SOIL ANALYSIS

- Application of organic manures and fertilizers could bring significant variation in respect to NPKS status of soil after harvesting of onion. However, Maximum available nitrogen phosphorous, potassium and sulphur in soil after harvest of onion crop(195.21 kg ha^{-1}, 28.24 kg ha^{-1}, 265.90 kg ha^{-1} and 15.68 kg ha^{-1}) were recorded with the application of 60 percent recomended dose of fertilizer of NPKS + NC(6q/ha) + VC (20q/ha) + *Azotobacter* + PSB (T_{13}) whereas, average minimum available NPKS in soil was recorded by applying 40 % RDF of NP + 100 % KS + *Azotobacter* + PSB (T_{11}).

6.5 ECONOMICS OF THE TREATMENTS

- The maximum net return of 325507 ` ha^{-1} and benefit cost ratio 3.97 was recorded by the application of 60% RDF of NPKS + NC (6 q ha^{-1}) +VC (20 q ha^{-1}) + *Azotobacter* + PSB.

7. CONCLUSION

The results of present investigation revealed that application of 60% RDF of NPKS through in organic fertilizers supplemented with NC 6 q ha^{-1} + VC 20 q ha^{-1} + Azotobacter + PSB was statiscally superior to enhance growth, yield and quality of onion cv-N53 in addition to increasing soil fertility status. The analysis of figure indicated that highest net return and benefit cost ratio were recorded by applying 60% RDF of NPKS + NC 6 q ha^{-1} + VC 20 q ha^{-1} + *Azotobacter* + PSB (⍰ 325507 ha^{-1} and 3.97). In the present investigation supplementation of neem cake, vermicompost and biofertilizers along with reduced level of chemical fertilizers improved soil fertility status. Therefore, to produce sustain higher yield and quality of onion it is recommended to make integrated use of inorganic (60% RDF NPKS), organic (NC 6 q ha^{-1} + VC 20 q ha^{-1}) and biofertilizers (*Azotobacter* + PSB) for onion cv. N-53 cultivation.

Table 4.1: Effect of INM on plant height in onion cv. N-53

TREATMENT	TREATMENT DETAIL	PLANT HEIGHT (CM)		
		30 DAP	60 DAP	90 DAP
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	18.82	28.39	40.02
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	15.78	26.01	36.00
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	15.80	26.01	36.33
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	17.10	27.12	38.66
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	16.56	26.12	37.64
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	17.09	26.43	39.62
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	17.42	26.75	37.13
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	17.89	27.94	39.82
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	16.15	26.61	37.44
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	16.55	26.43	36.80

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	15.84	26.20	39.71
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	19.24	29.71	41.94
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	18.98	29.68	41.84
	SEM±	0.12	0.21	0.33
	CD AT 5%	0.37	0.61	0.98

Note: DAP (Days after planting)

Table 4.2: Effect of INM on leaves per plant in onion cv. N-53

TREATMENT	TREATMENT DETAIL	NO. OF LEAVES / PLANT		
		30 DAP	60 DAP	90 DAP
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	2.87	4.93	7.00
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	2.40	4.00	5.40
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	2.53	4.33	5.60
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	2.47	4.53	6.20
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	2.60	4.07	5.80
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	2.80	4.87	6.20
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	2.47	4.07	6.40
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	2.93	5.00	7.20
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	2.80	4.60	6.80
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	2.60	4.33	6.20

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	2.53	4.07	6.60
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	3.27	5.33	7.60
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	2.93	5.00	7.40
	SEM±	0.03	0.05	0.04
	CD AT 5%	0.09	0.15	0.12

Table 4.3: Effect of INM on crop maturity and bolting in onion cv. N-53

TREATMENT	TREATMENT DETAIL	CROP MATURITY (DAYS)	BOLTING PERCENT AT 90 DAYS
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	145.78	4.33
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	145.35	2.55
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	140.28	3.56
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	143.18	3.37

T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	145.14	2.84
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	143.74	3.52
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	145.16	3.32
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	140.56	2.67
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	142.07	3.03
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	140.25	3.40
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	145.25	4.10
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	138.45	2.25
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	139.18	2.35
	SEM±	0.008	0.117
	CD AT 5 %	NS	0.351

Table 4.4: Effect of INM on bulb length (cm) and bulb diameter (cm) in onion cv. N-53

TREATMENT	TREATMENT DETAIL	BULB LENGTH (CM)	BULB DIAMETER (CM)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	4.27	4.52
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	4.34	3.95
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	4.29	3.85
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	4.26	3.99
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	4.31	3.90
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	4.25	4.20
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	4.25	4.10
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	4.34	4.33
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	4.28	4.25
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	4.26	3.85

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	4.25	3.80
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	4.45	5.20
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	4.41	4.85
	SEM±	0.130	0.138
	CD AT 5 %	NS	0.403

Table 4.5: Effect of INM on bulb yield in onion cv. N-53

TREATMENT	TREATMENT DETAIL	WEIGHT OF BULB (G)	YIELD PER PLOT (KG)	YIELD PER HECTARE (T)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	46.15	13.73	22.33
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	41.62	12.28	20.21
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	42.08	12.71	20.72

T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	43.07	13.05	21.36
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	43.69	13.22	21.79
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	48.66	14.96	23.85
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	47.36	13.95	23.16
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	49.55	15.23	24.43
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	48.26	14.21	23.55
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	37.58	11.16	19.39
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	34.98	10.51	18.84
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	52.32	16.05	27.17
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	52.21	15.52	26.61
	SEM±	1.68	0.340	0.788
	CD AT 5 %	4.91	0.991	2.30

Table 4.6: Effect of INM on TSS and protein content in onion cv. N-53

TREATMENT	TREATMENT DETAIL	TSS (°BRIX) IN BULB	PROTEIN CONTENT (%)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	12.70	5.09
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	12.03	4.84
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	11.44	4.40
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	12.03	5.00
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	12.07	5.07
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	12.78	5.05
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	12.52	5.17
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	13.12	5.43
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	12.97	5.15
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	11.14	4.27

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	10.85	4.23
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	15.19	6.10
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	13.48	5.74
	SEM±	0.21	0.32
	CD AT 5%	0.61	0.92

Table 4.7: Effect of INM on carbohydrate content and sugar content in onion cv. N-53

TREATMENT	TREATMENT DETAIL	CARBOHYDRATE CONTENT (%)	SUGAR CONTENT (%)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	7.36	5.93
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	6.98	5.47
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	6.90	5.50

T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	7.46	5.77
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	7.71	5.86
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	7.62	5.97
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	7.45	5.87
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	8.25	6.05
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	8.09	6.33
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	7.03	5.48
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	6.85	5.36
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	8.82	6.70
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	8.32	6.48
	SEM±	0.038	0.068
	CD AT 5%	0.110	0.197

Table 4.8: Effect of Integrated Nutrient Management on chlorophyll content and dry matter content in onion cv. N-53

TREATMENT	TREATMENT DETAIL	CHLOROPHYLL CONTENT OF LEAVES AT 90 DAP (MG G^{-1} FW)	DRY MATTER CONTENT (%)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	0.66	14.79
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	0.58	13.68
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	0.56	13.83
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	0.64	14.65
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	0.60	14.75
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	0.66	14.32
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	0.70	14.41
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	0.70	14.92
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	0.62	14.94

T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	0.57	13.58
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	0.55	13.56
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	0.76	16.39
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	0.73	15.32
	SEM±	0.004	0.543
	CD AT 5%	0.013	1.586

Table 4.9: Effect of INM on ascorbic acid and pyruvic acid in onion cv. N-53

TREATMENT	TREATMENT DETAIL	PYRUVIC ACID (µMOL $100G^{-1}$)	ASCORBIC ACID (MG $100G^{-1}$)
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	2.46	11.33
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	2.15	10.72
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	2.02	10.83

T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	2.23	11.54
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	2.25	11.32
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	2.35	11.61
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	2.23	11.48
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	2.49	12.09
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	2.24	12.03
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	1.99	11.02
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	1.87	10.60
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	2.74	13.01
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	2.56	12.98
	SEM±	0.057	0.065
	CD AT 5%	0.165	0.189

Table 4.10: Effect of INM on uptake of NPKS in onion bulb cv. N-53

TREATMENT	TREATMENT DETAILS	NPKS UPTAKE BY BULB IN (KG HA^{-1})			
		N	P	K	S
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	209.38	36.36	279.84	178.48
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	151.04	40.72	250.64	156.25
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	158.00	38.50	235.43	145.28
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	184.96	37.37	260.85	176.84
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	192.21	38.35	284.73	184.50
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	213.35	43.41	297.84	193.07
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	195.65	42.50	277.54	185.49
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	226.71	46.42	291.37	204.40
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	224.70	43.40	268.92	193.79
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	150.16	31.53	241.80	145.28

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	137.35	30.77	231.66	132.00
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	233.53	52.78	297.99	238.03
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	229.51	52.69	290.14	221.26
	SEM±	10.21	1.20	23.09	12.88
	CD AT 5%	29.81	3.51	67.38	37.59

Table 4.11: Effect of INM on percent weight loss during storage in onion cv. N-53

TREATMENT	TREATMENT DETAIL	LOSS IN WT (%) DURING STORAGE AT DAYS		
		10 DAH	20 DAH	30 DAH
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	2.81	4.36	6.12
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	2.68	4.19	5.88
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	2.67	4.23	5.83

T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	2.70	4.25	6.00
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	2.69	4.25	6.04
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	2.76	4.22	6.04
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	2.66	4.23	5.95
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	2.73	4.35	6.00
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	2.66	4.12	6.00
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	2.71	4.28	5.93
T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	2.76	4.33	6.04
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	2.58	4.10	5.78
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	2.61	4.18	5.83
	SEM±	0.001	0.003	0.001
	CD AT 5%	NS	NS	NS

Note: DAH (day after harvesting)

Table 4.12: Effect of INM on NPK status in soil after harvest of onion crop cv. N-53

TREATMENT	TREATMENT DETAIL	AVAILABLE NPKS AFTER HARVESTING (KG HA^{-1})			
		N	P	K	S
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	184.40	24.06	251.92	15.12
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	184.98	24.12	248.89	12.98
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	185.34	23.91	247.66	12.82
T_4	60% RDF OF NPKS + NC(6 Q HA^{-1})	185.68	24.87	250.91	13.53
T_5	40% RDF OF NPKS + NC (9 Q HA^{-1})	189.23	25.39	251.83	13.41
T_6	60% RDF OF NPKS + VC (20 Q HA^{-1})	185.97	25.19	254.59	14.64
T_7	40% RDF OF NPKS + VC (30 Q HA^{-1})	188.32	25.60	255.65	13.57
T_8	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})	191.58	26.01	258.92	14.07
T_9	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})	194.68	27.00	260.27	14.18
T_{10}	60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	183.16	22.74	246.54	14.01

T_{11}	40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB	181.88	22.41	245.04	13.98
T_{12}	60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB	195.22	28.24	265.90	15.68
T_{13}	40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB	194.26	27.28	264.26	15.49
	SEM±	1.23	0.14	1.37	0.63
	CD AT 5%	3.60	0.40	4.00	1.83

Note: The NPK content in soil before plating of crop : N_2 - 181.5 kg ha^{-1}, P_2O_5 - 22.50 kg ha^{-1} , K_2O – 250.60 kg ha^{-1}, S – 12.75 kg ha^{-1}

Table 4.13: Effect of INM on economics in onion crop cv. N-53

TREATMENT	TREATMENT DETAIL	GROSS RETURNS (` HA^{-1})	NET RETURNS (` HA^{-1})	B:C RATIO
T_1	100%RDF(NPKS 120:60:60:40 KG HA^{-1})	334950	264878	3.78
T_2	NC(6 Q HA^{-1}) + VC (30Q HA^{-1}) + *AZOTOBACTER* + PSB (SOLE ORGANIC)	303150	221150	2.70
T_3	NC(6 Q HA^{-1}) + VC (30Q HA^{-1})	310800	229000	2.80

T_4	**60% RDF OF NPKS + NC(6 Q HA^{-1})**	**320400**	**244557**	**3.22**
T_5	**40% RDF OF NPKS + NC (9 Q HA^{-1})**	**326850**	**248121**	**3.15**
T_6	**60% RDF OF NPKS + VC (20 Q HA^{-1})**	**358200**	**284157**	**3.84**
T_7	**40% RDF OF NPKS + VC (30 Q HA^{-1})**	**347400**	**271371**	**3.57**
T_8	**60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1})**	**370350**	**288507**	**3.53**
T_9	**40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1})**	**353250**	**265521**	**3.03**
T_{10}	**60% RDF OF NP&100%KS + *AZOTOBACTER* + PSB**	**290850**	**224053**	**3.35**
T_{11}	**40% RDF OF NP&100%KS + *AZOTOBACTER* + PSB**	**282600**	**216151**	**3.25**
T_{12}	**60% RDF OF NPKS + NC(6 Q HA^{-1}) + VC (20 Q HA^{-1}) + *AZOTOBACTER* + PSB**	**407550**	**325507**	**3.97**
T_{13}	**40% RDF OF NPKS + NC (9 Q HA^{-1}) + VC (30 Q HA^{-1}) + *AZOTOBACTER* + PSB**	**399150**	**311221**	**3.54**

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