Effect of integrated nutrient management on growth, yield, nutrient uptake and storage life of onion

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ABBREVIATIONS

%	Percentage
@	at the rate of
°C	Degree centigrade
cm	Centimeter
cv	Cultivar
Ca	Calcium
DAP	Days after planting
et.al	and others
Fe	Iron
Fig.	Figure
FYM	Farmyard manure
g	Gram
ha	hectare
i.e.	that is
K	Potassium
kg	Kilogram
Km	Kilometer
m	meter
Mg	Magnesium
MT	Metric tonne
N	Nitrogen
P	Phosphorus

Chapter 1

Introduction

INTRODUCTION

The shine of green, yellow and golden revolution in India left the long shades. Intensive agriculture involving exhaustive high-yielding varieties had led to heavy withdrawal of nutrients from the soil. The concept of integrated nutrient management has been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production (Nambiar and Abrol, 1992).

Onion (*Allium cepa* L.) is botanically a member of Liliaceae family and is cultivated in more than 125 countries worldwide (FAO, 2010). It is one of the most important commercial vegetable crops grown in India and is considered to have originated from Central Asia with diversity estimated to comprise as many as 300 species, of which many are native to North America. The world production under onion is about 7,59,77,209 MT from 39,71,505 hectare area with China being first in production (2,05,07,759 MT) and India second (1,51,18,000 MT) in production and first in area (10,64,000 ha) during 2010-2011. In India, Maharashtra is the leading onion growing state which contributes about 30% of country production. The other important states are Karnataka, Gujarat, Rajasthan, Bihar, Madhya Pradesh, Andhra Pradesh, Odisha, Haryana, Uttar Pradesh and Tamil Nadu. The onion production of 45,50,500 t from an area of 4,21,900 ha in 2000-2001 to reached a level of 1,63,41,450 t from an area of 10,45,370 ha during 2011-2012 (Indian Horticulture Database, 2012). India is the traditional exporter of onion since 1950 to countries like Malaysia, Singapore, West Asian, Gulf countries and Sri Lanka. India export volume reached to 15,52,904 t of onion worth Rs. 2,14,142.90 lakhs during 2011-2012 from 3,30,207 t worth Rs. 1,32,361.93 lakhs during 2000-2001.

Onions are grown on a wide range of climatic condition. However, most of the varieties are grown as winter crops in North India, while in Maharashtra and other Southern states as rainfed or autumn season crop. The moderate temperature (10°C to

28°C) and loose soil nature (sandy loam to loamy textured) favour the scope of cultivation of onion in north eastern region, but low photoperiodic availability coupled with lack of assured moisture supplied during winter months, and further earlier rain during maturity or harvesting period in the month of April - May restrict the expansion of onion production in the region during the winter season. Therefore, the majority of onion requirements (98%) in the north eastern region is met from Maharashtra and North India. However, there is scope to grow onion as rainfed/off season crop from August to December under foothill conditions with use of suitable variety. Preliminary observations indicate the possibility of growing rainfed/off season onion under terraced conditions of Nagaland as cash spinning crop (Singh, 2006). It was also observed that onion cultivation by bulblets was better than the seedlings due to quick establishment and better survivability in field condition.

Understanding how the onion plant grows and develop is a key part of developing a strategy to supply nutrients for optimum bulb yield and quality. The phenology of onion have five major growth phases viz., germination, leaf growth, bulbing/bulb initiation, bulb growth and maturation. Onion have an unusually long period of slow growth to the 3-leaf stage. During this period, root growth also occurs at regular pace. Maturation commonly is evaluated by the percentage of tops down and by the amount of dry leaves present. Achieving a proper degree of maturation before harvest is a key factor in producing high quality onions for storage. Hence, onion growth stages could be divided into three major stages viz., pre-bulbing (upto 45 days after planting), bulb formation (45-76 days after planting), and thereafter bulb development and enlargement takes place.

New roots are produced from the bulb basal plate as leaves develop above ground in pre-bulbing period. The bulbing growth stage is considered to begin when bulb diameter reaches twice that of the neck. Most onion varieties initiate bulb after 6-8 leaves have emerged. Leaves continue to emerge (12-14 true leaves) during bulbing and bulb growth which eventually coincides with maximum nutrient demand.

Onion being a heavy feeder of nutrients, although the amount of nutrient uptake by the crop is very small from germination to bulb initiation followed by rapid nutrient uptake from bulb initiation through bulb growth. Cumulative nutrient uptake by an onion crop follows a sigmoid curve. About 80% of nutrients present in plants at harvest are present in the bulb and remaining in the top. Crop response well to inorganic fertilizers (Kumar *et.al*. 2001), although onion have a shallow, sparsely branched root system with most roots remaining confined to top 9 cm soil throughout the season (Greenwood *et.al*.1982). The sparse, shallow rooting of onion has important implications for management of relatively immobile nutrients (P, K and Zn). The unbranched root system of onion is less effective than most crop plant in extracting immobile nutrients. Therefore, onion is more susceptible to nutrient deficiencies than most crops. On the other hand, shallow root system of onion are also an important consideration for efficient management of mobile nutrients such as NO_3^- N, and SO_4^- S. However, imbalanced inorganic nutrition has led to stagnation or even decline in soil productivity due to starvation of both macro as well as micro nutrients (nutrient mining) besides the degradation of soil biophysical properties.

One of the goals of nutrient management is to supply nutrients in a timely manner to maximise crop yield and quality. But in reverse case, an adverse effect of sub optimum supply of nutrients affects both yield and quality of onion (Brewster and Butler, 1989; Randle, 2000). The nutrient management strategy accordingly, changes whether to be executed on acidic or alkaline soil. Major soil fertility constraints vary greatly when acidic (low soil pH induced, Fe and Al-toxicity, acute shortage of Ca and Mg, excessive P-fixation, deficiencies of Zn, P and Cu) versus alkaline soil (high soil pH, excessive calcareousness, acute shortage N, P and all micro nutrients with salinity) is compared. Use of only nitrogen fertilizer is quite prevalent which is detrimental to the storage quality of onion (Chadha *et.al*. 2006). Manures like FYM, Pig manure, Vermicompost, poultry manure, compost are reliable and effective source of nutrients which can be readily assimilated by the crop (Mishra and Mishra, 2005).

The use of beneficial microorganisms in the form of biofertilizers have emerged as promising component of nutrient supply system in onion (Thamburaj, 1991). Being environment friendly and low cost, biofertilizers can play significant role in meeting the nutrient requirement of plants by mobilizing unavailable sources of elemental nitrogen, bound phosphates and decomposed plant residues into available form and at the same time enriching the rhizospheric soil by addition of growth promoting substances. Often the role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth attributing features and productivity indices (Jayanthilake *et. al.* 2002). Mixing organic manures with microbial biofertilizers has shown good response of onion on alfisol and ultisol belts of South East Asia (Warade *et. al.* 1995; Jayathilake *et. al.* 2002; Yadav. *et. al.* 2005; Shaheen *et. al.* 2007 and Mahantesh *et. al.* 2008a). Combination of *Azospirillium* and Phosphobacteria along with 45:45:30 kg NPK ha^{-1} produced much higher response than the application of recommended dose of 60:60:30 kg NPK ha^{-1}, which registered 18.3% higher increase in yield in addition to 25% saving of inorganic fertilizers input (Thilakavathy and Ramaswamy, 1998; Yadav *et.al.* 2005; Devi and Ado, 2005; Santhi *et.al.*2005 and Mahanthesh *et.al.* 2008a). Population of *Azospirillium brasilense* under field condition (sandy loam soil type with pH 7.5) was more with A*zospirillium* inoculation in the presence of fertilizers- N than the corresponding controls (Yadav *et.al.* 2005; Tilak and Saxena, 2008).

Integrated nutrient supply approach for the crops by judicious use of organic manures along with inorganic fertilizers has a number of agronomical and environmental efficiencies (Ahmed and Reddy, 2000). This approach is not only reliable for obtaining fairly high productivity with substantial fertilizer economy but also adds a concept of ecological soundness leading to sustainable production system (Singh *et.al.*2002). Studies have established much better growth parameters (plant height, number of leaves/plant, dry matter, accumulation in bulb), yield and yield attributes (bulb diameter and weight), quantity of bulb and nutrient uptake with combined application of biofertilizers, organic manures and chemical fertilizers over recommended doses of fertilizer irrespective of nature and properties of soil type (Warade *et.al.* 1995; Jayathilake *et.al*. 2003; Reddy *et.al.* 2004 and Mahanthesh *et.al.* 2008a).

Being a newly introduced crop in the region as off season, there is felt need to standardize the agro techniques based on location specific requirements. Keeping in view of the existing technology gaps, the present work entitled "**Effect of integrated nutrient management on growth, yield, nutrient uptake and storage life of onion**" cv. Agrifound Dark Red was carried out at Horticulture Research farm of SASRD, Medziphema during 2007-08 and 2008-09 with following objectives:

i. To study the effect of nutrient management on growth and yield of onion.
ii. To study the effect of nutrient management on nutrient uptake (N, P, K).
iii. To study the effect of nutrient management on fertility status of soil after harvest.
iv. To study the effect of nutrient management on storage life of onion.

Table 1: Chemical composition of onion bulb (per 100 g)

Content	Amount (per 100 g)
Edible portion	95
Moisture	86.6 g
Protein	1.2 g
Fat	0.1 g
Minerals	0.4 g
Fibre	0.6 g
Carbohydrates	11.1 g
Energy	50 K cal
Calcium	47 mg
Phosphate	50 mg
Iron	0.7 mg
Carotene	0 µg
Thiamine	0.08 mg
Riboflavin	0.01 mg
Niacin	0.4 µg
Vitamin C	11 mg

Source : Subbian *et.al.,* 2000

Chapter 2

Review of Literature

REVIEW OF LITERATURE

A good deal of research work has been done in India to evaluate the response of onion to applied organic manure as well as chemical fertilizers. However, the information is not up to the mark in relation to the combined effect of organic manures, biofertilizers and chemical fertilizers on improved varieties of onion with certain biofertilizers like *Azotobacter, Azospirillum* and PSB etc. The up-to-date literature available on these aspects has been reviewed in this chapter under the following headings:

v. Effect of integrated nutrient management on growth, yield and quality of onion.
vi. Effect of integrated nutrient management on nutrient uptake (N,P,K) by the plant.
vii. Effect of integrated nutrient management on fertility status of soil after harvest.
viii. Effect of integrated nutrient management on storage life of onion after harvest.
ix. Economics of onion production under various treatments.

2.1 Effect of integrated nutrient management on growth, yield and quality of onion

Muzika (1986) reported that when onions were grown as a 1-year or a 2-year crop with or without irrigation the best results were produced by 30 t FYM ha^{-1} + $N:P_2O_5:K_2O$ at 120-90:90:90 kg ha^{-1}, with increased yields of a 1-year crop by 45-48 centners ha^{-1} and of a 2-year crop by 63-68 centners ha-^{1} over the non-fertilized control. Raising the N rate to 180 kg ha^{-1} increased the yield only slightly and reduced storability.

Gurubatham *et. al*. (1989) in an experiment on the onion cultivar No.53 received N and P fertilization (schedule outlined) for 'biofertilizers' *Azospirillum* or vesicular arbuscular mycorrhizzas (VAM) were applied to the soil at planting or as a seed treatment. Bulb yields ranged from 15.9 t ha^{-1} in unfertilized control to 24.2 t ha^{-1} with 150 kg N - 150 kg P ha^{-1}. *Azospirillium* increased bulb yield from 19.1 t ha^{-1} to 20.0-20.5 t ha^{-1}. With the 2 biofertilizers, slightly better results with regard to yields were obtained when *Azospirillium* inoculum in a sticky paste was used to pellet the seed (100 g kg^{-1} seeds) or when VAM cultures were applied into the sowing furrows.

Galbiatti and Castellane (1990) conducted field trials with cultivar Piralopes, the plants received $N:P_2O_5:K_2O$ at 30:240:115 kg ha^{-1} or the effluent resulting from anaerobic digestion of cattle manure at 60 m^3 ha^{-1}, and were irrigated at 25, 50, 100 or 125% of daily evapotranspiration (average of 5 mm). Mean bulb yields were (14.1, 14.2, 25.0 and 30.9 t ha^{-1} at the 4 respective irrigation levels, and 23.8, 21.8 and 17.7 t ha^{-1} with mineral, organic and no fertilization, respectively.

Jana and Jahangir (1990) carried out field experiment in Darjeeling, India during 1985-87 on sandy loam soil (pH 5.6-6.2). Seedlings were transplanted in October at an inter-row spacing of 20 cm and an intra-row spacing of 15 cm, FYM at 20 t ha^{-1} was applied on all plots together with 100 kg N, 60 kg P and 100 kg K ha^{-1}. The full dose of P and K and half the N were applied before transplanting. Sulphur powder was applied at 0, 30, 40 and 50 kg ha^{-1}. Highest plant height (48.62 cm), number of leaves (9.14), bulb diameter (6.13 cm), root length (13.78 cm), weight of 10 bulbs (1.02 kg) and yield (30.69 t ha^{-1}) were obtained with sulphur at 30 kg ha^{-1}.

Singh and Sharma (1991) reported that increasing level of nitrogen upto 80kg N/ha increased diameter of bulb, dry weight of bulb and bulb yield of onion, 80 and 120 kg N/ha being at par. Nitrogen application at 80 ka/ha caused 38% increase in bulb yield over control.

Katwale and Saraf (1994) conducted field experiment on onion in Satpura plateau of M.P and reported that the onion bulb yield was highest with NPK at 125:60:100 kg/ha applied as urea, single super phosphate and murate of potash.

Singh and Singh (1995) studied on the response of onion to N, P, Zn and FYM and reported that the highest onion bulb yield (50.6 g pot^{-1}) was obtained from plants fertilized with FYM (10 tons ha^{-1}) + 40 kg N ha^{-1} + 60 kg P ha^{-1} on a sandy loam soil amended with N, P, Zn and/or farmyard manure (FYM).

Bhattarai and Subedi (1996) in an experiment to study the effect of cultivar (Red Creole and Mallajh) and manuring (FYM + NPK fertilizer or FYM alone) conducted over 7 outreach Research sites, marketable bulb yield responded to manuring practice only at Mallajh, Lower Salija and Hemja. At Hemja the marketable bulb yield with FYM alone was significantly higher than with FYM + NPK fertilizer whereas at Lower Salija and Mallajh it was higher with FYM + NPK application. Though the results were non-consistent across the sites, it seems likely that onion production can be successfully done purely under organic manuring practices.

Dixit (1997) carried out experiment on the evaluation of onions (N 53) grown on a silty loam with 5 rates of N (0, 40, 80, 120 and 160 kg ha^{-1}) in 10 treatment combinations with 2 rates of farmyard manure (10 and 20 t ha^{-1}) showed that increasing N application rates increased bulb yields upto 120 kg N ha^{-1}. Higher yields were also obtained with the higher farmyard manure rate.

Application of 120 kg N ha^{-1}, with 20 t farmyard manure, increased yields by 42.79% compared with the control.

Rumpel (1997) reported that onion yield were significantly higher with the combined fertilizer treatment (40 t FYM/ha + NPK at 150:100:200 kg/ha) compared to FYM alone which itself was significantly higher than NPK alone.

Singh *et al*. (1997) carried out experiment on the evaluation of organic manures viz., green manure, farmyard manure (25 t ha^{-1}) and vermicompost 2 t ha^{-1}, inorganic fertilizers viz., 100 kg N, 100 kg N - 50 kg P, 100 kg K - 25 kg P - 25 kg K and 100 kg N - 50 kg P - 50 kg K ha^{-1} in addition to control with no fertilizers and showed that organic fertilizers, farmyard manure produced the highest gross and marketable yield of 292.3 and 278.8 q ha^{-1}, respectively.

Stevens (1997) conducted an experiment and reported that at two adequately fertilized sites in the Columbia Basin, onion leaf tissue contained 2.5-3.5% K (on dry weight basis) at the 3-to-8 leaf growth stage, and root-K concentrations ranged from 3 to 5% (on dry weight basis) during the growing seasons.

Varu *et.al.* (1997) conducted a field experiment at Baroda in Gujarat to evaluate the effect of organic and inorganic fertilizers on onion. They found that the treatment of FYM + NPK + Dharatidhara gave the highest bulb yield (32.70 t/ha). This treatment also gave the highest bulb diameter, weight and volume.

Rumpel (1998) studied the effects of fertilizer application on the yield of onion Cv Blonska with the following treatments: an unfertilized control; farmyard manure (FYM) applied annually at 20, 40 or 60 t ha^{-1}, NPK applied at single, double or triple rates (single rate = 75 kg N, 50 kg P_2O_5 and 100 kg K_2O ha^{-1}) combinations of FYM at these rates and the double rates of NPK, the double rates of NPK + 10 kg Mg ha^{-1}, and PK, NK and NP (as in the double rates of NPK). FYM+NPK gave the highest marketable yields of bulbs (41.7, 44.2 ad 46.3 t ha^{-1}. respectively). FYM alone gave better results than NPK fertilizer only at low soil moisture, whereas with an adequate water supply, yields were similar for the 2 forms for fertilizer. Applying Mg had no beneficial effect. Fertilizers supplying only 2 of the 3 main nutrients (PK, NP or NP) produced low yields. The lowest yield, averaging 16.2 t ha^{-1} and of inferior quality was harvested from the unfertilized control.

Gupta *et. al.* (1999) revealed that FYM @ 72.0 q ha^{-1} along with ammonium sulphate @565 kg ha^{-1} were effective in increasing the growth, yield and quality contributing character such as bulb colour, compactness, TSS, dry matter and gave the highest net return.

Anonymous (2000) conducted a field trial at Karnal to assess the effect of different sources of nitrogen and foliar application of micronutrient on growth, yield and quality of onion variety Agrifound Light Red. They reported that application of NPK @ 100:50:50 Kg/ha + FYM @ 15 t/ha as basal dose and spray of polyfeed @ 1% at 15,30 and 40 DAP followed by multi K @ 1%, 60, 75 and 90DAP gave higher yield of onion bulbs under Karnal conditions.

Patel *et.al.* (2000) conducted a field experiment to study the effect of different sources of organic manures v/s chemical fertilizers on yield and quality of onion Cv. "White Local". The result revealed that the highest yield (75.17t/ha) and bulb diameter (67.71 mm) and bulb weight (138.13 g) as well as highest return were observed in FYM 32.5 t/ha along with 37.5 + 18.75 + 18.75 Kg NPK/ha and net profit (Rs. 1.17 lakh/ha).

Singh *et. al.* (2000) observed that onion productivity could be enhanced considerably by application of 100 kg N, 30.8 kg P_2O_5 and 83 kg K_2O ha^{-1}.

Singh *et. al.* (2001) conducted an experiment on the response of onion (*Allium cepa*) cv N 53 to the integrated application of nitrogen (0, 60, 90, 120 and 150 kg ha^{-1}) and farm yard manure (0, 5, 10 and 15 t ha^{-1}) and found that the average weight/bulb and bulb yield increased significantly up to 120 kg N ha^{-1} and farm yard manure (F) at 10 t ha^{-1}. However, maximum net returns and benefit:cost ratio was recorded with N application at 150 kg ha^{-1} and farmyard manure at 10 t ha^{-1}. When the bulb yield was described as a quadratic function of N x F, a combination of 148.88 kg N + 9.13 t farmyard manure ha^{-1} was found to be an optimum requirement for maximizing returns from the cultivation of rainy-season onion.

Yadav and Yadav (2001) evaluated the effect of NICAST (OM) in comparison to the recommended dose of manure and fertilizers in onion Cv. Ro 1. Out of various treatments, it was revealed that the treatments of recommended FYM (30 tonnes/ha) and recommended fertilizer (100:50:100 NPK Kg/ha) gave the highest significant bulb yield.

Alkaff *et.al.* (2002) evaluated the effect of biofertilizer (mixture of *Azospirillum, Azotobacter* and Klebsiella), mineral fertilizer, and farmyard manure on the bulb yields of onion Cv. Baftaim. The highest rate of increase in bulb weight (44%) was recorded with the mineral fertilizer, followed by the biofertilizer and FYM. The highest rate of increase in total yield was recorded by FYM, followed by mineral fertilizer and no biofertilizer.

Ayed Adelrazzag (2002) investigated the effect of chicken and sheep manure at rates 20, 40 and 80 t ha^{-1}, as well as inorganic fertilizers at rates of 400 kg N ha^{-1}, 200 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1} on yields, nutrient content, leaf area and dry weight of onion yield. The result revealed that there was no significant difference in yield of onion bulbs due to chicken manure in both years, but in general the yield increased significantly with sheep manure and inorganic fertilizer. In general, the yield of onion bulbs was higher in the second year compared with the first year. There was a significant difference in leaf area of onion only between sheep manure at level of 20 and 40 t/h with 20 t ha^{-1} of chicken manure only in first year.

Deho *et. al*. (2002) conducted a field experiment to determine the optimum dose of NPK fertilizers for the onion (*Allium cepa*), variety Phulkara on a loamy soil showed that compared to other fertilizer treatments, the application of 80 N - 60 P_2O_5 - 40 K_2O (kg ha^{-1}) produced more leaves and largest bulb size and gave the highest onion yield kg ha^{-1}.

Khalif *et. al*. (2002) conducted a field experiment at Sohag Governorate, Egypt, during 1999-2001 to study the effects of farmyard manure (FYM; 40, 50 and 60 m^3 $feddan^{-1}$) and chicken (20, 25, and 30 m^3 $feddan^{-1}$) manures on onion Cv shandaweel. N (100 kg $feddan^{-1}$ as urea) was also applied at 45 and 60 days after transplanting where as P (36 kg $feddan^{-1}$ as calcium superphosphate) was applied as basal dressing. K (24 kg $feddan^{-1}$ as potassium sulphate) was incorporated before transplanting. The tallest plants were obtained with 25 and 30 m^3 chicken manure $feddan^{-1}$. Chicken manure and inorganic fertilizers were more effective than FYM in increasing leaf number per plant. The highest average bulb weight, marketable bulb yield, and K content were recorded for 25 m^3 chicken manure $feddan^{-1}$. Chicken manures resulted in the highest total bulb yield, marketable bulb percentage, and P content. N content was highest with inorganic fertilizer application.

Paula *et. al*. (2002) found that the highest bulb yield was obtained with K_2SO_4, K_2SO_4, $MgSO_4$, and KCl + phosphor gypsum at 338 kg ha^{-1}. Gypsum addition to KCl also improved bulb storage and increased leaf and soil S contents compared to KCl alone. Bulb soluble solids, pyruvic acid and acidity as well as K, Ca, Mg and N in leaf dry matter were not affected by the treatments.

Santhi *et. al.* (2002) conducted soil test crop response correlation studies with onion under integrated plant nutrition system. Fertilizer adjustment equations under IPNS were formulated for onion. The nutrient requirement for producing one quintal of fresh onion bulbs was found to be

0.375, 0.329 and 0.466 kg of N, P_20_5 and K_20 respectively. The percent contributions from soil and fertilizer nutrients were found to be 14.13 and 38.28 for N, 35.33 and 56.61 for P_20_5 and 14.33 and 70.03 for K_20 respectively. Likewise, the percent contributions from farmyard manure (FYM) and FYM + *Azospirillum* were 20.32 and 22.51 for N, 16.55 and 17.12 for P_20_5 and 25.17 and 25.66 for K_20 respectively. The percent contribution of N from *Azospirillum* was found to be 22.38. The quantity of fertilizers that could be adjusted to the levels and sources of organic manures was evaluated to be 36, 15 and 27 Kg/ha of N, P_20_5 and K_20 respectively, for fertilizers with FYM; 12 Kg/ha for fertilizer with *Azospirillum* and 52, 16 and 27 Kg/ha of N, P_20_5 and K_20 respectively for fertilizers with FYM + *Azospirillum.*

Anonymous (2003) reported that among the manures and basal application, use of FYM @ 10 t/ha + vermicompost @ 2 t/ha + S @ 20 Kg/ha + NPK @ 50:50:50 Kg/ha performed better and gave higher yield of onion bulbs at Nasik.

Aziz Qureshi *et. al*. (2003) observed that nitrogen (as Nitrogold) equivalent to 60% of RDF alongwith P (single superphosphate) and K (muriate of potash) produced significant effect on all the growth parameters of onion.

Naik and Hosamani (2003) conducted field experiment during 1997-99 to investigate the effect of spacing (15 x 10, 15 x 15 and 15 x 20 cm) and N level (0, 50, 100, and 150 kg ha^{-1}) on the growth and yield of kharif onion under rainfed condition of Dharwad, Karnataka, India. Narrow spacing of 15 x 10 cm with application of 15 kg N ha^{-1} was found optimum for enhancing yield (169.02 q ha^{-1}) and other growth and quality parameters, such as plant height, leaf number per plant, bulb length, bulb diameter and bulb total soluble solid content. The maximum net return and benefit cost ratio were also recorded from this treatment combination.

Tumbare and Pawar (2003) showed that application of 100% inorganic fertilizer dose (100 kg N, 50 kg P and 50 kg K ha^{-1}) to onion crop preceded by soybean to which inorganic fertilizer with 25% nitrogen substituted through farmyard manure recorded the highest yield of onion bulbs. However, it was on a par with that of 75% recommended dose applied to onion, indicating a saving of recommended dose of fertilizer to the extent of 25% to onion crop in soybean-onion cropping sequence owing to substitution of 25% through farmyard manure to preceding crop of soybean. The substitution of nitrogen through farmyard manure and addition of bioinoculant (Rhizobium + phosphate-solubilising bacteria) and in-situ incorporation of soybean straw along with inorganic fertilizers registered minimum losses due to rotting, sprouting and physiological weight loss during both the years compared to application of only inorganic fertilizer.

Yadav *et. al.* (2003a) reported that the highest plant height (56.25 cm), fresh weight of bulb (49.83 g) and yield (247.79 q ha^{-1}) were obtained with 150 kg K ha^{-1}.

Banafar *et.al.* (2004) conducted field experiment to study the effect of various organic manures in combination with chemical fertilizers on growth, yield and quality of garlic. The result revealed that the highest yield of bulb/ha was recorded with N 100, P_20_5-60 + 100 Kg K20 ha^{-1} + FYM 10 t ha^-1 which produced 70 % and 93 % additional bulb yield. The highest diameter of bulb and yield were obtained with N 100 + P_20_5 + 100 Kg K_20 ha^{-1} + FYM and this treatment registered the highest gross return of 1,01,560/ha.

Nasreen and Hussain (2004) reported that application of N, P, K, S and Zn showed significant influence on nutrient uptake, yield and yield attributes of onion. Significantly, highest bulb yield, maximum net return and benefit cost ratio were obtained by applying 100 kg N, 100 kg P_2O_5, 100 kg K_2O, 20 kg S and 5 kg Zn ha^{-1}.

Sharma *et.al.*(2004) found that application of vermicompost 3 t/ha with 50 % recommended dose of NPK recorded the highest yield 254.90 q/ha at par with recommended dose of NPK @ 150:100:50 Kg/ha. Vermicompost 3 t/ha with 25% dose of NPK and vermicompost 3 t/ha alone increased the onion yield by 57.78 and 40.22 % respectively over no use of fertilizer and organic manure.

Abu-Rayyan and Al-Hadidi (2005) found that the highest N dose of 140 kg N ha^{-1} showed the highest potential producing dry yield especially the marketable (1^{st} + 2^{nd} categories) in both seasons. Also, it showed the lowest waste global nitrogen quantity (51 kg ha^{-1}). The 150 kg N ha^{-1} dose was found to be the closest one to the optimum dose, since the 140 kg N ha^{-1} dose gave the best results, but the onion plants still needed 11 kg N ha^{-1}, while at 160 kg N ha^{-1} about 25 kg N ha^{-1} were wasted. For higher doses, the wasted nitrogen space increased as more nitrogen is added and the impact on the environment became heavier.

Dimri and Singh (2005) reported that application of FYM @ 15 tonnes per hectare produced the highest bulb weight i.e. 74.75 g (1996) and 72.38 g (1997-98) with total onion yield of 291.02 q ha^{-1} (1996-97) and 233.75 q ha^{-1} (1997-98).

Singh *et. al.* (2005a) observed that application of FYM @ 20 t ha^{-1} + neemcake @ 1 t ha^{-1} + S@ 20 kg ha^{-1} + NPK @ 50 : 50 : 50 kg ha^{-1} as basal and *Trichoderma viride* @ 1.25 kg ha^{-1} at 50 DAP + groneem @ 0.4% at 30, 45 and 60 DAP and macozeb @ 0.25% at 60 and 70 DAP and N @ 50 kg ha^{-1} in two splits at 30 and 50 DAP performed better in giving higher gross yield (407.99 q ha^{-1}), marketable yield (383.37 q ha^{-1}), bulb diameter (6.19 cm) and bulb size index (24.46 cm^2).

El-Desuki *et. al*. (2006) observed that mixture of Nitrobeine + Phosphorene (biofertilizers that are commercial products containing active microorganisms responsible for fixation of nitrogen and hydrolyzing insoluble phosphate into soluble one, respectively) gave the highest values of all parameters (6.05 tons fed^{-1} marketable yield, 188.8 g bulb weight, 13.1% TSS, 16.5% carbohydrate, 2.46% N, 0.65% P and 2.06% K) followed by adding nitrobeine alongwith 100% of mineral fertilizers. But the lowest values were recorded with using Phosphorene. As for the interaction effect, results clear that adding 70% of the recommended dose of mineral fertilizer with the mixture of nitrobeine + Phosphorene gave the best vegetative growth, bulbs yield and quality.

Jha *et. al*. (2006) observed that co-inoculation of VAM with non-symbiotic N_2-fixing PGPR (plant growth promoting rhizobacteria strains proved to be the best treatment to promote growth and yield of onion. Dual inoculation could meet almost 50 percent of the nitrogen and phosphorus demand of the crop. All the traits studied, showed a significant increase with the application of half of the recommended dose of N and P along with *Endogoneduseii* (VAM) and PGPRs. The better performing PGPR were *Azospirillium brasilense* CD, *Azotobacter chroococcum* CBD-15, fluorescent *Pseudomonad* strains PF-1 and PF-IV. The soil available nutrients, especially N, after crop harvest were moderately improved.

Lee *et. al*. (2006) carried out a study to evaluate the effect of liquid pig manure (LPM) on the nutrient uptake, yield of onion and soil properties. The LPM applied to onion field contained 4.2 g L kg^{-1} N, 0.34 g L kg^{-1} P, 1.2 g L kg^{-1} K and it was diluted with water by 1:2 top dressing, which was applied separately 4 to 6 times from February to April. The LPM application rate for basal fertilization was 19,280 kg L ha^{-1} which included 80 kg N, 6.6 kg P, and 22 kg K. The application rate for top-dressing was 101, 910 kg L ha^{-1} which included 160 kg N, 13 kg P, and 53 kg K.

Aisha *et. al.* (2007) found that addition of organic nitrogen fertilizer (Town refuse) at higher rate (4 tons $fedden^{-1}$) resulted the heaviest tonnage of onion bulbs yield, i.e.11.96 and 15.429 tons fed^{-1} in 1st and 2nd season respectively as well as the better physical average bulb weight, length and diameter as well as chemical values i.e. TSS, N, P, K, Cu, Mn, Zn an Fe in bulb tissues. The application of organic nitrogen at two levels and natural P and K caused a great effect on plant growth, total bulbs yield and its physical and chemical properties. By other means the best vigor growth and the heaviest bulbs yield as well as the best values of physical and chemical properties, all of them were obtained with that of onion plant which received the higher organic nitrogen rate (4 tons fed^{-1}) and the highest P and K levels (100:100 for each per fed).

Nasreen *et. al.* (2007) suggested application of 120 kg N – 40 kg S – 90 kg P_2O_5 – 90 kg K_2O – 5 kg ZnO – 5 tons cowdung ha^{-1} as optimum INM combination for onion production in Grey Terrace soil (AericAlbaquept) representing Chhiata series at Joydebpur, Bangladesh.

Keniseto *et.al.* (2009) conducted experiment at the Experimental Farm of School of Agricultural Sciences and Rural Development, Medziphema, during August to December 2004 to find out the effect of integrated nutrient management on growth, yield and quality in rainfed onion (cv. N-53) under terraced condition of Nagaland and it was concluded that integration of 50% organic manure (FYM @ 10 t ha^{-1}) and 50% chemical fertilizer (50:25:25 kg ha^{-1} NPK) recorded the maximum growth, yield and quality in rainfed onion (cv. N-53) under terraced condition of Nagaland.

Sharma *et. al*. (2009) studied under field conditions on the effect of applying organic manures (vermicompost and farmyard manure) and inorganic fertilizers on yield and nutrient uptake by okra (*Abelmoschus esculentus*) – onion (*Allium cepa*) and nutrient build up in the soil. Highest yield of *okra* was recorded in the treatment comprising 100% recommended NPK + vermicompost @10 t ha^{-1}, 11.10 and 11.63 t ha^{-1} during 2003 and 2004, respectively. Similarly, maximum yield of onion was observed in plots receiving 100% recommended NPK plus 25 t vermicompost ha^{-1} during both the years i.e. 9.83 and 14.67 t ha^{-1} during 2003-04 and 2004-05, respectively. Similarly yield of onion obtained at 12.5 t vermicompost ha^{-1} plus 100% NPK (8.38 and 12.56 t ha^{-1} during 2003-04 and 2004-05) was at par with that under 25 t farmyard manure ha^{-1} plus 100% NPK (8.86 and 12.08 t ha^{-1} during 2003-04 and 2004-05). This demonstrated the superiority of vermicompost over farmyard manure in okra-onion sequence.

Yeptho *et.al*. (2009) reported that the treatment poultry manure + *Azotobacter* caused maximum weight of bulb (81.31 g) and significantly superior to most of the treatments except with the treatment poultry manure @20 t/ha where it statistically remained at par. The application of FYM at 40 t/ha in combination with *Azotobacter* proves next best treatment with regard to weight of bulb. The highest yield of 203.33 q/ha was recorded with treatment poultry manure + *Azotobacter*.

Bagali *et.al*. (2012) reported that higher level of inorganics i.e., M_3 (162:32:148 kg NPK/ha) produced significantly higher bulb yield (41.55t/ha) which was on par with M_2 i.e., 81:16:74 kg per ha (41.09 t/ha). When compared to RPP none of the inorganics levels were found significant for growth and yield parameters and yield. With organics, significantly higher and on par bulb yield of 40.56, 41.65 and 40.88 t per ha was recorded with FYM 30 t per ha (S_2), vermicompost@ 6 t per ha (S_4) and poultry manure @ 3 t per ha (S_6) respectively, compared to their respective lower levels. The combination of higher levels of inorganics (M_2 and M_3) with higher levels of organics (S_2, S_4 and S_6) recorded higher bulb yield. When compare to RPP, none of the treatment combinations were found significantly different for growth and yield parameters and yield.

Prabhakar *et.al.*(2012) studied the effect of levels of organic manure and conventional practices on growth, yield and quality of rose onion (*Allium cepa* L.) and found that the treatment which received 100 % recommended N (RDN) equivalent through organics produced highest yield of 21.06 tonnes/ha, which was followed by the treatment received 75 % RDN through organics and conventional practices (20.91 and 19.44 tonnes/ha). Plant growth characters such as plant height (32.5 cm), number of leaves/plant (8.5), leaf area/plant (375 cm) and leaf area index (5.95) were also higher in this treatment resulting in better bulb yield. Yield parameters like bulb diameter (3.8 cm) and mean bulb weight (21.7g) were also higher in organic treatments that received 75 to 100 % nitrogen equivalent.

Raju *et.al.*(2013) carried out field experiment and found that significantly higher values of all growth attributes parameter were recorded in the treatment (T_7) i.e, application of 75% RDF + 1.65 t ha^{-1} VC and *Azotobacter*, PSB each 5 kg ha^{-1} to the crop found to be sound integrated practice, where it recorded maximum plant height (84.95 cm), number of leaves (11.02), chlorophyll content (1.66 mg 100 gm-1), diameter of bulb (7.33 cm), weight of bulb (75.26 gm), yield (11.23 kg plot-1, 416.04 q ha^{-1}), total soluble solids (14.26%), oleoresin content (249.12gm kg^{-1}) over all the treatments. Whereas minimum (0.94 cm) neck thickness was recorded in control and minimum (120.53) days required for maturity was observed in T_{12} i.e, RDF + *Azotobacter* and PSB each 5 kg ha^{-1}.

2.2 Effect of integrated nutrient management on nutrient uptake (N,P,K) by the plant

Inorganic fertilizers once applied in soil, bring definite changes in supply level of nutrients in soil, and accordingly, nutrient uptake pattern is governed which eventually dictates the quantum of yield response. Nitrogen supplied to onion crop comes from several sources. The available N supply is made of: i. preplant soil NO_3-N and NH_4-N, ii. N mineralized from crop residues and soil organic matter, iii. N supplied in irrigation water, and iv. fertilizer-N applied (Brown 1997).

Patel *et. al*. (1992) observed that the N and P uptake were greater with application of 120 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1}.

Sharma and Raina (1994) reported that P application to an onion crop grown on an Alfisol increased bulb yield and P uptake. However, incorporation of 10 t FYM ha^{-1} along with P, generally further improved bulb yield ad P uptake. P use efficiency both from fertilizer and native soil sources was highest at 30 kg P ha^{-1} and declined as P application rates increased up to 120 kg ha^{-1}. The overall increase in P use efficiency was 26% following FYM application.

Subbian (1994) reported that 50, 75 and 100% of recommended N dose + 100% of P had significant effect on nutrient uptake.

Vimala and Yoeng (1994) demonstrated that 48 kg N, 8 kg P_2O_5 and 45 kg K_2O ha^{-1} are removed by 33 t ha^{-1} bulb yield.

Mallanagouda *et. al.* (1995) conducted an experiment on the nutrient management on onion and found that the highest uptake of N, P and K (186.32, 24.61 and 102.09 kg ha^{-1}, respectively) was reported with the application of recommended rate of FYM + NPK.

Chee *et. al*. (1998) reported that the combined application of vermicompost and mycorrhizal inoculation slightly decreased arbuscular colonization without affecting yields of Long White onion (*Allium cepa*), but on the contrarily increased P and K content, demonstrating that simultaneous application of 2 or more biofertilizers is not always applicable.

Geetha *et. al.* (1999) reported that application of FYM @ 25 t ha^{-1} and K fertilizer @200 t ha^{-1} i.e., muriate of potash and interaction of both increased the day matter production, K content, K uptake and bulb yields of onion at harvest of the crop.

Boff *et. al.* (2000) reported that thermophilic compost (produced from ground *Penniselum purpureum*, cattle manure and rotten onion bulbs) increase emergence and survival of onion cv. Crionla plantlets compared with mineral and organo-mineral fertilizer.

Halverson *et. al*. (2002) reported that Nitrogen use efficiency of onion, based on soil NO_3-N (0-60 cm depth) plus fertilizer-N applied (total of 579 kg N ha^{-1}), was very low. Total N uptake in tops plus bulbs, based on dry matter (DM) accumulation and plant N concentration, was only 80 kg N ha^{-1}, with a nitrogen use efficiency (NUE) of 13.8% or 9.2 kg DM ha^{-1} kg^{-1} available N for the 224 kg N ha^{-1} fertilizer treatment. With no N fertilizer applied, NUE was 17% or 12.5 kg DM ha^{-1} kg^{-1} available N. Nitrogen use efficiency based on bulb N removal or harvested portion of the crop was 7.3 kg DM ha^{-1} kg^{-1} available N for the 224 kg N ha^{-1} fertilizer treatment. Total NUE was 11.4% for N removal in bulbs. With no fertilizer N applied, NUE was 12.8% for N removed in bulbs. Nitrogen use efficiency was low because of the high level of available N in the root zone at planting compared with the total amount of N taken up by the onion plants.

Mathuramalingam *et. al*. (2002) reported that the plot treatment with closer spacing of 45 x 5 cm and higher dose of manurial treatment 60:60:30 kg ha^{-1} along with FYM at 25 ha^{-1}, *Azospirillum* at 2 kg ha^{-1} and *phosphor bacterium* at 2 kg ha^{-1} recorded highest uptake of N, P and K nutrients and resulted in maximum bulb yield.

Santhi *et. al*. (2005) reported that the uptake of N in treated plots recorded a range of 41.17-69.63, 42.92-71.14, 44.51-72.50 and 41.14-72.06 kg ha^{-1} with mean values of 53.74, 59.85, 60.19 and 62.18 kg ha^{-1} in strips S I, S II, S III and S IV respectively. The P uptake ranged from 12.06-32.52, 14.76-33.78, 14.47-34.19 and 12.4-33.37 kg ha^{-1} with mean values of 24.12, 26.46, 26.25 and 27.15 kg ha^{-1} in strips S I, S II, S III and S IV respectively. Regarding the uptake of K, the range was 35.65-70.48, 41.34-77.03, 44.57-77.77 and 39.37-78.17 kg ha^{-1} with mean values 51.87, 63.77 and 65.47 kg ha^{-1} in strips S I, S II, S III and S IV respectively.

Singh *et.al.* (2005b) observed that nitrogen (84.52 and 84.68 kg ha^{-1}) and potassium uptake (81.24 and 82.00 kg ha^{-1}) was recorded significantly higher with application of N_{150} and K_{120} levels respectively than the lower doses of nitrogen (N_{50} and N_{100}) and potassium (K_{40} and K_{80}).

De Laune *et. al*. (2006) observed that composted poultry litter regardless of treatment, had higher P concentration than fresh poultry litter and reduced N/P ratio by as much by 51%.

Lester and Jifon (2007) reported higher concentration of potassium in onion bulb due to soil application of KNO_3 and foliar spray of calcium chloride.

Nasreen *et. al.* (2007) observed the antagonistic effect of nitrogen and sulfur on the uptake of N (433 kg ha^{-1}) and S (56 kg ha^{-1}) by bulb, yield components and yield on onion (Var. BARI Piaz-1) when they were applied together at higher rates of nitrogen (160 kg ha^{-1}) and sulfur (40 kg ha^{-1}) on AericAlbaquept soil type.

Tilak and Saxena (2008) conducted laboratory and field studies to study the response of onion (*Allium cepa* L.) var. Pusa Red to inoculation with *Azospirillium brasilense*. Extensive colonization by the organism occurred when plants were grown in field under unstertile conditions. Seedlings of eight weeks when inoculated with *A.brasilense* increased the mean bulb yield for three years. The mean increase in bulb due to inoculation over uninoculated control was also seen with increasing levels of fertilization nitrogen (urea). Inoculation alone constituted for increased nitrogen uptake of onion with varying fertilizer N application under sandy loam conditions (pH: 7.5). The effects of inoculation were more prominent at lower levels of nitrogen than at higher levels. The population of *Azospirillium* under field conditions was also more with *Azospirillium* inoculation in the presence of fertilizer N than the corresponding controls.

Yeledhalli and Ravi (2008) found that using potassium nitrate as a source of nitrogen alone or in combination with FYM gave the highest values of N, P and K content in leaves and bulbs, whereas the lowest values were obtained by urea alone as a source of nitrogen. The P concentration of leaf and bulb was 0.19% due to 100 per cent RDN (Recommended dose of nitrogen) through urea which increased to 0.25 and 0.32 per cent in leaf bulbs due to 75 per cent RDN through FYM and 25 per cent RDN through KNO_3

2.3 Effect of integrated nutrient management on fertility status of soil after harvest

Singh and Singh (1993) reported that the available nutrients in soil after the crop harvest increased significantly with increase in the rates of N application. The highest available N and P contents in soil were recorded in the treatment $N_{40}P_{60}$ + FYM which were significantly higher than those under all other treatments.

Sharma *et. al.* (2003) conducted an experiment on the effect of combined use of NPK and farmyard manure on the yield and nutrient uptake by onion and observed that application of fertilizers at the rate of 100 (125 kg N, 33 kg P and 50 kg K ha^{-1}) and 150% (187 kg N, 49 kg P and 75 kg K ha^{-1}) of recommended dose registered an increase of 42% and 56% over 50% NPK dose in bulb yield on onion. Use of NPK fertilizers along with farmyard manure also resulted in significant improvement in available NPK status of soil.

Patil *et.al*. (2005) carried out an experiment with sixteen treatment combination s of four levels of flyash (viz., 0, 5,15 and 30 t ha^{-1}) and four levels of FYM (viz., 0, 5,15 and 30 t ha^{-1}) in onion and reported that the available phosphorus and nitrogen content in soil was increased with the increasing levels of flyash and FYM.

Yadav *et.al*. (2005) revealed a slight increase in available nitrogen content in soil with increasing dose of nitrogen in all the samplings. Highest nitrogen content was recorded with 100 % recommended dose and lowest in control. A significant increase in available nitrogen was found in 1^{st} sampling during second year, in 2^{nd} sampling during second and third year. In 3^{rd} sampling i.e., after harvest of crop, no significant difference in available nitrogen was observed in all the years. As regards application of *Azospirillum*, a increasing trend of available nitrogen content in soil for all the samplings was found and significant difference was noticed in 2^{nd} sampling of third year and 3^{rd} sampling of first year only. The increase in available nitrogen was 10.97 and 11.14 kg/ha, respectively.

Singh and Pandey (2006) conducted experiment with 9 different modules involving NPK (50, 75 and 100% recommended dose), FYM (10 t ha^{ha-1}) and *Azotobacter* (200 g culture $litre^{-1}$ solution) and reported that available N, P, K and S status of soil was significantly higher than initial status under almost all the treatments. Improvement in N, P and K was noted due to increase in the rate of NPK from 50% to 100% of the recommended dose. An application of 75% NPK + FYM showed a significant increase in the status of available nutrients over the control. The increase in available NPK and S with 75% NPK + FYM + *Azotobacter* were 100.3, 9.0 and 51.0 kg ha^{-1} and 2.9 mg ka^{-1} over the control, respectively

Sharma *et.al*. (2009) reported that after completion of the experiment, the highest available NPK content (303, 28.1, 345 kg ha^{-1}, respectively) were recorded in case of the treatment consisting of 10 t vermicompost ha^{-1} to *okra* and 25 t vermicompost ha^{-1} to onion along with 100% NPK to these crops.

2.4 Effect of integrated nutrient management on storage life of onion after harvest

Very limited effort has been made to prolong shelf life of onions through improved plant nutrition. Plant nutrition has a definite role in shelf life of onion bulbs, e.g., After 54 days of storage, 70% of B-deficient bulbs had rotted and the others had lost most fresh weight than normal bulbs during the same period (Calbo *et. al*. 1986).

Pandey and Pandey (1994) conducted an experiment on the storage of onion and found that as N application rate during production increased, postharvest storage losses due to sprouting, rotting, rooting, moisture loss and weight loss increased. As MH (Maleic hydrazide) concentration increased (0 to 3500 ppm), these losses decreased; spraying 21 days before harvest gave the best results.

Lancaster *et. al*. (2001) investigated the effect of sulphur nutrition on bulb quality. It was showed that the storage was adversely affected due to low supply of sulphur and it was revealed that S content in cell walls of bulb was reduced leading to reduced firmness of bulbs and pungency.

Mohanty *et. al*. (2002) observed that the varieties such as Pusa Madhavi, Arka Niketan and Punjab Red Round had the greatest potential for better storage quality. It was found that rabi cultivars grown in kharif season can produce equally good yield as that of kharif cultivars. Agrifound Dark Red was suggested for cultivation during kharif season since it had larger bulb elucidating poor keeping quality. Arka Niketan and Punjab Red Round with better keeping quality, medium bulbs and moderate yield were advocated for large scale cultivation during kharif season.

Singh *et. al*. (2002) observed lowest decay and total weight loss of stored onion with basal application of FYM at 25 tons ha^{-1}.

Aziz Qureshi and Lawande (2006) observed that storage losses were reduced by 10.4% over a period of 6 months storage due to application of S @ 45 kg S ha^{-1} in comparison to only NPK treatment. Simple linear regression analysis revealed significant negative correlation between storage losses of onion bulbs taken as dependent variable and pyruvic acid and total soluble solids as independent variables.

2.5 Economics of onion production under various treatments

Warade *et. al.* (1995) conducted an experiment on onion and found that the highest bulb yield (27.7 t ha^{-1}) and cost: benefit ratio was obtained with 40 t FYM + 50 kg P_2O_5 ha^{-1}.

Kumar and Singh (1996) working on garlic variety White skin found that when plants were supplied with 0, 50, 100 or 150 Kg N/ha,0, 40 or 80 Kg P_20_5 and 0 or 60 Kg K_20/ha, the highest yield (134.8 q/ha) was obtained with 100 kg N+80 kg P_20_5 + 60 Kg K_20/ha. This treatment resulted in highest net returns and cost benefit ratio.

Bhonde *et. al*. (1997) conducted field trials at the Regional Research Station, Nasik, India during 1993-96, onion Cv Agrifound Light Red. The seedlings were transplanted to the flat beds (1.5 x 1.5 m) after dipping for 5 min in a solution of *Azotobacter* (1500 g in 50 litres water). Fertilizer treatments were: farmyard manure (FYM) + N at recommended rate (RR) [not specified]; *Azotobacter* + FYM RR; *Azotobacter* + N at 100, 50, or 25% of RR; and *Azotobacter* + NK at RR. *Azotobacter + 50%* N gave the highest market yield (230.62 q ha^{-1}) with a net return of Rs. 37,196 ha^{-1}. Azotobacter+ 100% N gave net return of Rs. 35,773 ha^{-1}.

Chapter 3

Materials & Methods

MATERIALS AND METHODS

The present investigation entitled “Effect of integrated nutrient management on growth, yield, nutrient uptake and storage life of onion” cv. Agrifound Dark Red was conducted at the Horticulture Research farm of the School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema, Nagaland, during the year 2007-08 and 2008-09. The details of material used and procedures adopted/followed during the investigation for recording various observation and analysis are presented below:

3.1 Experimental site

The experimental farm is located in the foothills on Nagaland at an altitude of 304.8m, above mean sea level with the geographical location of 25° 45’43” N latitude and 93° 53’04”E longitude.

3.2 Climatic condition

The site of the experimental area enjoys sub-tropical climate with high humidity and moderate temperature with medium to high rainfall. The temperature ranges from 12°C during winter to 32°C during summer. The average annual rainfall varies from 2000 to 2500 mm, occurring over about 6 months *i.e.* April to September. However, the remaining period from October to March receive very lesser amount of rainfall. A more informative description of the climate is represented in ombrothermic diagram recorded at the meteorological observatory of ICAR for NE region situated about 2 Km away having identical agro-climatic condition.

3.3 Collection of Soil sample

Soil samples from a depth of 0-15 cm were collected from 15 different locations of the experimental field randomly with the help of a screw auger. The soil sample was then dried in shade and ground with a wooden roller after removing the inert materials and plant debris to pass through 2 mm sieve.

Table 2 (a). Meteorological data of Medziphema area during the period of investigation (September 2007 to February 2008)

Month	Temperature (°C)		Mean	Total rainfall (mm)	Relatively humidity
	Max	Min			
September 2007	30.2	23.0	26.6	214.0	85
October 2007	29.0	20.1	24.55	198.9	85
November 2007	26.0	16.0	21.0	076.0	83
December 2007	22.3	11.0	16.65	014.5	80
January 2008	22.0	10.0	16.0	030.1	78
February 2008	22.4	10.0	16.2	014.2	78

Table 2 (b). Meteorological data of Medziphema area during the period of investigation (September 2008 to February 2009)

Month	Temperature (°C)		Mean	Total rainfall (mm)	Relatively humidity
	Max	Min			
September 2008	30.35	23.05	84.00	286.60	88.00
October 2008	23.38	20.70	87.09	22.67	87.09
November 2008	26.79	13.80	83.00	4.83	83.00
December 2008	24.50	12.40	81.00	6.50	81.00
January 2009	23.70	9.50	78.00	0.00	78.00
February 2009	27.90	10.00	77.00	5.10	77.00

Source : ICAR Complex, Jharnapani

Table 3: Initial fertility status of experimental plots

Parameter	Value	Status	Method employed
pH	5.1	Acidic	Digital pH meter (Single electrode meter)
Organic carbon (%)	2.11	High	Walkley and Black method, Rapid titration method (Piper, 1966)
Available N (kg ha^{-1})	248.8	Low	Micro-Kjeldhal method (Black 1965)
Available P_2O_5 (kg ha^{-1})	11.8	Medium	Spectrophotometer Vanado molybdate yellow color method (Jackson, 1969)
Available K_2O (kg ha^{-1})	178.3	Medium	Flame photometer (Chapman and Pratt,1961)

3.4 Composition of organic manures

Locally available FYM, pig manure, poultry manure and vermicompost which were used in the present investigation were actually intended by the authority of the University, SASRD, Medziphema from recognized dealer and analysed the same for available Nitrogen, Phosphorus and Potash and data are given below:

Source	Nitrogen (%)	Phosphorus (%)	Potash (%)
FYM	0.50	0.20	0.35
Pig manure	1.00	0.50	0.60
Poultry manure	2.14	0.22	1.52
Vermicompost	3.00	1.00	1.50

3.5 Experimental Details

Experimental design : Randomized Block Design

Number of treatments : 16 (Sixteen)

Number of replication : 3 (Three)

Plot size : 1.5 m x 1.5 m

Treatments

T_1	:	Control
T_2	:	100% RDF(120:60:60 NPK)
T_3	:	FYM @30 MT/ha
T_4	:	Pig manure @ 20 MT/ha
T_5	:	Poultry manure @10 MT/ha
T_6	:	Vermicompost @6 MT/ha
T_7	:	50% RDF + 50% FYM @15 MT/ha
T_8	:	50% RDF + 50% Pig manure @10 MT/ha
T_9	:	50% RDF +50% Poultry manure @5 MT/ha
T_{10}	:	50% RDF + 50% Vermicompost @3 MT/ha
T_{11}	:	50% RDF + *Azotobacter*
T_{12}	:	50% RDF + *Azospirillum*
T_{13}	:	50% RDF + Phosphotica
T_{14}	:	75% RDF + *Azotobacter*
T_{15}	:	75% RDF + *Azospirillum*
T_{16}	:	75% RDF + Phosphotica

3.6 Planting and after care

The experimental field was thoroughly prepared to well fine tilth, breaking all clods as well as eliminating all weeds. The plots were then made on flat land with a size of 1.5 x 1.5 m that were prepared in a raised manner to avoid water accumulation under terraced conditions. Recommended doses of organic manures *i.e.* FYM, pig manure, poultry manure and vermicompost were incorporated at the final stage of field preparation. Full dose of P, K, and half dose of N were applied each year at the time of planting and the remaining half dose of N was applied 30 days after planting in respective plots. For the biofertilisers, the bulblets were dipped in treatment slurries at the rate of 10 g/kg bulblets and then dried under shade before planting. Experimental plots were treated with *Trichoderma* to minimise the incidence of damping-off disease. The bulblets were planted on 3rd September in both the years at a spacing of 10 x 15 cm accommodating about 110 bulblets per plot. Intercultural operations like mulching, weeding, hoeing and earthing up was carried out. Mulching was done after planting with dried thatch grass inorder to conserve moisture. Weeding was done manually to keep the experimental plots clean as well as to reduce the crop weed competition. Hoeing and earthing up were also carried out at an interval of 2 weeks to keep the soil loose which facilitates proper aeration. Irrigation was given in absence of rainfall as and when required. The detail of the layout of experimental plots is presented in Fig.2

3.7 Sampling and observation recorded

For recording the observation on various morphological growth parameters, five plants in each plot were selected randomly and tagged for recording the observations at an interval of 15 days throughout their growing period.

3.7.1 Growth parameters

3.7.1.1 Plant height

Observation on the height of the plant was started at 15 days after planting and continued upto 120 days at an interval of 15 days. The height of the plant was measured from the ground level to the tip and the mean values were calculated in terms of centimetre.

3.7.1.2 Number of leaves/plant

The leaves of tagged plants from each plot were counted in each plant and their average values were estimated.

3.7.1.3 Leaf area index

The leaf area was determined with the help of a leaf area meter and their values represented in terms of square centimetre (cm^2).

3.7.1.4 Neck thickness

After 45 days of planting, the neck thickness of the tagged plants were measured with the help of vernier calliper and the data thus obtained were represented in centimeter.

3.7.1.5 Doubling

Number of doubles from each plots were counted after harvest and their average values were expressed in percentage.

3.7.1.6 Bolting

The number of boltings in each plots were recorded and continued till harvest and their average values were expressed in percentage.

3.7.2 Yield and yield attributes

3.7.2.1 Diameter of the bulb

Diameter of each bulbs from 5 tagged plants were measured with the help of vernier calliper at the mid point of the bulb, and the result thus obtained were expressed in terms of centimetre (cm).

3.7.2.2 Weight of the bulb

The fresh weight of each bulb from the five selected plants were recorded after harvest with the help of weighing balance and the average bulb weight for each treatment was worked out and represented in terms of gram (g).

3.7.2.3 Yield per plot

The yield of the entire produce from each plot was recorded and expressed in terms of kilogram (kg).

3.7.2.4 Yield per hectare

The yield per hectare in respect of various treatments was calculated by using the following formulae.

$$y = \frac{A \times 10000}{S}$$

where A= Yield per plot

S= Plot area

Y= Yield per ha

The result thus obtained were expressed in quintal (q ha^{-1}).

3.7.3 Quality parameters

3.7.3.1 Dry matter of bulb

For estimating dry matter in onion, 100 gm of onion bulb from each plot were taken and cut into small pieces which were then put into the oven at a temperature of 50^{o} C till the samples reached to a constant weight. The dry matter was estimated with the following formulae:

Dry matter percentage = Weight of sample taken (g) - Weight loss (g)

3.7.3.2 Total Soluble Solids

The total soluble solid was determined by using hand refractometer calibrated at 20° C. For estimating the TSS in onion, the bulbs were squeezed thoroughly to extract the juice and 2 drops of the juice was taken in the specimen chamber of the hand refractometer with the help of a glass rod.

Then the reading of the transaction point between the light and shaded portion is taken. The result were expressed in ° Brix.

3.7.3.3 Protein content

Crude protein was determined in accordance with AOAC (1995) method

Protein = Total Kjeldahl nitrogen x CF

Where, CF= 6.25

3.7.3.4 Total and Reducing Sugar

Total and reducing sugar of onion were estimated by titrating the juice against Fehling A and Fehling B reagents using Methylene blue as an indicator (A.O.A.C. 1994). The result thus obtained were presented in terms of percentage.

3.7.3.5 Non-reducing sugar

The non-reducing sugar content was calculated by using the formula-

Non- reducing sugar = (Total sugar- reducing sugar) x 0.95

The result thus obtained was expressed in percentage.

3.7.3.6 Concentration of N, P and K in leaves and bulb

The dried samples of both bulb and leaf were powdered and sieved for determination of NPK contents. Nitrogen was determined by Kjeldhal method as described by Black (1965). Phosphorus was estimated by Vanado molybdate yellow color method (Jackson, 1969) and potassium content was estimated by Flame-photometer (Chapman and Pratt, 1961). The result thus obtained was represented in terms of percentage on dry weight basis

3.7.3.7 Total nutrient uptake

Nutrient uptake by crop was worked out as percent nutrient content into dry matter yield. The result thus obtained was expressed in terms of kg ha^{-1}.

3.7.3.7 Sulphur content

For determining the available sulphur in soil, the soil samples were collected at random from five spots in each experimental plot after harvesting at a depth of 10-15 cm with the help of screw type auger. The collected soil samples were mixed and reduced into 500g and dried in shade, grounded, sieved and digested in diacid mixture of HNO_3:$HClO_4$ (5:1) and determined by turbidimetric method as described by Chesnin and Yien (1951).

3.8 Fertility status of the soil after harvest

3.8.1 Collection of soil samples

The soil samples were collected at random from five spots in each experimental plot after harvesting at a depth of 10-15 cm with the help of screw type auger. The collected soil samples were mixed and reduced into 500g and dried in shade, grounded and sieved for determination of following nutrient status.

3.8.1.1 Organic carbon

Organic carbon was determined by Walkley and Black rapid titration method as described by Piper (1966). The result were presented in terms of percentage.

3.8.1.2 Soil pH

The pH of the soil was determined in 1:2 soil water suspension using model LI 120 digital meter (A.O.A.C. 1988)

3.8.1.3 Available Nitrogen

The available soil Nitrogen (N) was estimated by Micro-Kjeldhal method as suggested by Black 1965 and the data were calculated in terms of kg ha^{-1}.

3.8.1.4 Available phosphorus

The available soil phosphorus (P_2O_5) was determined by Spectrophotometer Vanado molybdate yellow color method (Jackson, 1969). The results thus obtained was expressed as kg ha^{-1}.

3.8.1.5 Available potassium

The available potassium (K_2O) was determined by Flame photometer (Chapman and Pratt,1961). The results obtained were expressed in kg ha^{-1}.

3.9 Storage

3.9.1 Rotting loss

After 40 days of storage, the rotting percentage was determined by observing onion bulbs showing symptoms of rotting. The rotting bulb was separated, weight and calculated by using the formula:

$$\text{Rotting percentage} = \frac{\text{Weight of the rotted bulb}}{\text{Initial weight of bulb}} \times 100$$

3.9.2 Sprouting loss

The sprouting percentage after 40 days of storage was determined by observing the bulbs showing sprout. The sprouted bulbs were separated, weighed on an electronic balance and calculated by using the formula:

$$\text{Sprouting percentage} = \frac{\text{Weight of the sprouted bulb}}{\text{Initial weight of bulb}} \times 100$$

3.9.3 Physiological weight loss

The physiological loss in weight percentage was calculated using the formula:

$$PLW(\%) = \frac{P_o - P_n}{P_o} \times 100$$

Where,

P_o = Initial weight

P_n = Weight after n days

3.10 Economic analysis

Treatment-wise, economics were carried out by calculating the cost of cultivation based on prevailing rates input and output. Gross income was calculated by yield multiplied by whole sale rate of onion. Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment. Cost benefit ratio was also worked out by the relationship given below:

$$\text{Cost benefit ratio} = \frac{\text{Net return}}{\text{Total cost of cultivation}}$$

3.11 Method of statistical analysis

The data obtained during the period of investigation was analysed by the analysis of variance method (Panse and Sukhatme, 1978) and the significance sources of variation were tested by error mean square using Fisher Shedecor 'F' test of probability at 0.05 per cent level.

Chapter 4

Experimental Findings

EXPERIMENTAL FINDINGS

The experimental findings on "Effect of integrated nutrient management on growth, yield, nutrient uptake and storage life of onion" cv. Agrifound Dark Red" are presented in this chapter and duly supported by tables and figures.

4.1 Growth attributes

4.1.1 Plant height (cm)

Observation on height of plant as influenced by various treatments was recorded at different stages of plant growth viz., 15, 30, 45, 60 and 75 days after planting during 2007-08 and 2008-09. The results are presented in Table 4 and Fig. 2. In general, a significant difference for this character was found amongst the various treatments comprising of various combination of organic manures, inorganic fertilizers and biofertilizers on onion during both the years of investigation.

The treatment T_9 (50% RDF +50 % Poultry manure) caused maximum plant height of onion at all stages of observation and maximum height 40.50 cm and 41.73 cm during 2007-08 and 2008-09 respectively was recorded at 75 DAP followed by T_7 (50% RDF + 50% FYM) and T_{10} (50% RDF + 50% vermicompost). Most of the treatments were also found to be significantly superior to control with regard to height of plant. The 50% RDF + 50 % of organic manures treatments were found superior to 100% RDF and 100% organic manure.

4.1.2 Number of leaves per plant

The data on number of leaves per plant are presented in Table 5 and Fig.3. Number of leaves per plant of different treatment was found to be significant at all stages of growth during both years of investigation. The highest mean number of leaves 5.43, 6.25, 6.78, 8.16 and 8.78 was recorded in treatment T_9 (50% RDF +50 % Poultry manure) at 15, 30, 45, 60 and 75 days after planting (DAP) respectively. While the lowest number of leaves 4.12, 4.46, 4.93, 5.68 and 6.19 was recorded by control (T_1) at different stages of observation during both years. The treatments like T_8 (50% RDF + 50 % Pig manure) and T_6 (Vermicompost @6 MT/ha) were also found to have significant impact in increasing the number of leaves during both years of investigation.

4.1.3 Leaf area index (cm^2)

The leaf area index was recorded at 15, 30, 45, 60 and 75 days after planting. The data are presented in Table 6 and Fig.4. A significant difference for this character was found amongst various treatments during both years of experimentation. The maximum increase in the mean leaf area index

Plate 1: Onion bulblets for planting

Plate 2: General view of the experimental plot

Table 4: Effect of integrated nutrient management on height of the plant (cm) of onion

Treatment	15 DAP		Pool Mean	30 DAP		Pool Mean	45 DAP		Pool Mean	60 DAP		Pool Mean	75 DAP		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	11.31	10.53	10.92	16.39	10.93	13.66	18.86	11.06	14.96	19.56	18.26	18.91	25.46	20.70	23.08
T_2- 100 % RDF	16.32	16.66	16.49	26.60	18.30	22.45	29.03	21.0	25.01	35.03	26.70	30.86	35.83	30.10	32.96
T_3- FYM @ 30 MT/ha	15.61	16.0	15.80	23.57	16.53	20.05	27.03	20.10	23.56	29.53	26.83	28.18	32.23	30.13	31.18
T_4- Pig manure @ 20 MT/ha	15.78	15.76	15.77	25.00	15.93	20.46	27.43	19.40	23.41	30.0	25.53	27.76	33.56	29.76	31.66
T_5- Poultry manure @ 10MT/ha	16.00	16.73	16.36	25.48	17.43	21.45	27.83	21.03	24.43	33.66	28.45	31.05	38.56	32.10	35.33
T_6- Vermicompost @ 6 MT/ha	16.23	15.73	15.98	26.00	16.16	21.08	27.96	19.63	23.79	33.73	24.53	29.13	35.68	29.33	32.50
T_7-50% RDF + 50% FYM	17.69	18.73	18.21	20.86	29.82	25.34	33.0	26.0	29.50	40.63	30.31	35.47	39.22	40.00	39.61
T_8-50% RDF + 50% pig manure	16.43	17.71	17.07	26.28	18.10	22.19	29.26	21.73	25.49	35.80	26.76	31.28	36.26	30.06	33.16
T_9- 50% RDF + 50% poultry manure	18.00	19.43	18.71	26.24	25.38	25.81	36.26	26.60	31.43	42.38	32.05	37.21	40.50	41.73	41.11
T_{10} - 50% RDF +50% vermicompost	17.00	18.0	17.50	29.94	19.03	24.48	31.90	21.83	26.86	37.16	26.73	31.94	39.23	36.39	37.81
T_{11}-50% RDF + *Azotobacter*	14.84	15.33	15.08	22.75	15.73	19.24	26.36	22.70	24.53	29.10	28.75	28.92	31.61	32.70	32.15
T_{12}-50% RDF + *Azospirillum*	14.76	15.30	15.03	21.86	15.33	18.59	26.0	22.10	24.05	29.10	26.73	27.91	30.60	31.43	31.01
T_{13}-50% RDF + Phosphotika	14.33	15.70	15.01	21.38	15.93	18.65	25.28	22.66	23.97	26.73	29.36	28.04	30.46	33.06	31.76
T_{14}- 75% RDF + *Azotobacter*	15.38	15.63	15.50	23.10	15.76	19.43	26.58	22.66	24.62	29.93	28.66	29.29	32.23	31.43	31.83
T_{15} - 75% RDF + *Azospirillum*	15.68	15.71	15.69	24.94	16.06	20.50	27.33	23.03	25.18	29.56	29.10	29.33	32.76	32.90	32.83
T_{16}- 75% RDF + Phosphotika	15.84	15.68	15.76	25.08	16.0	20.54	27.80	23.0	25.40	32.80	27.26	30.03	34.46	29.76	32.11
CD at 5%	1.81	2.92	-	3.32	2.86	-	4.35	3.50	-	2.15	2.75	-	5.54	3.12	-

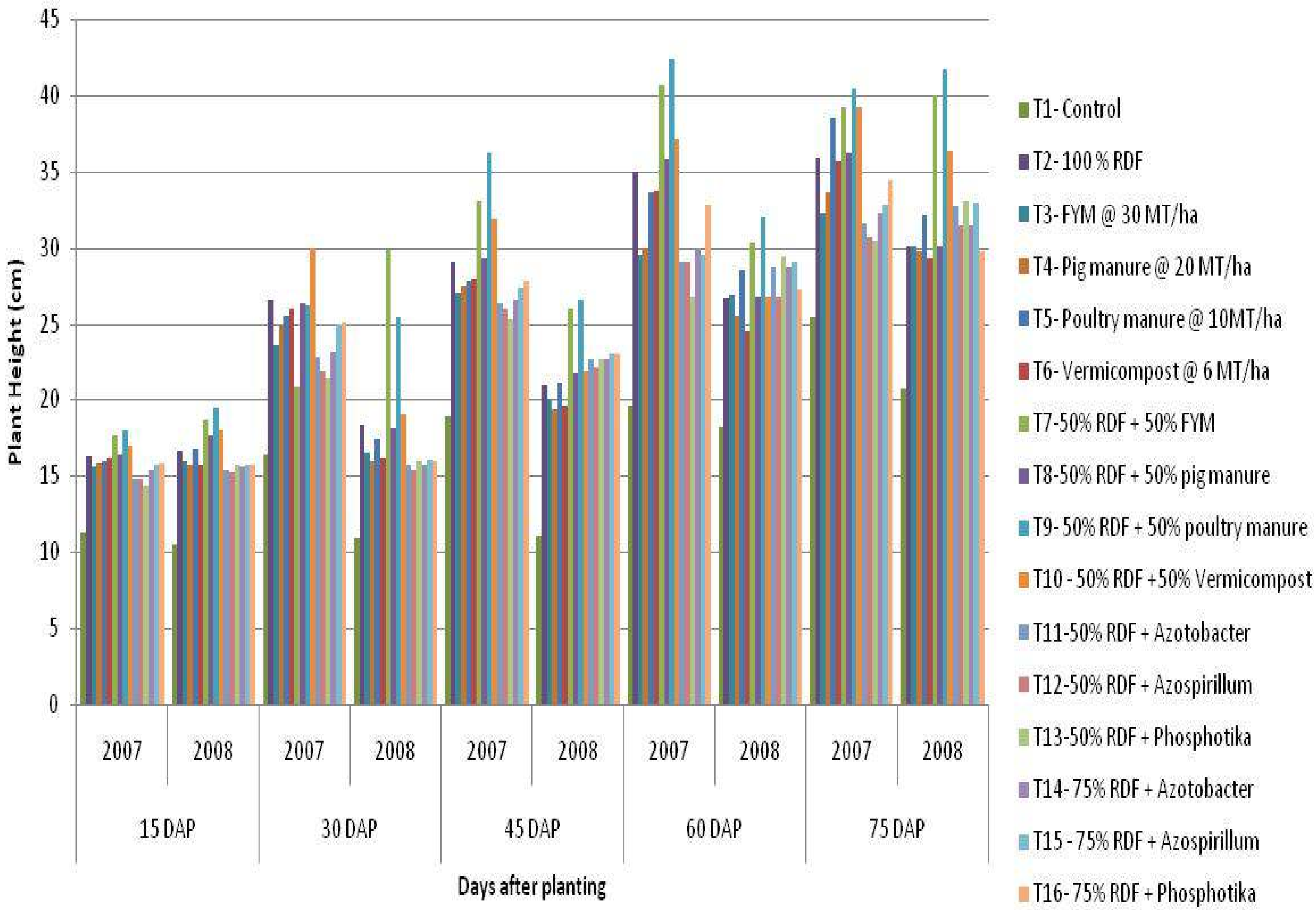

Fig. 2,. Effect of integrated nutrient management on height of the plant (cm) of onion

Table 5: Effect of integrated nutrient management on number of leaves per plant of onion

Treatment	15 DAP			30 DAP			45 DAP			60 DAP			75 DAP		
	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean
T_1- Control	4.29	3.96	4.12	4.60	4.33	4.46	5.26	4.60	4.93	5.93	5.43	5.68	6.53	5.86	6.19
T_2- 100 % RDF	4.60	5.03	4.81	5.53	5.40	5.46	6.32	5.70	6.01	7.40	6.43	6.91	8.26	7.10	7.68
T_3- FYM @ 30 MT/ha	4.46	5.20	4.83	5.13	5.43	5.28	6.26	5.66	5.96	7.40	6.36	6.88	8.40	7.06	7.73
T_4- Pig manure @ 20 MT/ha	4.33	5.40	4.86	5.40	5.93	5.66	6.06	6.03	6.04	7.26	6.76	7.01	8.06	7.66	7.86
T_5- Poultry manure @ 10 MT/ha	4.53	5.60	5.06	5.83	6.00	5.91	6.80	6.26	6.53	7.46	6.73	7.09	8.14	7.26	7.70
T_6- Vermicompost @ 6 MT/ha	4.73	5.76	5.24	5.60	5.96	5.78	7.00	6.20	6.60	7.40	6.70	7.05	9.33	7.63	8.48
T_7-50% RDF + 50% FYM	4.66	5.73	5.19	6.26	6.00	6.13	6.50	6.30	6.40	7.20	7.00	7.10	7.93	8.06	7.99
T_8-50% RDF + 50% pig manure	4.60	6.10	5.35	5.93	6.36	6.14	6.83	6.66	6.74	8.60	6.93	7.76	8.53	8.73	8.63
T_9- 50% RDF + 50% poultry manure	5.00	5.86	5.43	6.00	6.50	6.25	7.20	6.36	6.78	9.13	7.20	8.16	9.46	8.10	8.78
T_{10} - 50% RDF +50% vermicompost	4.41	5.30	4.85	6.06	6.13	6.09	6.83	5.73	6.28	7.53	7.86	7.69	8.53	7.80	8.16
T_{11}-50% RDF + *Azotobacter*	4.46	6.06	5.26	5.46	5.46	5.46	6.06	6.60	6.33	7.80	6.86	7.33	9.26	7.36	8.31
T_{12}-50% RDF + *Azospirillum*	4.53	4.56	4.54	6.26	4.66	5.46	6.50	4.90	5.70	6.63	6.13	6.38	7.20	7.20	7.20
T_{13}-50% RDF + Phosphotika	4.60	4.06	4.33	5.83	4.43	5.13	5.73	4.70	5.21	6.73	6.20	6.46	7.40	7.76	7.58
T_{14}- 75% RDF + *Azotobacter*	4.66	4.49	4.57	6.00	4.39	5.19	7.13	4.96	6.04	7.73	5.80	6.76	8.93	6.56	7.74
T_{15} - 75% RDF + *Azospirillum*	4.46	5.20	4.83	4.86	5.50	5.18	6.20	5.73	5.96	7.00	6.10	6.55	7.66	7.00	7.33
T_{16}- 75% RDF + Phosphotika	4.26	5.40	4.83	5.46	6.00	5.73	6.07	6.23	6.15	7.13	6.86	6.99	7.66	8.00	7.83
CD at 5%	1.40	0.51	-	1.33	0.82	-	1.00	0.90	-	0.74	1.09	-	1.41	1.21	-

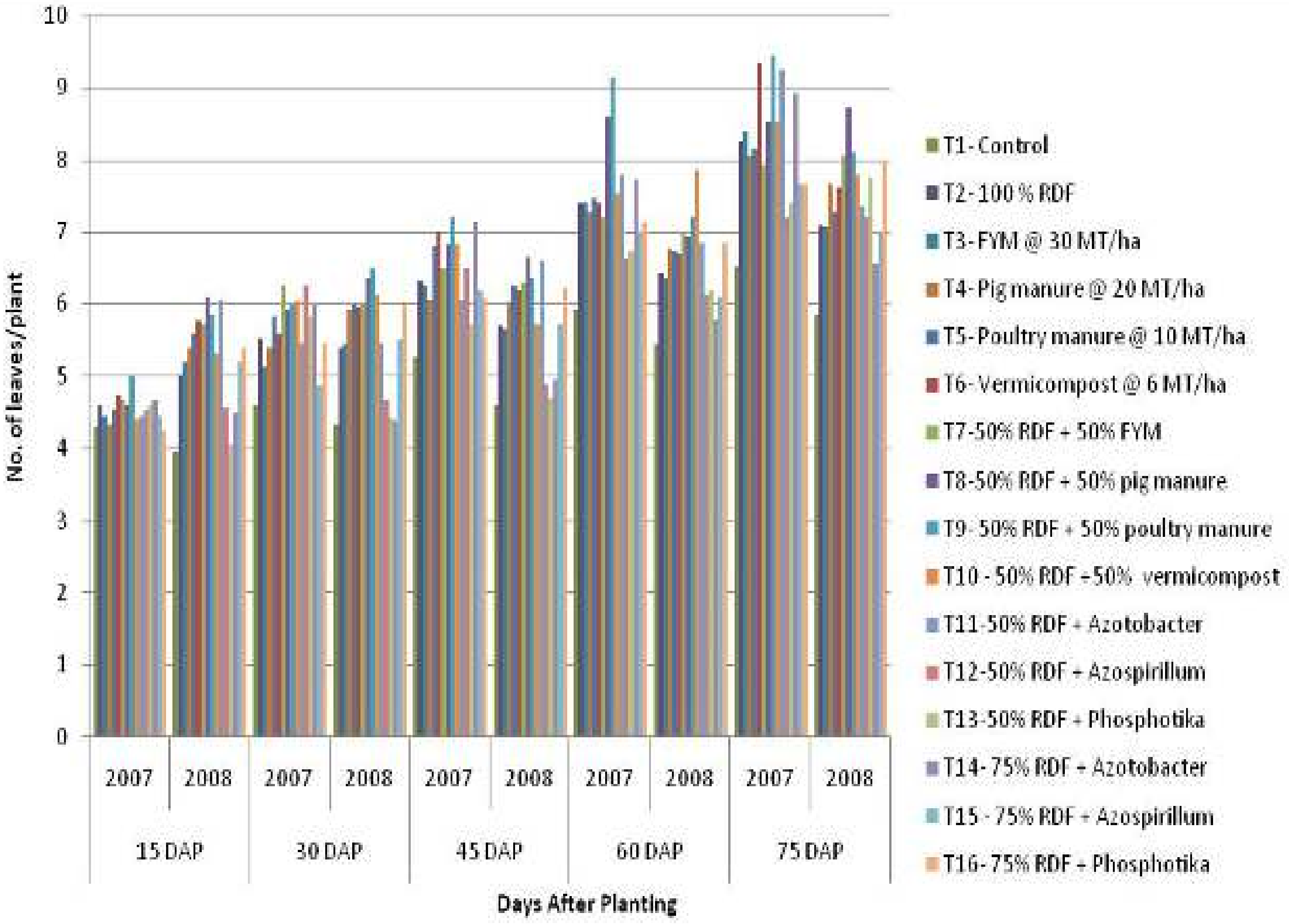

Fig.3. Effect of integrated nutrient management on number of leaves per plant of onion

Table 6: Effect of integrated nutrient management on Leaf area index (cm^2) of onion

Treatment	15 DAP		Pool Mean	30 DAP		Pool Mean	45 DAP		Pool Mean	60 DAP		Pool Mean	75 DAP		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	406	511	458	892	615	753	761	1510	1135	1680	1533	1606	1746	1645	1695
T_2- 100 % RDF	603	683	643	1238	863	1050	996	1896	1446	1992	2219	2105	1982	2463	2222
T_3- FYM @ 30 MT/ha	470	547	508	926	703	814	875	1637	1256	1747	1652	1699	1780	1742	1761
T_4- Pig manure @ 20 MT/ha	483	581	532	943	728	835	880	1672	1276	1781	1686	1733	1782	1936	1859
T_5- Poultry manure @ 10MT/ha	686	789	737	1328	896	1112	1108	2352	1730	2375	2515	2445	2376	2576	2476
T_6- Vermicompost @ 6 MT/ha	583	627	605	1105	815	960	986	1847	1416	2392	2000	2196	1916	2323	2119
T_7-50% RDF + 50% FYM	705	816	760	1356	901	1128	1269	2386	1827	2371	2520	2445	2468	2625	2546
T_8-50% RDF + 50% pig manure	671	786	728	1297	885	1091	1101	2319	1710	2370	2467	2418	2352	2538	2445
T_9- 50% RDF + 50% poultry manure	712	825	768	1386	936	1161	1302	2413	1857	2416	2526	2471	2584	2681	2632
T_{10} - 50% RDF +50% vermicompost	621	770	695	1275	876	1075	1420	1480	1450	2105	2438	2271	2318	2479	2398
T_{11}-50% RDF + *Azotobacter*	511	609	560	962	768	865	981	1801	1391	1853	1765	1809	1828	2176	2002
T_{12}-50% RDF + *Azospirillum*	452	526	489	911	685	798	865	1618	1241	1718	1628	1673	1773	2105	1939
T_{13}-50% RDF + Phosphotika	535	618	576	983	787	885	873	1728	1300	1916	1931	1923	1866	2220	2043
T_{14}- 75% RDF + *Azotobacter*	546	20	373	1101	720	910	982	1823	1402	1933	1965	1949	1893	2268	2080
T_{15}- 75% RDF + *Azospirillum*	601	652	626	1210	842	1026	991	1866	1428	1986	2108	2047	1942	2376	2159
T_{16}- 75% RDF + Phosphotika	502	586	544	951	739	845	887	1726	1306	1824	1728	1776	1810	2110	1960
CD at 5%	106	120	-	124	100	-	101	115	-	100	42	-	120	100	-

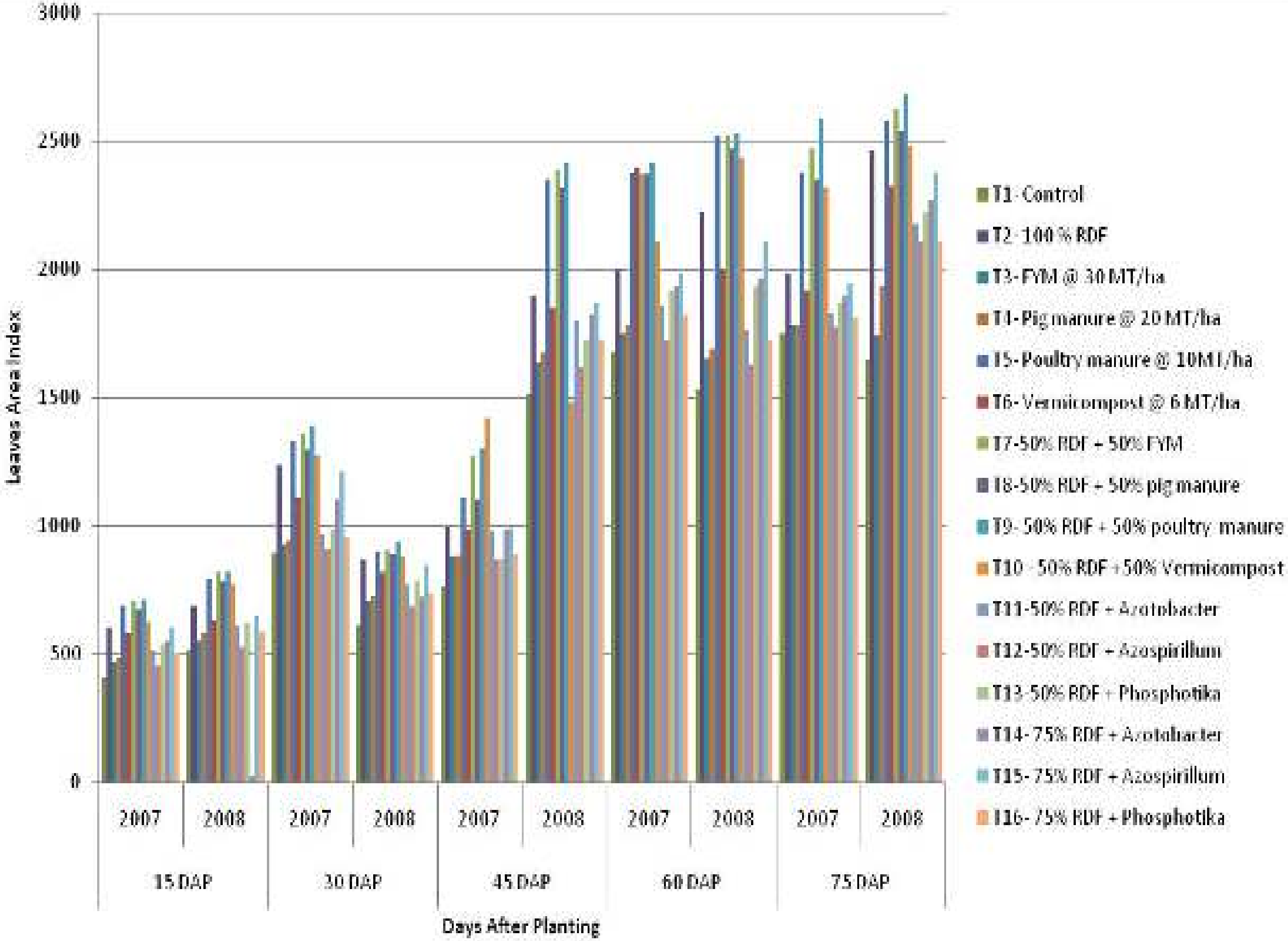

Fig. 4. Effect of integrated nutrient management on leaf area Index in Onion (cm²)

Plate 3: 10 Days after planting

Plate 4: Growth of plant from treatment 50% RDF + 50% poultry manure

768, 1161, 1857, 2471 and 2632 was noticed in treatment T_9 (50% RDF +50 % Poultry manure) at 15, 30, 45, 60 and 75 DAP respectively which remain at par with treatment T_7 (50% RDF + 50% FYM), T_5 (Poultry manure @10 MT/ha), T_8 (50% RDF + 50 % Pig manure) and T_{10} (50% RDF + 50% vermicompost). The minimum mean leaf area index 458, 753, 458, 1606 and 1695 at 15, 30, 45, 60 and 75 days after planting was recorded in T_1 (Control) in both years of experimentation.

4.2 Yield attributes

4.2.1 Doubling (%)

It is evident from the Table 7 and Fig.5 that maximum mean doubling (16.10% and 14.02%) during the year 2007-08 and 2008-09 were observed with treatment T_7 (50% RDF + 50% FYM) which remained statistically at par with T_8 (50% RDF + 50 % Pig manure), T_6 (Vermicompost @6MT/ha) and T_{13} (50% RDF + Phosphotica) while the minimum mean doubling percentage of (10.05% and 10.07%) was observed in control (T_1) in both the years of experimentation.

4.2.2 Bolting (%)

Data pertaining to bolting percentage are presented in Table 7 and Figure 6. Maximum mean bolting was recorded with 13.40 % and 11.80 % during 2007-08 and 2008-09 respectively with the treatment T_5 (Poultry manure@10 MT/ha) followed by T_6 (Vermicompost @ 6MT/ha) which was statistically at par with T_2 (100% RDF), T_{10} (50% RDF + 50% vermicompost) and T_{13} (50% RDF + Phosphotica). The lowest bolting percentage (7.49 % and 6.19 %) was recorded in control (T_1) in both the years of experimentation.

4.2.3 Neck thickness at 45 DAP (cm)

The data presented in Table 7 and Fig.7 shows that there was appreciable impact of various organic manures in enhancing the neck thickness of onion. The average highest neck thickness (3.32 cm and 2.08 cm) during the year 2007-08 and 2008-09 respectively was recorded in treatment T_3 (FYM @30 MT/ha) at 45 days after planting followed by treatment T_5 (Poultry manure @10 MT/ha) which was statistically at par with T_4 (Pig manure @20 MT/ha), T_{10} (50% RDF + 50% vermicompost) and T_6 (Vermicompost @ 6 MT/ha). All the treatments recorded significant increase in neck thickness as compared to control (T_1) during both years of experimentation.

4.2.4 Diameter of the bulb (cm)

Data on size of the bulbs are presented in Table 7 and Fig.8. All the treatments recorded significantly higher bulb size over control in both the years of study. As like growth characters, the

Table 7: Effect of integrated nutrient m anagement on yield and yield attributing characters of onion

Treatment	Doubling (%)		Pool Mean	Bolting (%)		Pool Mean	Neck thickness (cm)		Pool Mean	Bulb diameter (cm)		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	10.05	10.10	10.07	7.49	6.19	6.84	1.15	1.11	1.13	3.44	4.20	3.82
T_2- 100 % RDF	13.10	11.86	12.48	12.86	10.80	11.83	2.61	1.86	2.23	3.46	4.00	3.73
T_3- FYM @ 30 MT/ha	14.30	13.12	13.71	11.00	7.22	9.11	3.32	2.08	2.70	5.16	5.88	5.52
T_4- Pig manure @ 20 MT/ha	14.05	13.01	13.53	12.83	10.75	11.79	2.74	1.96	2.35	5.09	5.77	5.43
T_5- Poultry manure @ 10 MT/ha	13.98	12.80	13.39	13.42	12.96	13.19	2.77	2.03	2.40	5.18	5.90	5.54
T_6- Vermicompost @ 6 MT/ha	15.90	13.42	14.66	13.40	11.80	12.60	2.77	1.57	2.17	4.95	5.31	5.13
T_7-50% RDF + 50% FYM	16.10	14.02	15.06	11.60	7.82	9.71	2.56	1.25	1.90	5.83	6.15	5.99
T_8-50% RDF + 50% pig manure	16.02	14.00	15.01	11.26	7.56	9.41	2.41	1.73	2.07	5.68	6.12	5.90
T_9- 50% RDF + 50% poultry manure	11.67	11.25	11.46	12.36	10.10	11.23	2.47	1.24	1.85	6.14	6.38	6.26
T_{10} - 50% RDF +50% vermicompost	13.39	12.15	12.77	12.80	10.86	11.83	2.63	2.00	2.31	5.32	6.00	5.66
T_{11}-50% RDF + *Azotobacter*	13.29	12.13	12.71	12.15	8.85	10.50	1.75	1.25	1.50	4.49	5.01	4.75
T_{12}-50% RDF + *Azospirillum*	13.38	12.14	12.76	12.65	10.35	11.50	1.77	1.12	1.44	4.63	5.09	4.86
T_{13}-50% RDF + Phosphotika	15.32	13.20	14.26	12.81	10.45	11.63	1.65	1.13	1.39	4.94	5.28	5.11
T_{14}- 75% RDF + *Azotobacter*	12.82	11.60	12.21	12.59	10.33	11.46	2.15	1.33	1.74	5.04	5.68	5.36
T_{15}- 75% RDF + *Azospirillum*	12.00	11.52	11.76	12.13	8.53	10.32	2.18	1.54	1.86	5.08	5.70	5.39
T_{16}- 75% RDF + Phosphotika	12.90	11.74	12.32	11.48	7.76	9.62	2.55	1.36	1.95	5.04	5.40	5.22
CD at 5%	3.39	3.85	-	1.64	3.10	-	1.15	1.10	-	1.21	1.42	-

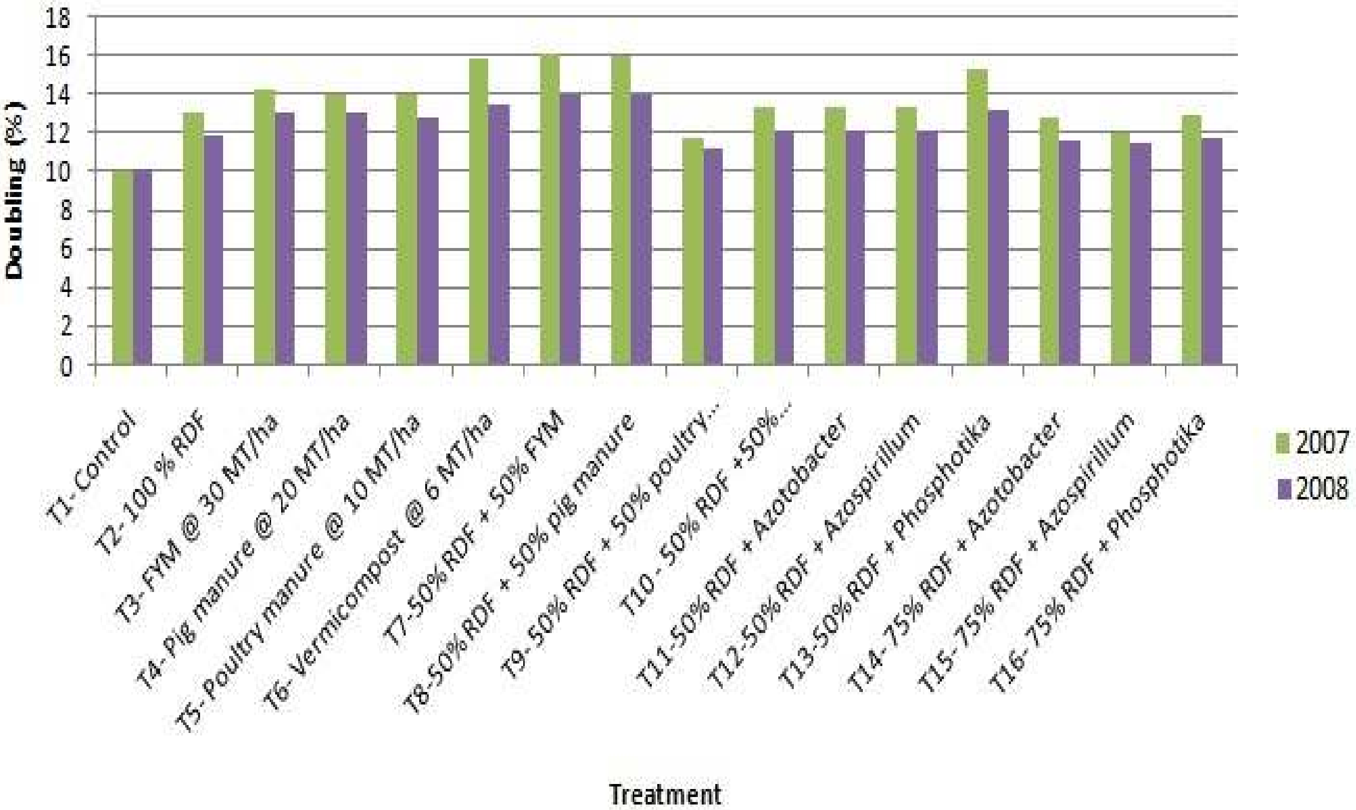

Fig. 5. Effect of integrated nutrient managemnt on doubling (%)

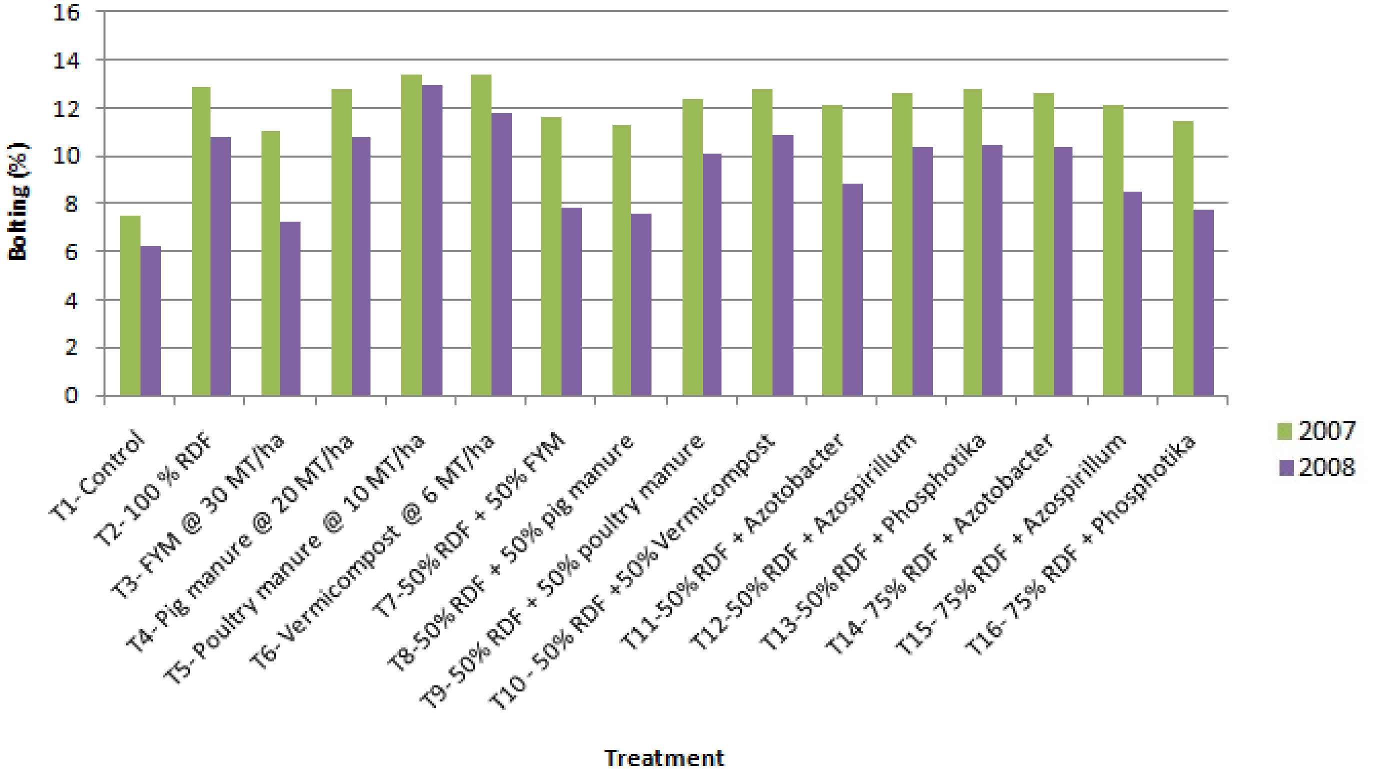

Fig. 6. Effect of integrated nutrient managemnt on bolting (%)

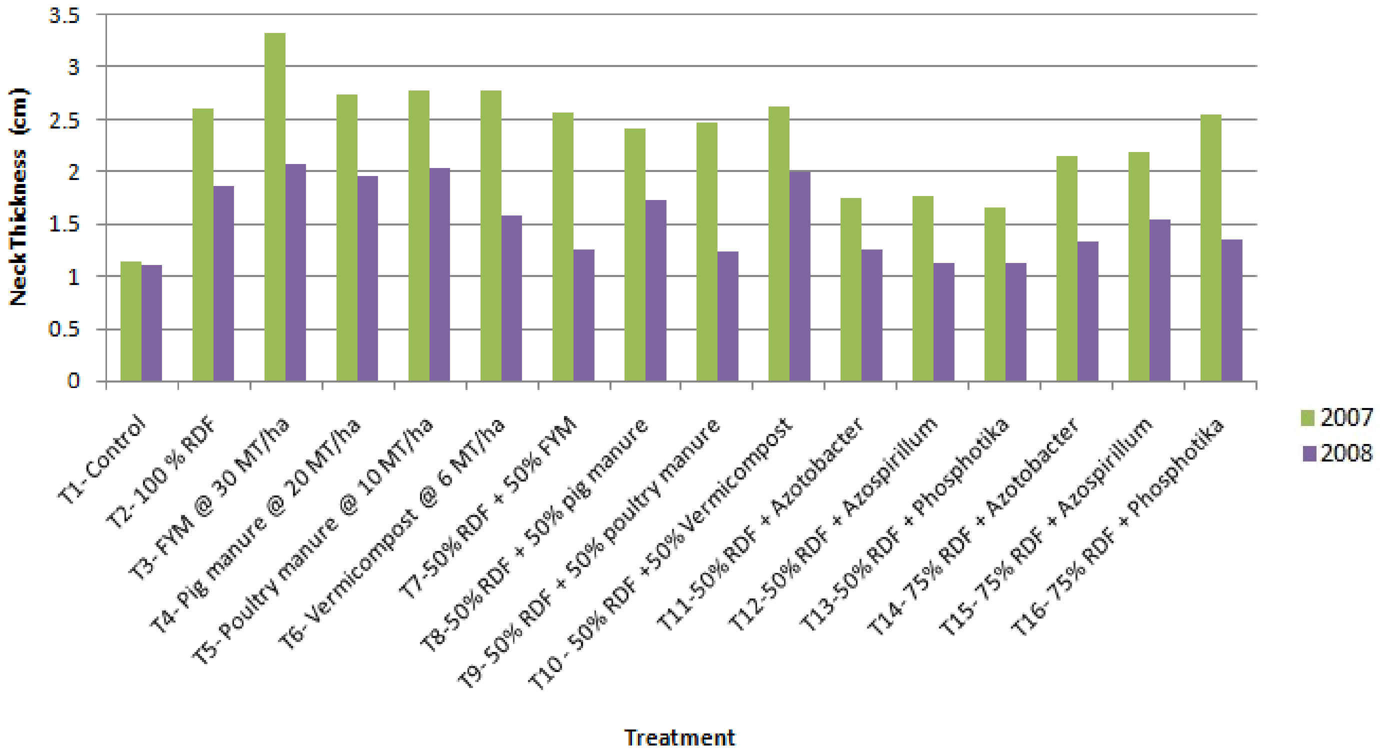

Fig. 7. Effect of nutrient management on neck thickness (cm)

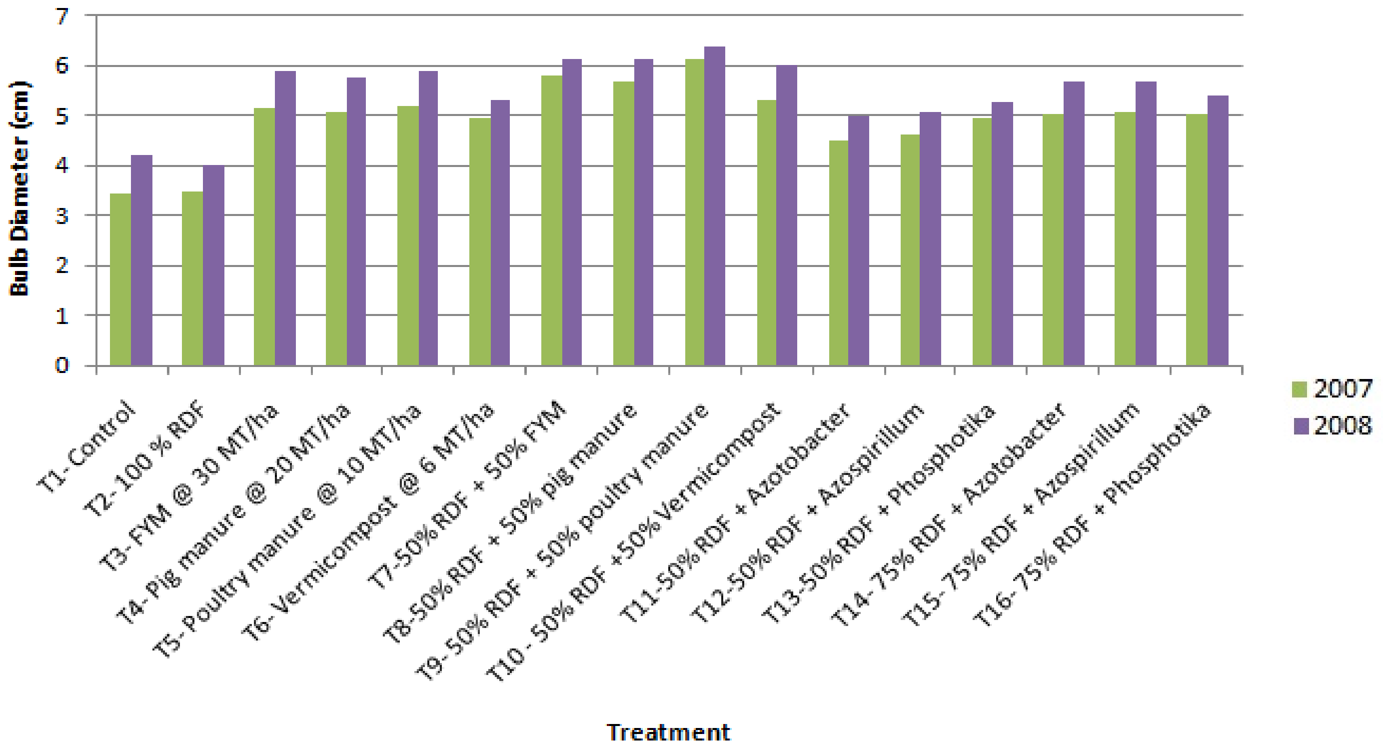

Fig. 8. Effect of integrated nutrient managemnt on bulb diameter (cm)

Plate 5: Onion bulbs from treatment with 50% RDF + 50% poultry manure

Plate 6: Doubling from treatment with 50% RDF + 50% FYM

treatment T_9 (50% RDF +50 % Poultry manure) proved superiority with regard to mean bulb size (6.14 cm and 6.38 cm) in the year 2007-08 and 2008-09 respectively followed by T_7 - 50% RDF + 50% FYM (5.83 cm and 6.15 cm), T_8 - 50% RDF + 50 % Pig manure (5.68 cm and 6.12 cm) and T_{10} - 50% RDF + 50% Vermicompost (5.32 cm and 6.00 cm). However, they remained statistically at par with each other. These combinations were also found significantly superior to several other treatments. Lowest bulb size (3.44 and 4.20 cm) during 2007-08 and 2008-09 respectively was recorded in control (T_1).

4.2.5 Weight of the bulb (g)

There was a good impact of various treatments in increasing the weight of bulbs Table 8 and Fig.9. Maximum weight of the bulb (102.00 g and 126.66 g) was recorded in the treatment combination of 50% RDF +50 % Poultry manure (T_9) in the year 2007-08 and 2008-09 respectively. However, it remained at par with T_7 (50% RDF + 50% FYM), T_4 (Pig manure @ 20 MT/ha), T_8 (50% RDF + 50 % Pig manure), T_2 (100% RDF), T_5 (Poultry manure @ 10MT/ha), T_6 (Vermicompost @ 6MT/ha) and T_{12} (50% RDF + *Azospirillum*). Most of the treatments showed significant impact in increasing the weight of bulbs as compared to control in both the years of study.

4.2.6 Yield per plot (kg)

The mean data recorded on yield per plot has been presented in Table 8 and Fig.10. It was revealed that there was a significant impact on yield of onion per plot by application of various organic manures, inorganic fertilizers and biofertilizers. However, combined application of 50 % RDF with 50 % of organic manures yielded more than individual application of organic and inorganic fertilizers. The average highest yield (3.81 kg and 4.19 kg) per plot during the year 2007-08 and 2008-09 respectively was recorded in T_9 (50 % RDF +50 % Poultry manure). Treatment T_7(50 % RDF + 50% FYM) exhibited as second best treatment for mean higher yield of onion (3.84 kg) per plot however, it remained statistically at par with treatment T_8 (50% RDF + 50 % Pig manure), and T_{10} (50% RDF + 50 % Vermicompost) in both years of experimentation. The lowest yield per plot (2.33 kg) was recorded in control (T_1).

4.2.7 Marketable yield per plot (kg)

Data pertaining to marketable yield per plot has been represented in Table 8 and Fig.10. Marketable yield varied among the different treatments. The highest marketable yield of 3.55 kg and 3.70 kg per plot was recorded in treatment T_9 (50% RDF + 50% Poultry manure) during 2007-08 and 2008-09 respectively followed by treatment T_7 (50% RDF + 50% FYM), T_{10} (50% RDF + 50 % Vermicompost), T_6 (Vermicompost @6 MT/ha) and T_8 (50% RDF + 50 % Pig manure). However, they remained at par among each other. Other treatments also caused significant increase in marketable yield of onion to control (1.44 kg) per plot.

4.2.8 Projected yield per hectare (q)

There was profound impaction of different treatments in increasing the projected yield (Table 8 and Fig. 12). The highest yield of 173.85 q ha^{-1} and 186.15 q ha^{-1} was recorded in treatment T_9 (50% RDF + 50% Poultry manure) in the year 2007-08 and 2008-09 respectively followed by T_7 (50% RDF + 50% FYM) and T_8 (50% RDF + 50 % Pig manure) which were at par with each other. The treatment T_{10} (50% RDF + 50 % Vermicompost) also exhibited potential yield of onion and were significantly superior to many treatments. Among the biofertilizers, Phosphotica and *Azospirillum* showed significant impact with 75% RDF. The lowest yield was noticed with control (T_1) in both years of experimentation.

4.3 Quality analysis

4.3.1 Dry matter (%)

The mean data on dry matter content is represented in the Table 9 and Fig.13. The highest value of dry matter content of bulb (11.25%) was recorded in treatment T_7 (50% RDF + 50% FYM) which was significantly superior than other treatments. The other treatment also showed the positive impact in enhancing the dry matter accumulation in leaves and bulbs in both years of experimentation. Among biofertilizers, phosphotica caused significant increase in dry matter in the leaves and bulbs along with 50 % RDF and 75 % RDF to control.

4.3.1.1 Dry matter of bulb per hectare (q)

It is evident from Table 9 and Fig. 14 that the maximum bulb dry matter content of 22.18 q ha^{-1} was recorded with treatment T_9 (50% RDF +50 % Poultry manure) followed by 21.76 q ha^{-1} in T_7 (50% RDF + 50% FYM). The treatment T_9 was found significantly superior over other treatments but was at par with treatment T_7 (50% RDF + 50% FYM), T_6 (Vermicompost @6 MT/ha) and T_8 (50% RDF + 50 % Pig manure).The lowest dry matter content per hectare was obtained in control (8.31 q ha^{-1}) in both years of investigation.

4.3.1.2 Dry matter of leaves per hectare (q)

The mean presented in Table 9 and Fig. 15 revealed that the maximum leaf dry matter of 5.28 q ha^{-1} was obtained with treatment T_7 (50% RDF + 50% FYM) followed by 5.21 q ha^{-1} in T_8 (50%

Table 8: Effect of integrated nutrient management on yield and yield attributing characters of onion

Treatment	Fresh weight of bulb (g)		Pool Mean	Yield/plot (kg)		Pool Mean	Marketable yield/plot (kg)		Pool Mean	Projected yield/ha (q)		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	65.20	72.38	68.79	1.80	2.86	2.33	0.98	1.03	1.00	86.15	94.44	90.29
T_2- 100 % RDF	93.15	91.83	92.49	2.21	2.91	2.56	1.90	2.47	2.18	120.68	120.35	120.51
T_3- FYM @ 30 MT/ha	89.00	103.32	96.16	2.96	3.08	3.02	2.79	2.63	2.71	130.70	137.49	134.09
T_4- Pig manure @ 20 MT/ha	100.75	119.91	110.33	2.98	3.24	3.11	2.85	2.71	2.78	135.16	141.36	138.26
T_5- Poultry manure @ 10 MT/ha	95.60	113.72	104.66	3.18	3.42	3.30	2.78	3.18	2.98	137.72	155.63	146.67
T_6- Vermicompost @ 6 MT/ha	95.00	113.66	104.33	3.20	3.86	3.53	3.29	3.15	3.22	153.78	160.06	156.92
T_7-50% RDF + 50% FYM	102.50	120.82	111.66	3.58	4.10	3.84	3.38	3.56	3.47	164.51	176.91	170.71
T_8-50% RDF + 50% pig manure	98.30	118.36	108.33	3.36	4.00	3.68	2.92	3.35	3.13	151.26	176.08	163.67
T_9- 50% RDF + 50% poultry manure	102.00	126.66	114.33	3.81	4.19	4.00	3.55	3.70	3.62	173.85	186.15	180.00
T_{10} - 50% RDF +50% vermicompost	91.10	106.22	98.66	3.34	3.96	3.65	3.17	3.30	3.23	155.62	168.34	161.98
T_{11}-50% RDF + *Azotobacter*	85.20	101.46	93.33	2.73	2.91	2.82	2.47	2.67	2.57	124.93	133.51	129.22
T_{12}-50% RDF + *Azospirillum*	93.42	108.56	100.99	2.73	2.93	2.84	2.48	2.32	2.40	122.34	129.84	126.09
T_{13}-50% RDF + Phosphotika	84.61	94.39	89.50	2.81	3.01	2.91	2.40	2.60	2.50	120.93	129.41	125.17
T_{14}- 75% RDF + *Azotobacter*	87.10	102.22	94.66	2.95	3.07	3.01	2.65	2.71	2.68	132.42	135.25	133.83
T_{15}- 75% RDF + *Azospirillum*	91.51	107.47	99.49	2.97	3.19	3.08	2.70	2.78	2.74	133.51	140.43	136.97
T_{16}- 75% RDF + Phosphotika	91.48	107.18	99.33	2.99	3.25	3.12	2.85	2.73	2.79	136.18	141.26	138.72
CD at 5%	9.15	12.34	-	1.18	1.10	-	1.22	0.48	-	14.15	29.13	-

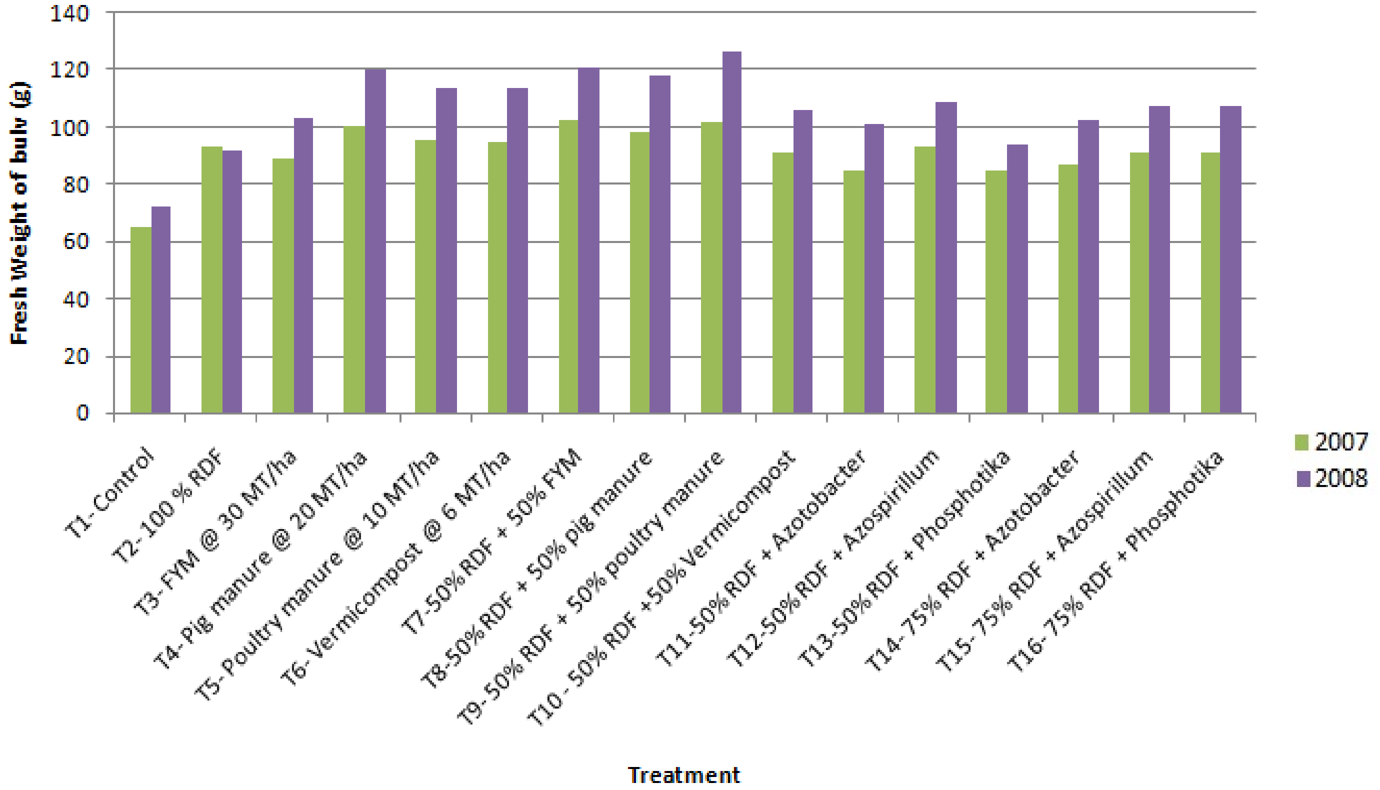

Fig. 9. Effect of integrated nutrient management on fresh weight of bulb (g)

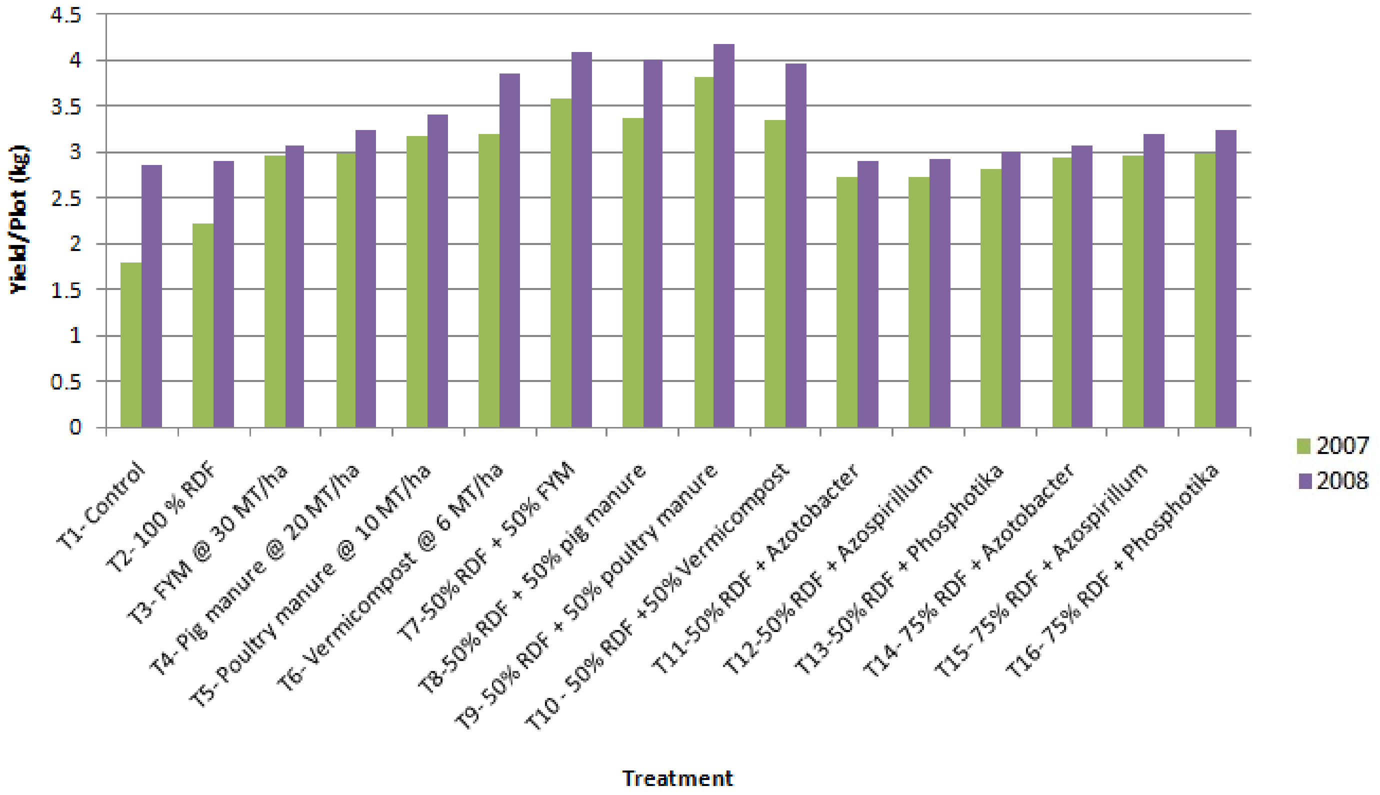

Fig. 10. Effect of integrated nutrient management on yield/plot (kg)

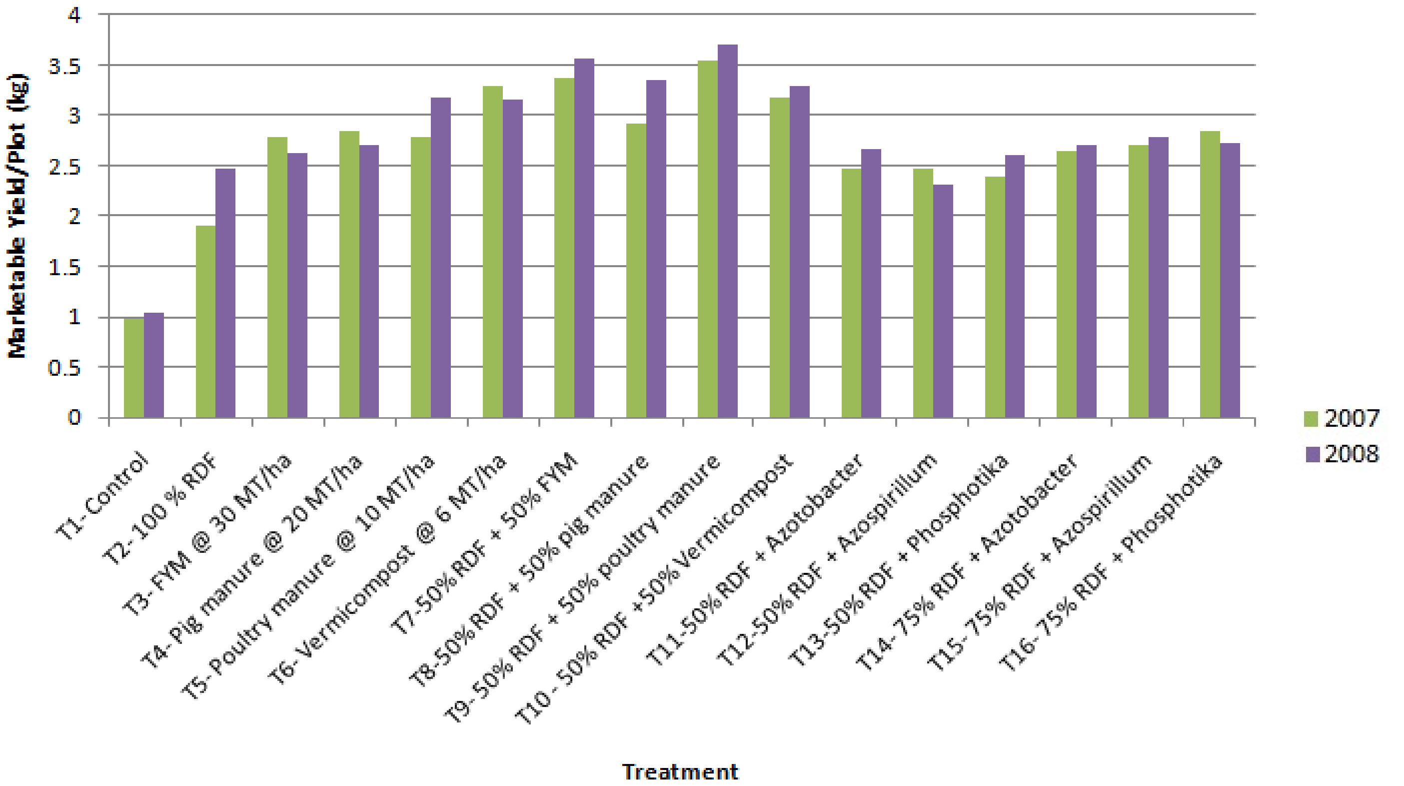

Fig. 11. Effect of integrated nutrient management on marketable yield/plot (kg)

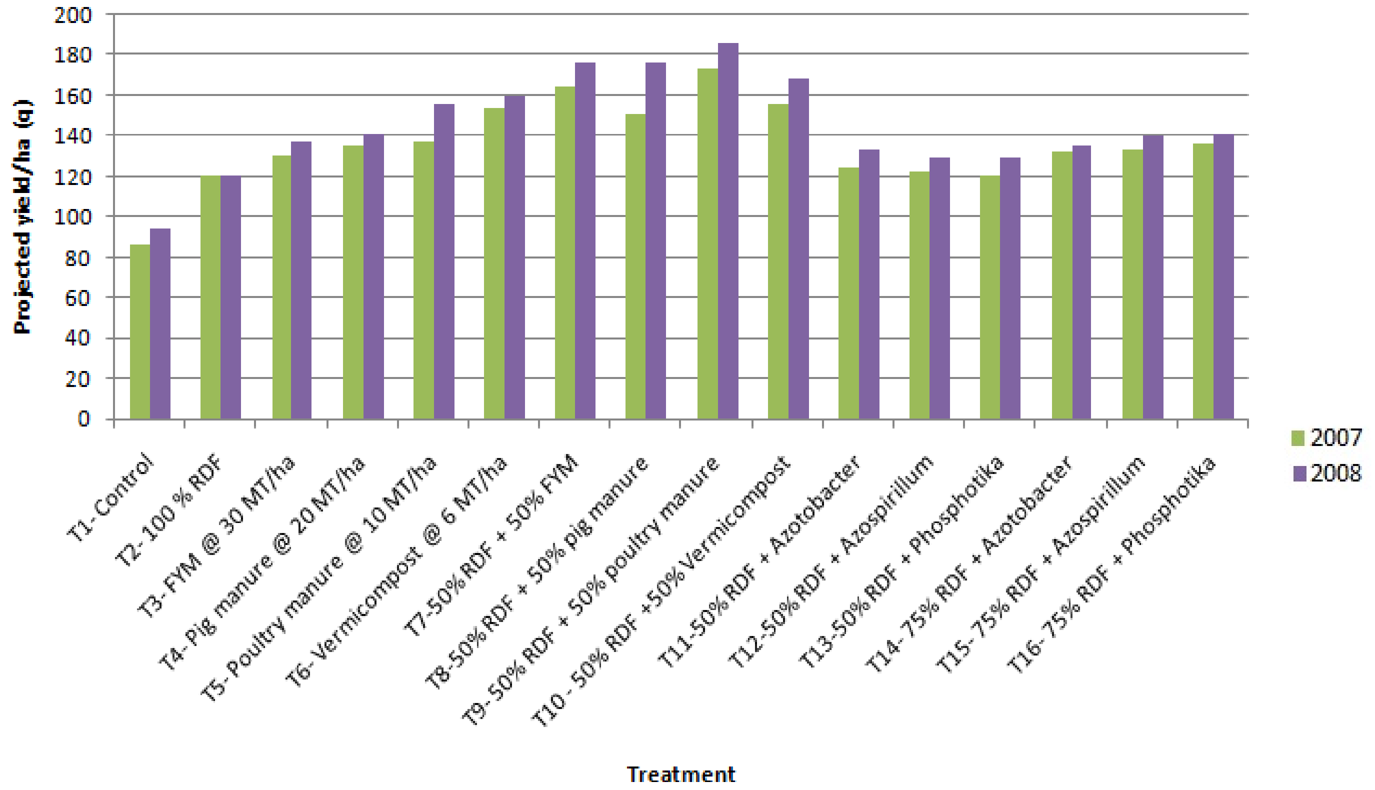

Fig. 12. Effect of integrated nutrient management on projected yield/ha (q)

RDF + 50 % Pig manure). In general all the treatment recorded significantly higher dry matter of leaves as compared to control (2.18 q ha^{-1}) in the year 2007-08 and 2008-09.

4.3.2 Total soluble solids (°Brix)

The data of the total soluble solids have been represented in the Table 9 and Fig.16. Here, the average highest total soluble solids (11.13°Brix and 11.17°Brix) was recorded in treatment combination of 50% RDF + 50% Poultry manure (T_9) during the year 2007-08 and 2008-09 respectively followed by T_8 (RDF + 50% Pig manure). However, it remained at par to each other. T_1 (Control) recorded the lowest TSS in both years of investigation.

4.3.3 Protein content (%)

The data presented in Table 9 and Fig.17 showed significant difference for protein content in onion bulb under various treatments. Application of pig manure @ 20 MT/ha (T_4) recorded maximum protein content (6.38% and 6.42%) in the year 2007-08 and 2008-09 respectively followed by T_{10} (50% RDF + 50% vermicompost) and T_9 (50% RDF + 50% Poultry manure). However, they remained at par. All other treatments also caused significant impact in enhancing the protein content of onion bulbs to control. The 75% RDF + *Azospirillum* treatment exerted better impact on protein content of bulbs in comparison to other biofertilizer combination.

4.3.4. Sugar content

4.3.4.1 Reducing sugar (%)

Table 10 and Fig. 18 revealed that the various treatments varied significantly for the reducing sugar content in onion bulb during both years of experimentation. The maximum mean percentage of reducing sugar (2.92% and 2.94 %) during 2007-08 and 2008-09 was recorded with T_9 (50% RDF +50 % Poultry manure) followed by T_8(50% RDF + 50 % Pig manure) and remained at par with T_7 (50% RDF +50 % FYM) and T_{10} 50% RDF +50 % vermicompost). The minimum reducing sugar was recorded in control (T_1) in both the years.

4.3.4.2 Non reducing sugar (%)

It is evident from Table 10 and Fig. 19 that the maximum mean percentage of non reducing sugar content (5.89% and 5.91 %) during 2007-08 and 2008-09 respectively was recorded with treatment T_9 (50% RDF +50 % Poultry manure). However, it remained statistically at par with T_8 (50% RDF + 50 % Pig manure), T_7 (50% RDF + 50 % FYM), T_{10} (50% RDF + 50 %

Vermicompost) and T_2 (100% RDF). During the both the years of investigation, the lowest percentage of non reducing sugar content was obtained in control (T_1) *i.e.*3.79%.

4.3.4.3 Total sugar (%)

Data pertaining to total sugar content (%) has been represented in Table 10 and Fig. 20. The total sugar content varied significantly among the different treatments. The maximum mean total sugar content (8.80% and 8.85 %) in the year 2007-08 and 2008-09 respectively was recorded in treatment T_9 (50% RDF + 50% Poultry manure) followed by treatment T_8 (50% RDF + 50 % Pig manure) with 8.77% and remained at par with T_7 (50% RDF + 50% FYM) and T_{10} (50% RDF + 50 % Vermicompost) and T_2 (100%RDF) while the lowest total sugar content was noticed in control (T-$_1$) i.e. 5.18%.

4.3.5 Concentration N, P and K in leaves and bulb

4.3.5.1 N, P and K content (%) in leaves

It is evident from Table 11 and Fig. 21 that different treatments and their combinations significantly influenced the concentration of nitrogen in leaves. During both the years of experimentation, treatment T_9 (50% RDF +50 % Poultry manure) recorded maximum mean nitrogen concentration (1.26%). However, it remained at par with T_7 (50% RDF + 50% FYM), T_8 (50% RDF + 50 % Pig manure), T_6 (Vermicompost @6 MT/ha), T_{11} (50% RDF + *Azotobacter*), T_5 (Poultry manure @ 10 MT/ha) and T_{10} (50% RDF + 50% vermicompost). Treatment T_1 (Control) recorded the lowest nitrogen concentration during both the years.

Combined application of 50% RDF +50% Pig manure (T_8) recorded maximum mean concentration of phosphorus with 0.47 % and 0.51% during 2007-08 and 2008-09 respectively and remained at par with T_9 (50% RDF + 50% poultry manure), T_6 (Vermicompost @6MT/ha), T_4 (Pig manure @20MT/ha), T_7 (50% RDF + 50% FYM), T_{15} (75% RDF + *Azospirillum*) and T_{10} (50% RDF + 50 % Vermicompost). The lowest phosphorus concentration (0.31%) was recorded in T_1 (Control).

Treatment T_{10} (50% RDF + 50% Vermicompost) caused maximum mean concentration of potassium in both the years of experimentation (1.72% and 1.80% respectively) followed by T_8 (50% RDF + 50 % Pig manure) with 1.73% and remained at par with T_7 (50% RDF + 50% FYM), T_2 (100% RDF) and T_{12} (50%RDF +*Azospirillum*). In both years, T_1 (Control) recorded minimum mean potassium concentration (1.18%).

Table 9: Effect of integrated nutrient management on qualitative characters of onion

Treatment	Dry matter (%)		Pool Mean	Bulb dry matter (q/ha)		Pool Mean	Dry matter of leaves (q/ha)		Pool Mean	TSS (°Brix)		Pool Mean	Protein (%)		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	9.30	8.90	9.10	7.36	9.26	8.31	2.15	2.21	2.18	9.30	9.21	9.25	4.05	3.86	3.95
T_2- 100 % RDF	10.73	10.75	10.74	18.35	19.27	18.81	4.12	5.00	4.56	10.25	10.35	10.30	6.70	4.30	5.50
T_3- FYM @ 30 MT/ha	10.15	10.05	10.10	13.25	14.14	13.71	4.10	3.53	3.80	10.20	10.23	10.21	5.46	5.71	5.58
T_4- Pig manure @ 20 MT/ha	9.08	9.00	9.04	13.48	17.18	15.33	5.25	5.11	5.18	10.15	10.35	10.25	6.38	6.42	6.40
T_5- Poultry manure @ 10 MT/ha	10.52	10.03	10.27	17.25	19.41	18.33	4.30	4.26	4.28	10.00	10.58	10.29	6.98	3.96	5.47
T_6- Vermicompost @ 6 MT/ha	10.18	10.26	10.22	20.35	20.99	20.67	4.36	5.28	4.82	10.43	9.92	10.17	7.0	4.32	5.66
T_7-50% RDF + 50% FYM	11.60	10.90	11.25	12.30	12.48	21.76	5.18	5.38	5.28	10.85	10.68	10.76	5.46	4.76	5.11
T_8-50% RDF + 50% pig manure	9.79	9.53	9.66	19.02	21.10	20.01	5.51	5.24	5.21	11.00	11.16	11.08	5.40	5.36	5.38
T_9- 50% RDF + 50% poultry manure	10.05	10.05	10.05	20.15	23.14	22.18	5.33	5.20	5.10	11.13	11.17	11.15	6.05	6.15	6.10
T_{10} - 50% RDF +50% vermicompost	9.52	9.16	9.34	12.05	13.31	12.68	4.30	4.83	4.60	10.35	10.53	10.44	6.16	6.20	6.18
T_{11}-50% RDF + *Azotobacter*	9.80	9.66	9.73	10.35	12.17	11.26	5.10	5.08	5.09	9.50	10.10	9.80	4.32	4.98	4.65
T_{12}-50% RDF + *Azospirillum*	10.21	10.13	10.17	17.45	22.07	19.76	4.04	6.00	5.02	9.76	10.20	9.98	5.45	6.23	5.84
T_{13}-50% RDF + Phosphotika	11.00	11.10	11.05	17.05	18.07	17.56	3.15	4.09	3.56	9.76	9.83	9.79	4.33	5.25	4.79
T_{14}- 75% RDF + *Azotobacter*	9.82	9.95	9.88	16.54	16.38	16.46	3.86	3.26	3.25	9.70	10.01	9.85	4.26	4.76	4.51
T_{15}- 75% RDF + *Azospirillum*	9.48	9.33	9.40	16.05	15.11	17.25	3.96	3.2	5.12	9.73	9.76	9.74	6.76	4.48	5.62
T_{16}- 75% RDF + Phosphotika	10.15	9.86	10.00	20.02	15.01	19.23	4.80	5.30	4.15	9.76	9.53	9.64	5.82	5.20	5.51
CD at 5%	0.36	NS	-	3.66	2.02	-	4.09	1.44	-	NS	1.03	-	1.25	1.02	-

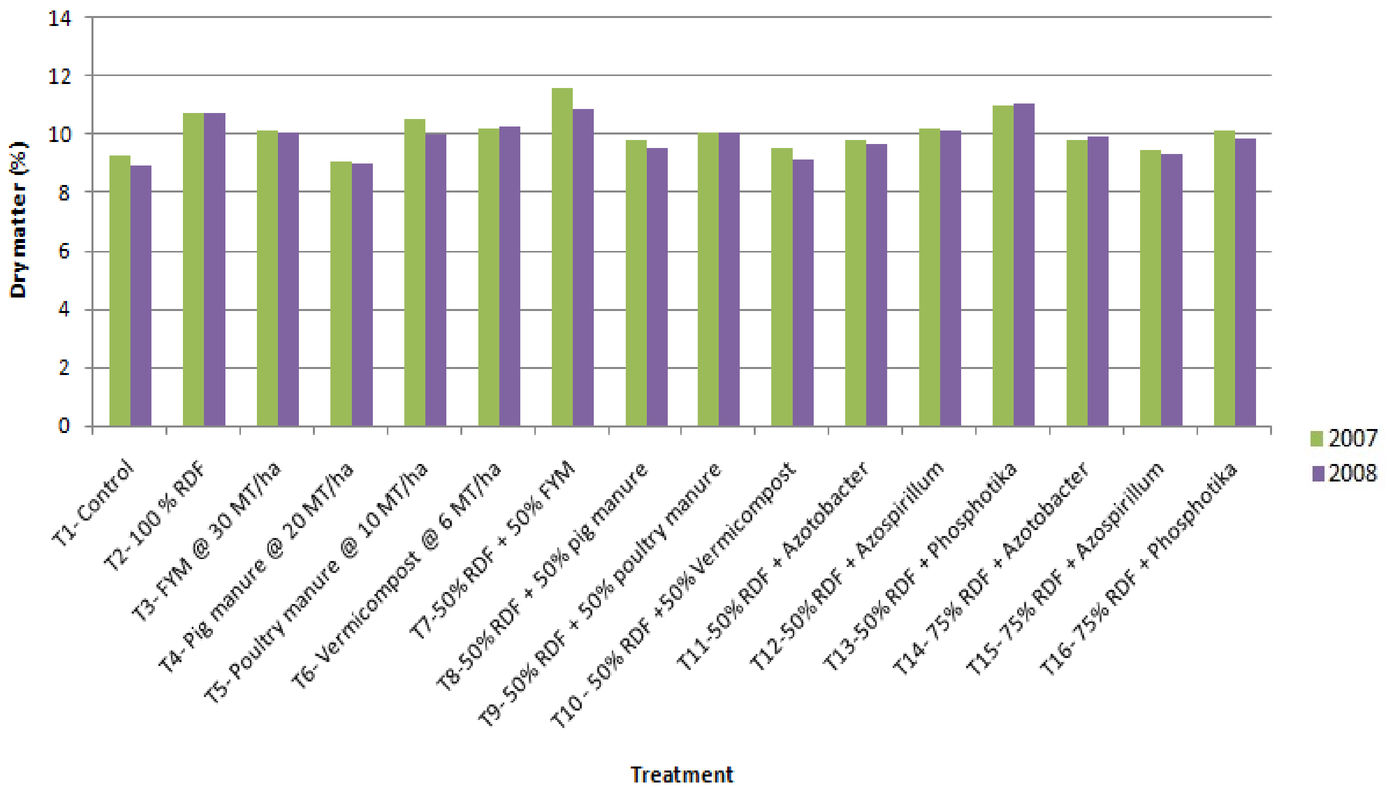

Fig. 13. Effect of integrated nutrient management on dry matter (%)

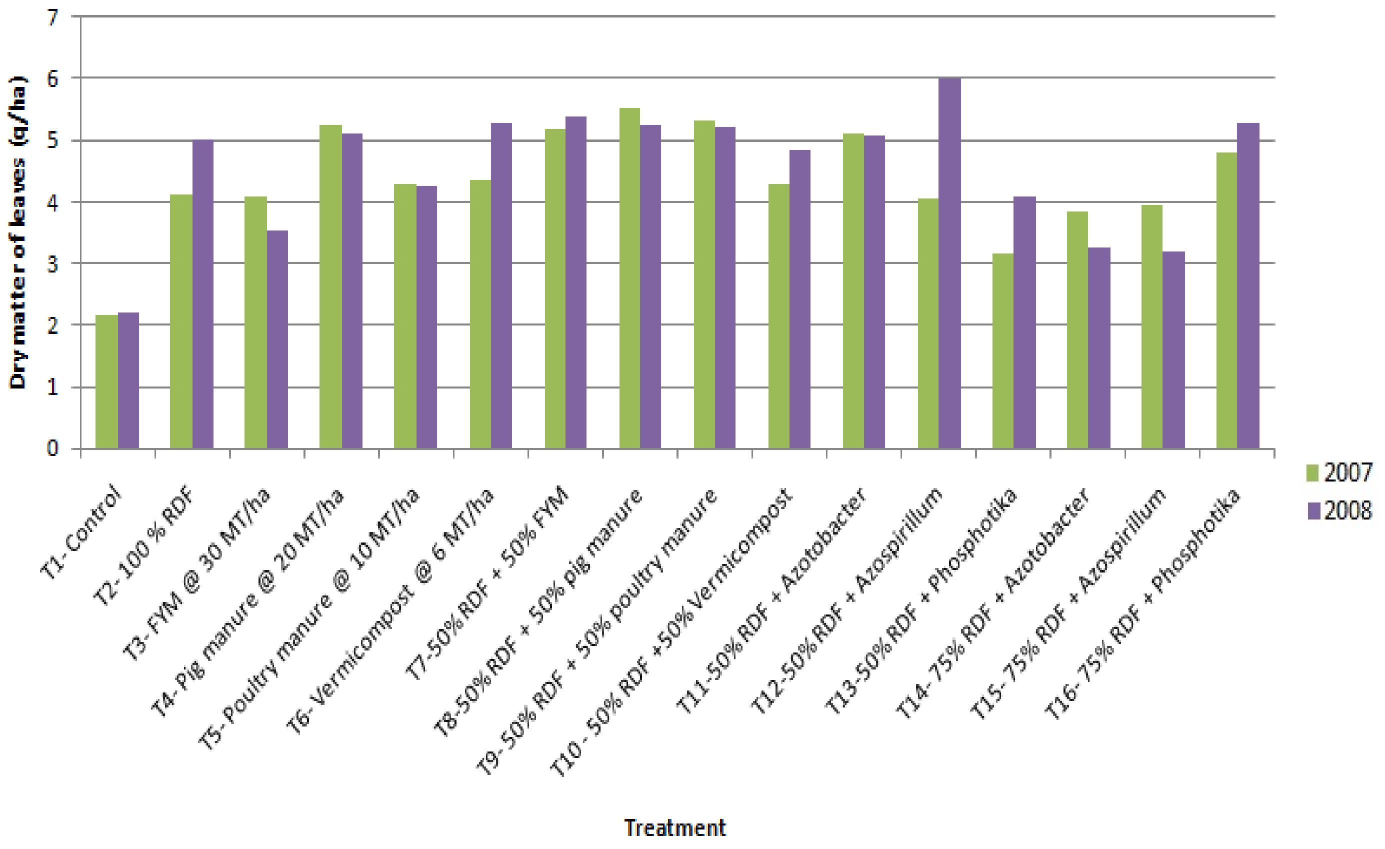

Fig. 15. Effect of integrated nutrient management on dry matter of leaves (q/ha)

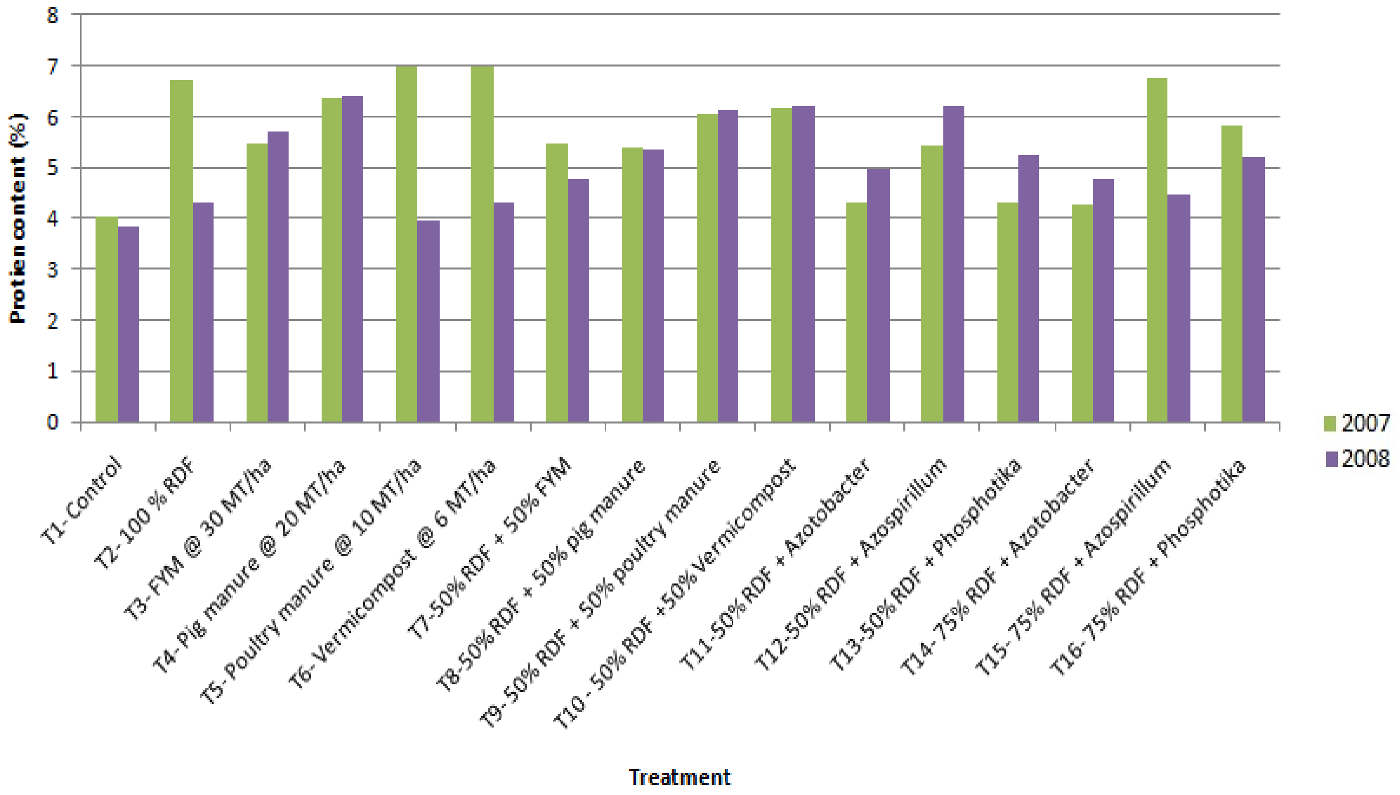

Fig. 17. Effect of integrated nutrient management on Protien content (%)

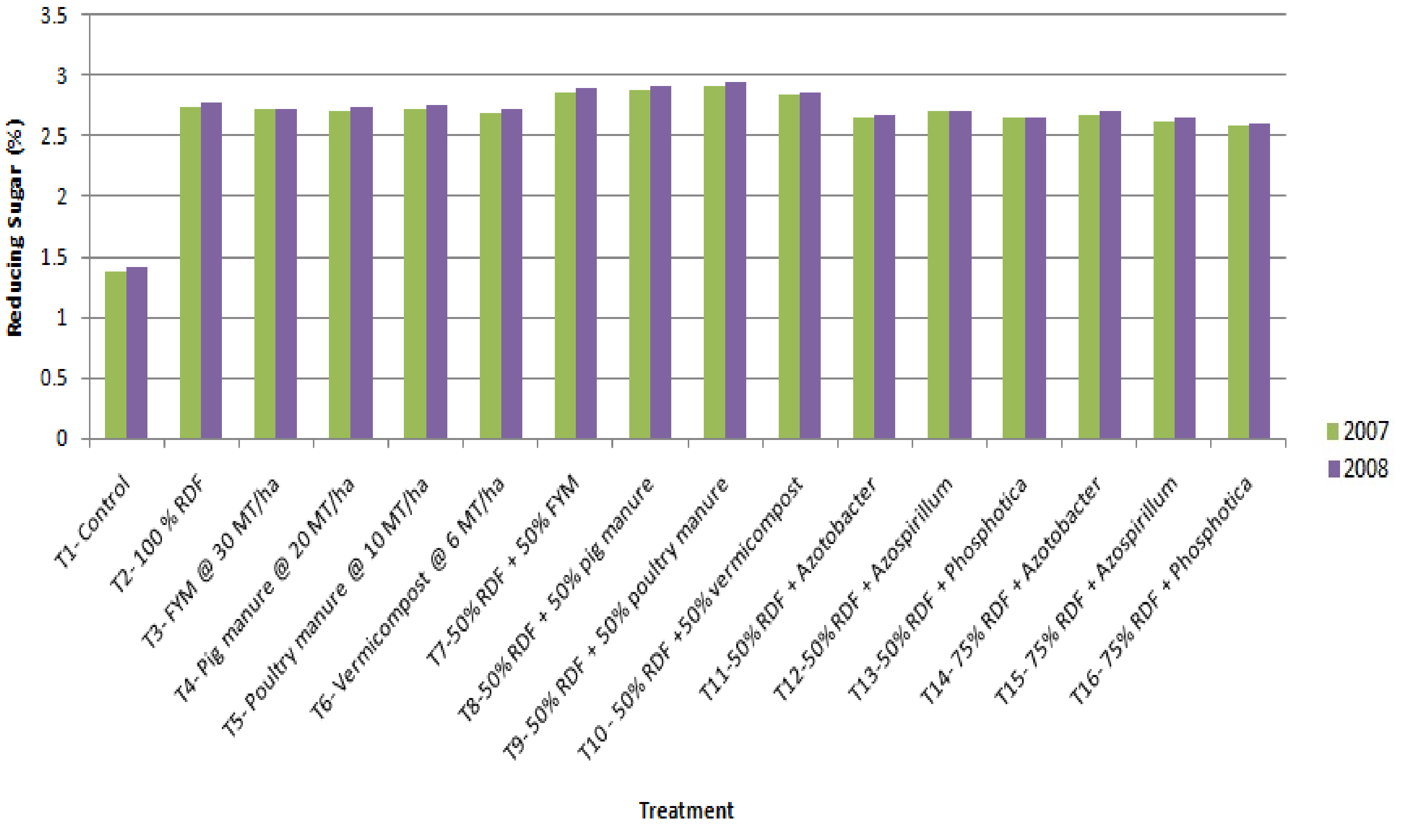

Fig. 18. Effect of integrated nutrient management on reducing sugar (%)

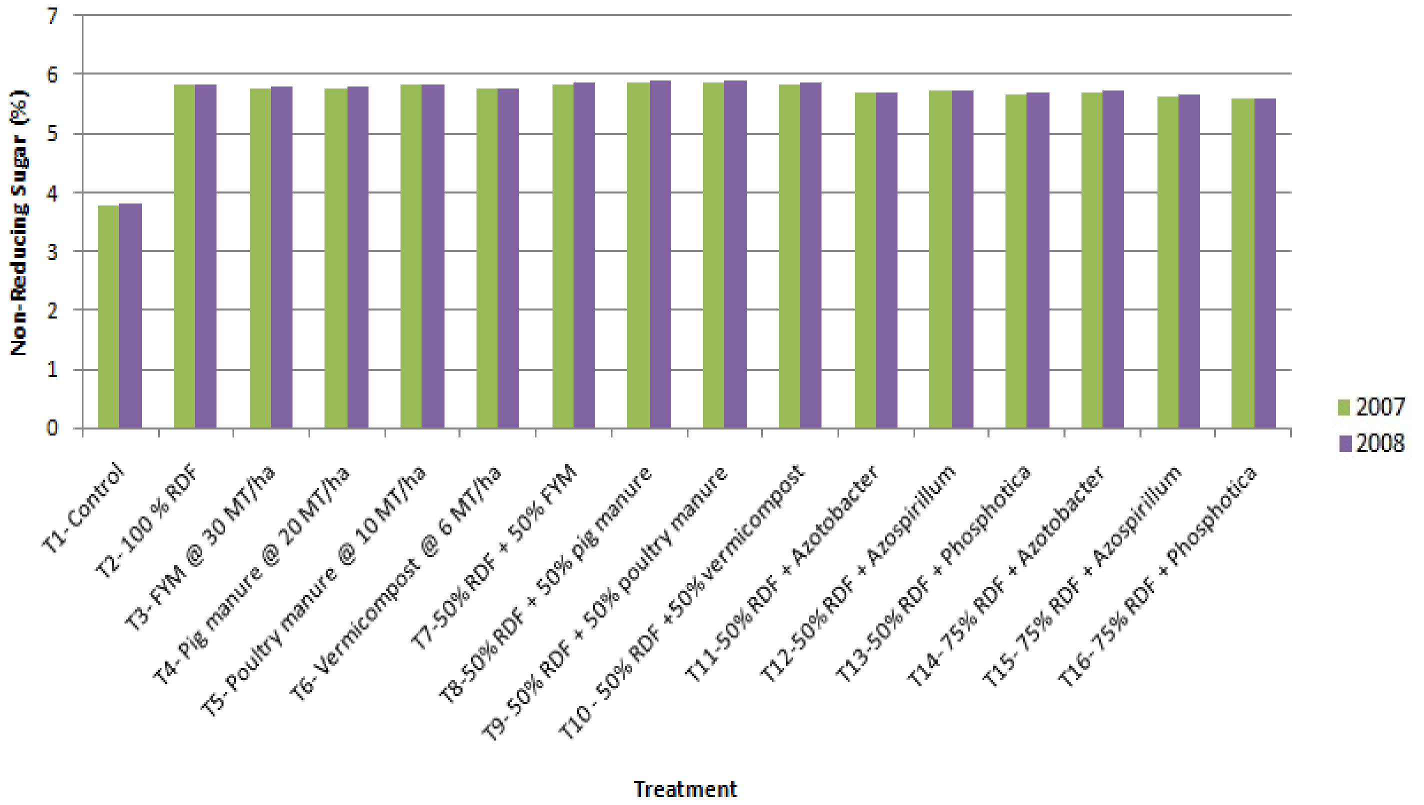

Fig. 19. Effect of integrated nutrient management on non-reducing sugar (%)

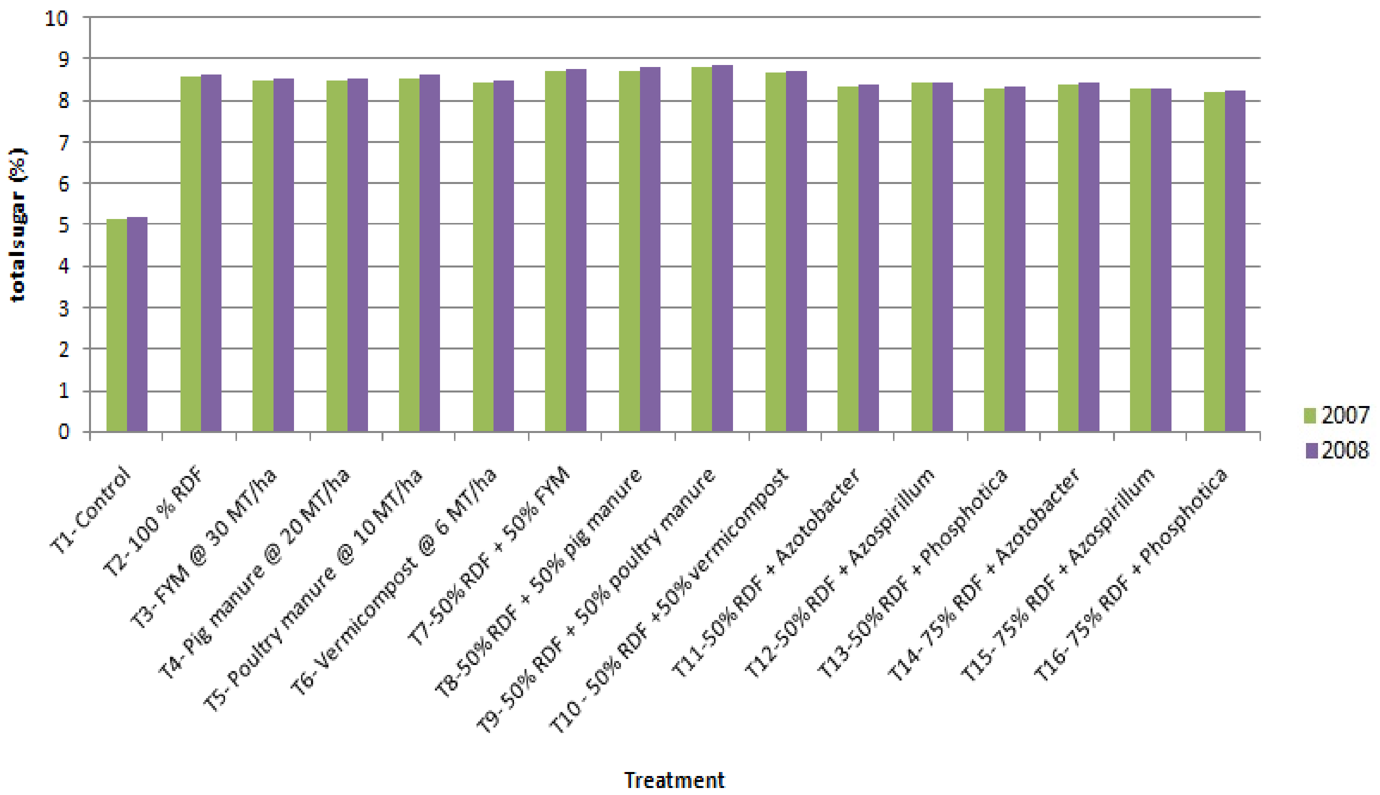

Fig. 20. Effect of integrated nutrient management on total sugar (%)

4.3.5.2 N, P and K content (%) in bulb

The data represented in Table 11 and Fig. 22 revealed that different treatments and their combinations significantly influenced the accumulation of nitrogen and phosphorus but failed to exert any significant effect on potassium concentration.

Average higher concentration of nitrogen (1.12% and 1.20%) during 2007-08 and 2008-09 respectively was recorded in treatment T_9 (50% RDF +50 % Poultry manure) and remained at par with T_7 (50% RDF + 50% FYM) and T_6 (Vermicompost @6 MT/ha). The lowest mean nitrogen accumulation (0.60%) was recorded in T_1 (Control).

Among the treatments, T_6 (Vermicompost @6MT/ha) recorded average highest phosphorus concentration (0.58%). However, it remained at par with T_7 (50% RDF + 50% FYM), T_{11} (50% RDF + *Azotobacter*), T_9 (50% RDF + 50% Poultry manure), T_3 (FYM @30MT/ha), T_2 (100% RDF), T_{12} (50% RDF + *Azotobacter)* and T_{16} (75% RDF + Phosphotica). In both the years, T_1 (control) recorded minimum potassium concentration (0.38%).

In both years of investigation, application of poultry manure @ 10MT/ha (T_5) recorded maximum man concentration of potassium (2.48%). However, it remained statistically at par with T_9 (50% RDF +50 % Poultry manure), T_3 (FYM @30MT/ha), T_8 (50% RDF +50 % pig manure), T_6 (Vermicompost @ 6MT/ha) and T_{13} (50% RDF + Phosphotica) while T_1 (Control) recorded lowest potassium concentration in bulb (0.38%).

4.4. Nutrient uptake by the crop

The data presented in Table 12 and Fig. 23 revealed that application of organic manures, inorganic fertilizers and biofertilizers have appreciable impact on influencing the nitrogen uptake. All the treatments recorded higher uptake of nitrogen as compared to control. Maximum mean uptake of nitrogen (38.69 kg ha^{-1}) was recorded with treatment T_7 (50% RDF + 50% FYM) which was found significantly superior over all other treatments and control but statistically remained at par with treatment T_9 (50% RDF +50 % Poultry manure) and T_{10} (50% RDF + 50 % Vermicompost).

As evident from Table 12 and Fig. 24 that minimum mean uptake of phosphorus (3.15 kg ha^{-1}) was noted in T_1 (Control) while maximum mean uptake of phosphorus (12.64 kg ha^{-1}) was recorded in treatment T_9 (50% RDF +50 % Poultry manure) and remained at par with treatment T_7 (50% RDF + 50% FYM), T_8 (50% RDF + 50 % Pig manure) and T_3 (FYM @30 MT/ha) in both years of study.

Table 11: Effect of integrated nutrient management on concentration of NPK in leaves and bulb (%)

Treatment	Leaves									Bulb								
	N			P			K			N			P			K		
	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean	2007-08	2008-09	Pool Mean
T_1- Control	0.34	0.96	0.65	0.26	0.36	0.31	1.13	1.23	1.18	0.51	0.65	0.58	0.36	0.41	0.38	1.76	1.86	1.81
T_2- 100 % RDF	1.04	1.08	1.06	0.33	0.41	0.37	1.57	1.69	1.63	0.68	0.82	0.75	0.41	0.60	0.50	2.16	2.26	2.21
T_3- FYM @ 30 MT/ha	0.98	1.02	1.00	0.28	0.42	0.35	1.32	1.72	1.52	0.83	0.91	0.87	0.46	0.56	0.51	2.34	2.46	2.40
T_4- Pig manure @ 20 MT/ha	0.48	1.06	0.77	0.38	0.46	0.42	1.46	1.52	1.49	0.86	0.98	0.92	0.38	0.42	0.40	2.21	2.29	2.25
T_5- Poultry manure @ 10 MT/ha	1.10	1.20	1.15	0.33	0.39	0.36	1.28	1.36	1.32	0.93	0.99	0.96	0.41	0.45	0.43	2.45	2.51	2.48
T_6- Vermicompost @ 6 MT/ha	1.18	1.20	1.19	0.43	0.49	0.46	1.32	1.38	1.35	1.04	1.20	1.12	0.56	0.60	0.58	2.30	2.40	2.35
T_7-50% RDF + 50% FYM	1.22	1.26	1.24	0.44	0.46	0.45	1.66	1.70	1.68	1.09	1.19	1.14	0.53	0.59	0.56	2.11	2.21	2.16
T_8-50% RDF + 50% pig manure	1.18	1.26	1.22	0.47	0.51	0.49	1.70	1.76	1.73	0.98	1.00	0.99	0.45	0.49	0.47	2.32	2.42	2.37
T_9- 50% RDF + 50% poultry manure	1.23	1.29	1.26	0.46	0.50	0.48	1.40	1.48	1.44	1.12	1.20	1.16	0.45	0.59	0.52	2.42	2.50	2.46
T_{10} - 50% RDF +50% vermicompost	1.10	1.18	1.14	0.40	0.42	0.41	1.72	1.80	1.76	0.73	0.89	0.81	0.40	0.42	0.41	2.27	2.33	2.30
T_{11}-50% RDF + *Azotobacter*	1.15	1.17	1.16	0.29	0.39	0.34	1.36	1.40	1.38	0.81	0.91	0.86	0.48	0.58	0.53	2.22	2.34	2.28
T_{12}-50% RDF + *Azospirillum*	0.47	0.99	0.73	0.36	0.40	0.38	1.55	1.65	1.60	0.59	0.83	0.71	0.49	0.51	0.50	2.16	2.20	2.18
T_{13}-50% RDF + Phosphotika	1.06	1.14	1.10	0.35	0.40	0.37	1.48	1.56	1.52	0.71	0.81	0.76	0.43	0.49	0.46	2.29	2.37	2.33
T_{14}- 75% RDF + *Azotobacter*	0.29	0.99	0.64	0.22	0.29	0.25	1.54	1.62	1.58	0.78	0.86	0.82	0.41	0.43	0.42	2.10	2.25	2.17
T_{15}- 75% RDF + *Azospirillum*	0.35	1.09	0.72	0.44	0.44	0.44	1.36	1.42	1.39	0.97	0.99	0.98	0.43	0.47	0.45	2.09	2.11	2.10
T_{16}- 75% RDF + Phosphotika	1.10	0.90	1.00	0.20	0.29	0.24	1.50	1.10	1.38	0.50	0.80	0.65	0.50	0.50	0.50	2.20	2.30	2.25
CD at 5%	0.16	0.12	-	0.10	0.18	-	0.53	0.72	-	0.39	0.35	-	0.23	0.22	-	1.29	1.02	-

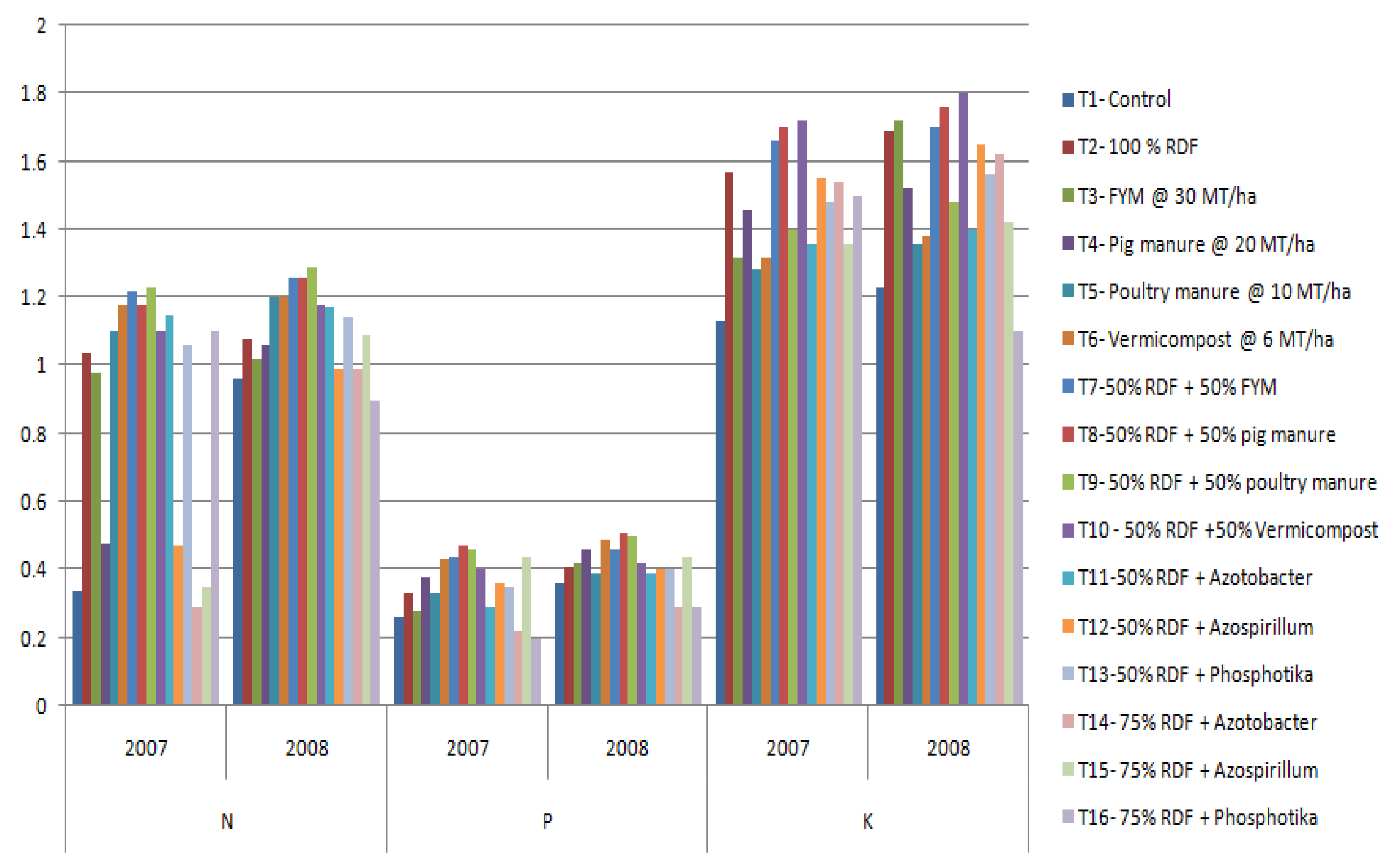

Fig. 21. Effect of integrated nutrient management on concentration of NPK in leaves

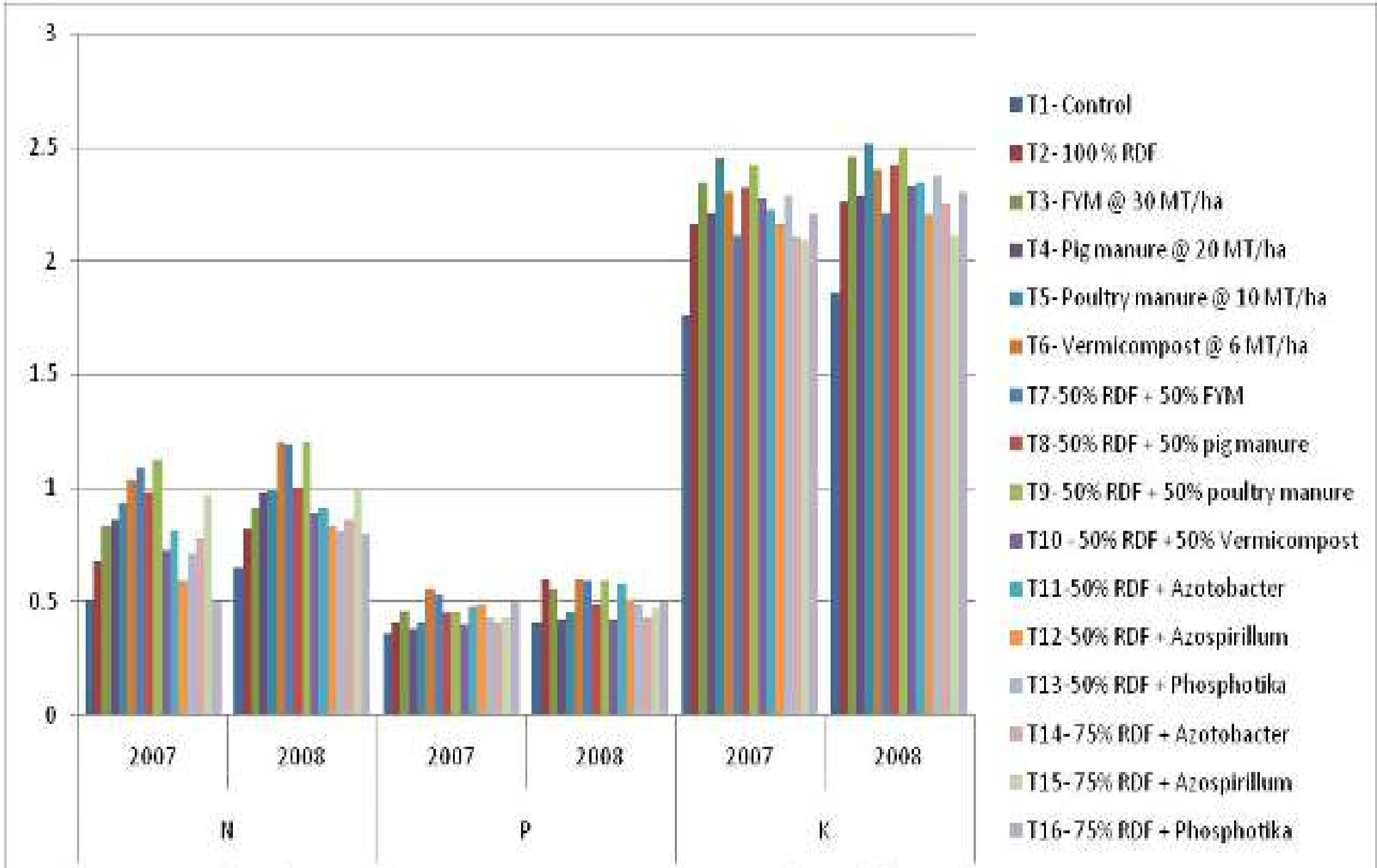

Fig. 22. Effect of integrated nutrient management on concentration of NPK in bulbs

The data represented in Table 12 and Fig. 25 showed better uptake of potassium 55.91 kg ha^{-1} and 59.35 kg ha^{-1} during 2007-08 and 2008-09 respectively with treatment T_9 (50% RDF +50 % Poultry manure) which was followed by T_7 (50% RDF + 50% FYM), T_{12} (50% RDF + Phosphotica), T_5 (Poultry manure @10 MT/ha) and T_2 (100% RDF). However, it remained statistically at par to each other while the lowest uptake of potassium was observed in T_1 (Control).

It is revealed from the data in Table 12 and Fig. 26 that the sulphur uptake showed a significant difference as influenced by the organic manures, inorganic fertilizers and biofertilizers and their combinations. In both the years, maximum mean sulphur uptake (0.70% and 0.73%) respectively was recorded with treatment T_6 (Vericomost @6MT/ha) and T_9 (50% RDF +50 % Poultry manure). These treatments were significantly superior to control (0.60%) but statistically at par with other treatments.

4.5 Fertility status of soil after harvest

The data presented in Table 13 revealed that application of organic manures, inorganic fertilizers and biofertilizers exerted significant influence of soil pH after harvest. Both treatment T_9 (Poultry manure + *Azotobacter*) and T_{13} (50% RDF + Phosphotica) recorder the highest mean soil pH (5.31) and remined statistically at par with T_6 (Vermicompost @ 6MT/ha), T_8 (50% RDF + 50 % Pig manure), T_7 (50% RDF + 50 % FYM), T_2 (100% RDF) and T_4 (Pig manure @ 20MT/ha) while the lowest soil pH was found in T_1 (Control).

As evident from the data presented in Table 13 FYM @30 MT/ha was found significantly superior over all the other treatments with 3.15% and 3.30% organic carbon during 2007-08 and 2008-09 respectively followed by T_4 (Pig manure @ 20 MT/ha) and T_8 (50% RDF + 50 % Pig manure). Most of other treatment also showed positive trend on enhancing organic carbon significantly to control in both the years of experimentation.

It is evident from Table 13 that all the treatments recorded higher available nitrogen after harvest over control. Maximum mean available nitrogen (298.92 kg ha^{-1}) was recorded in treatment T_8 (50% RDF + 50 % Pig manure) followed by T_2 (100% RDF), T_9 (50% RDF +50 % Poultry manure), T_{16} (75% RDF +Phosphotica) and T_6 (Vermicompost @ 6MT/ha). Other treatment also significantly influenced the nitrogen content of soil during both years.

Table 12: Effect of integrated nutrient management on nutrient uptake (kg ha^{-1}) by onion crop

Treatment	N		Pool Mean	P		Pool Mean	K		Pool Mean	Sulphur		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	8.09	8.21	8.15	3.09	3.21	3.15	16.77	17.15	16.96	0.60	0.61	0.60
T_2- 100 % RDF	16.81	16.23	16.52	6.90	7.10	7.00	50.01	51.41	50.71	0.63	0.67	0.65
T_3- FYM @ 30 MT/ha	10.43	17.05	13.74	11.20	12.93	12.06	42.38	31.62	37.00	0.63	0.67	0.65
T_4- Pig manure @ 20 MT/ha	18.78	20.10	19.44	8.23	9.05	8.64	47.90	41.16	47.53	0.68	0.71	0.68
T_5- Poultry manure @ 10 MT/ha	26.11	25.53	25.82	10.46	10.96	10.71	48.42	53.70	51.06	0.65	0.69	0.67
T_6- Vermicompost @ 6 MT/ha	25.24	26.78	26.01	7.47	8.85	8.16	31.82	33.30	32.56	0.70	0.73	0.71
T_7-50% RDF + 50% FYM	41.20	36.18	38.69	12.34	12.62	12.48	53.12	57.20	55.16	0.61	0.68	0.34
T_8-50% RDF + 50% pig manure	28.26	29.06	28.66	11.61	13.10	12.35	38.42	51.10	44.76	0.65	0.69	0.67
T_9- 50% RDF + 50% poultry manure	34.82	36.38	35.60	12.42	12.86	12.64	55.91	59.35	57.63	0.70	0.73	0.71
T_{10} - 50% RDF +50% vermicompost	33.91	36.25	35.08	9.65	10.77	10.21	41.31	43.05	42.18	0.61	0.62	0.61
T_{11}-50% RDF + *Azotobacter*	18.87	20.15	19.51	11.83	12.01	11.92	29.12	30.98	30.05	0.68	0.71	0.69
T_{12}-50% RDF + *Azospirillum*	29.17	30.35	29.76	10.84	11.56	11.20	51.34	53.36	52.35	0.70	0.73	0.69
T_{13}-50% RDF + Phosphotika	16.70	29.44	23.07	11.33	12.19	11.76	47.47	48.61	48.07	0.61	0.62	0.61
T_{14}- 75% RDF + *Azotobacter*	19.26	20.46	19.86	8.53	8.91	8.72	28.75	31.45	30.11	0.62	0.65	0.63
T_{15}- 75% RDF + *Azospirillum*	15.14	16.98	16.06	10.38	10.66	10.52	45.69	48.35	47.02	0.68	0.71	0.69
T_{16}- 75% RDF + Phosphotika	19.90	20.00	19.95	9.60	10.00	9.80	47.20	49.10	48.15	0.61	0.62	0.61
CD at 5%	4.31	3.36	-	1.63	0.79	-	13.52	9.45	-	0.13	0.21	-

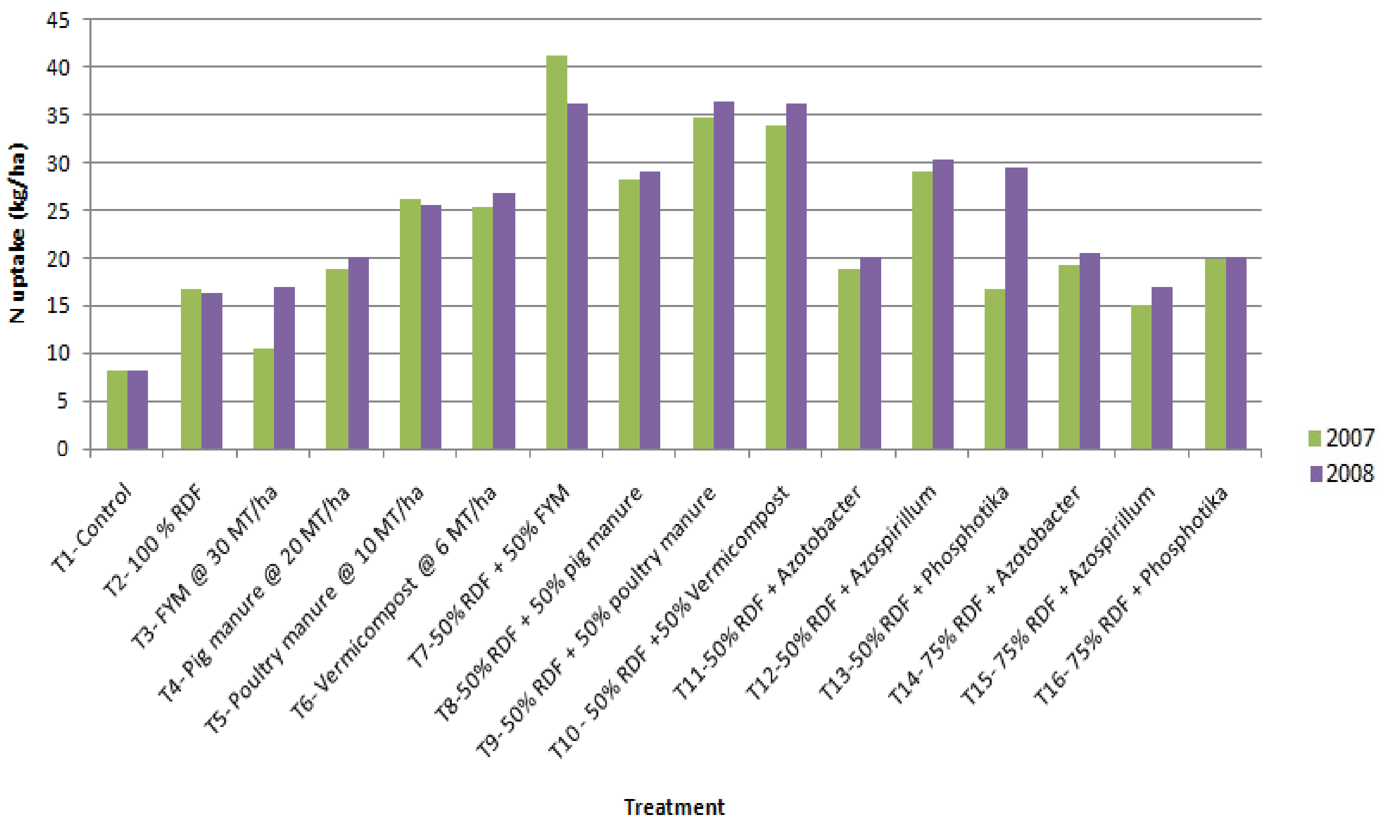

Fig. 23. Effect of integrated nutrient management on N uptake (kg/ha) by onion crop

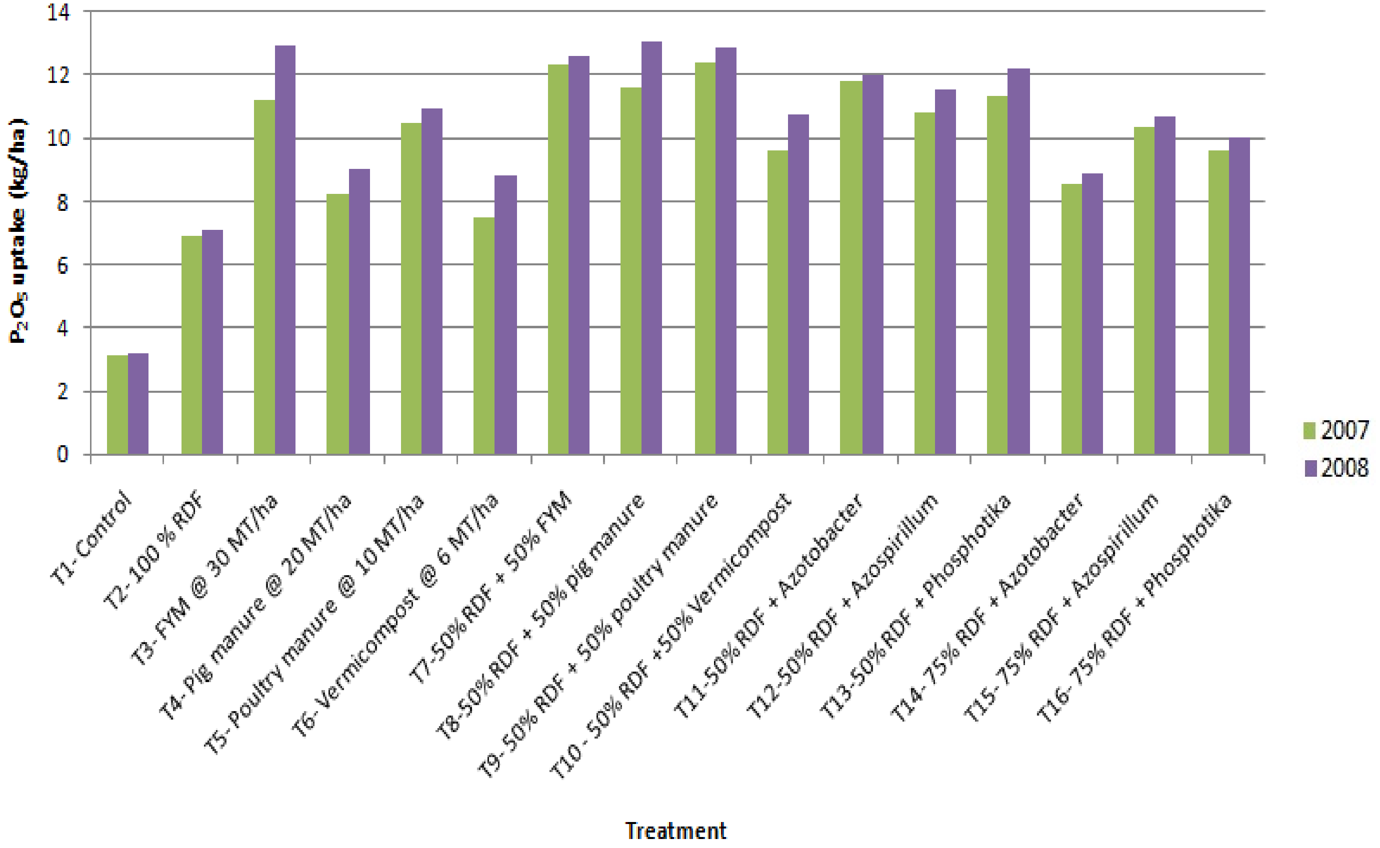

Fig. 24. Effect of integrated nutrient management on P_2O_5 uptake (kg/ha) by onion crop

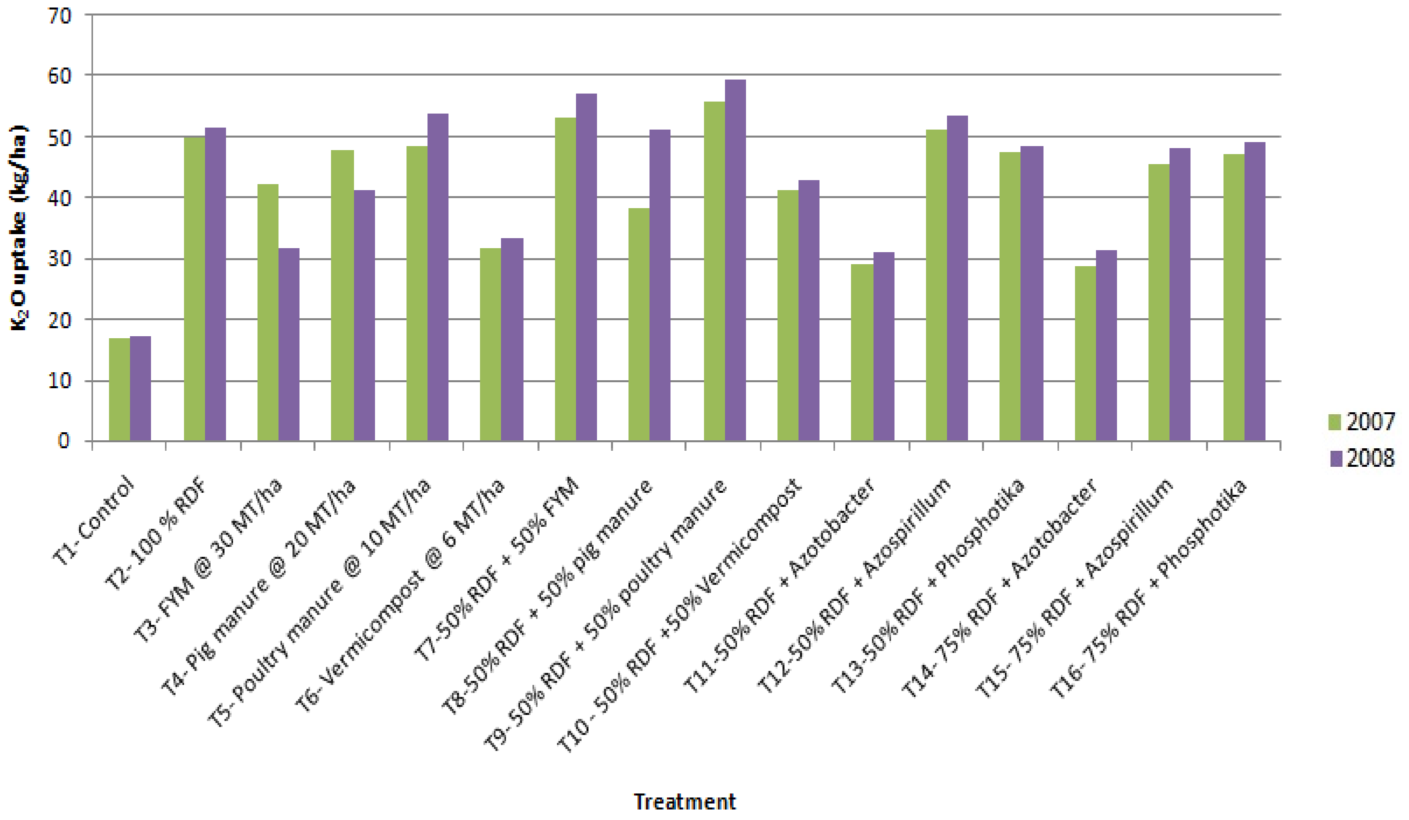

Fig. 25. Effect of integrated nutrient management on K_2O uptake (kg/ha) by onion crop

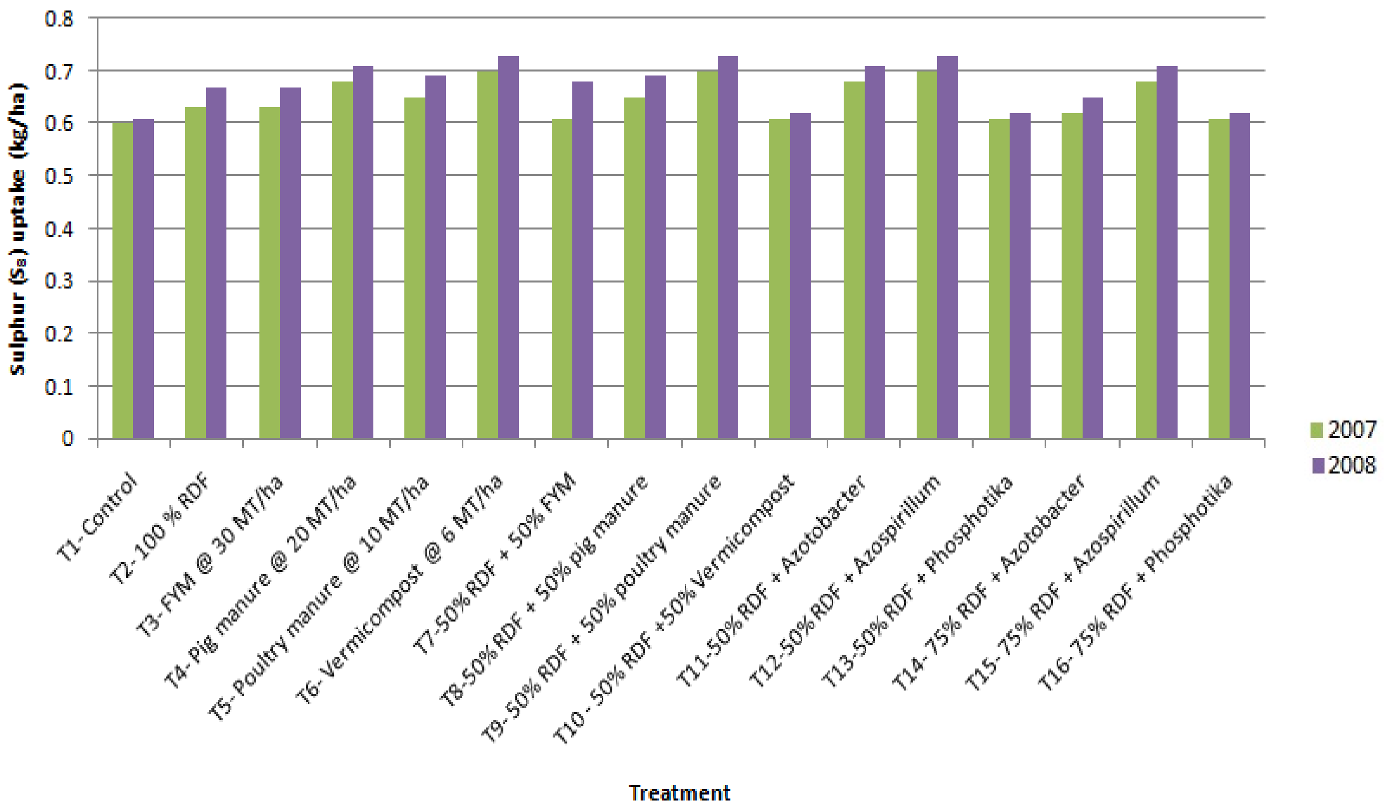

Fig. 26. Effect of integrated nutrient management on sulphur (S_8) uptake (kg/ha) by onion crop

All the treatments recorded higher P_2O_5 over control (9.51 kg ha^{-1}). The maximum mean available P_2O_5 (14.26 kg ha^{-1}) was recorded with treatment T_8 (50% RDF + 50 % Pig manure) which was noted at par with T_{10} - 50% RDF +50% vermicompost, T_7 (50% RDF + 50% FYM), T_9 (50% RDF +50 % Poultry manure), T_{16} (75% RDF + Phosphotica) and T_3 (FYM @30 MT/ha). In both the years, T_1 (Control) recorded minimum available potassium.

Similarly, it is evident from Table 13 that control treatment recorded minimum available K_2O (165.30 kg ha^{-1}) as compared to other treatments. Maximum mean available K_2O (245.35 kg ha^{-1}) was recorded with treatment T_9 (50% RDF +50 % Poultry manure) followed by T_8 (50% RDF + 50 % Pig manure), T_{13} (50% RDF + Phosphotica and T_3 (FYM @ 30MT/ha).

4.6 Storage

4.6.1 Rotting loss (%)

The rotting percentage was recorded at 40 days after storage of onion bulbs during the year 2007-08 and 2008-09. The statistical analysis of the data (Table 14 and Fig. 27) shows that a significant difference was found in the rotting percentage as influenced by various organic, inorganic fertilizers and biofertilizers and their combination. The maximum mean rotting percentage (25.75%) in onion bulbs was reported in treatment T_8 (50% RDF + 50 % Pig manure) followed by T_2 (100% RDF), T_{14} (75% RDF + *Azotobacter*), T_{15} (75% RDF + *Azospirillum*) and T_{16} (75% RDF + Phosphotica). However, they remained statistically at par. Application of 50% RDF +50 % Poultry manure (T_9) recorded minimum mean rotting loss (15.71%)

4.6.2 Sprouting loss (%)

The data presented in Table 14 and Fig. 27 showed significant differences for sprouting loss under various treatments. Application of 100% recommended dose of fertilizer (T_2) recorded higher mean sprouting loss 6.72% and 6.31% during 2007-08 and 2008-09 respectively followed by T_{11} (50% RDF + *Azotobacter*), T_{12} (50% RDF + *Azospirillum*), T_{14} (75% RDF + *Azotobacter*), T_{15} (75% RDF + *Azospirillum*) and T_{16} (75% RDF + Phosphotica). Minimum sprouting loss (4.24%) was observed in T_5 (Poultry manure @10MT/ha) in both the years.

4.6.3 Physiological weight loss (%)

It is evident from the Table 14 and Fig. 27 that the various treatments varied significantly for the different treatments. The maximum physiological weight loss 18.72% and 18.07% was recorded by application of 100% RDF (T_2) during 2007-08 and 2008-09 respectively followed by T_{14} (75% RDF + *Azotobacter*) and T_{15} (75% RDF + *Azospirillum*). However, they remained statistically at par.

Table 13: Effect of integrated nutrient management on fertility status of soil after harvest

Treatment	Available N (kg ha^{-1})		Pool Mean	Available P_2O_5 (Kg ha^{-1})		Pool Mean	Available K_2O (Kg ha^{-1})		Pool Mean	Organic Carbon (%)		Pool Mean	pH		Pool Mean
	2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09		2007-08	2008-09	
T_1- Control	186.00	188.00	187.00	9.03	10.00	9.51	165.00	165.60	165.30	1.90	1.94	1.92	5.10	5.00	5.05
T_2- 100 % RDF	276.15	317.17	296.66	12.14	13.38	12.76	206.35	214.21	210.28	2.30	2.40	2.35	5.32	5.20	5.26
T_3- FYM @ 30 MT/ha	240.00	286.00	263.00	12.83	13.92	13.37	226.51	235.15	230.83	3.15	3.30	3.22	5.26	5.19	5.22
T_4- Pig manure @ 20 MT/ha	274.33	322.00	242.66	11.31	13.64	12.47	181.69	196.22	188.95	2.45	2.35	2.40	5.30	5.20	5.25
T_5- Poultry manure @ 10 MT/ha	271.35	286.00	231.66	11.76	13.43	12.59	186.10	199.22	192.65	2.11	2.15	2.13	5.18	5.12	5.15
T_6- Vermicompost @ 6 MT/ha	273.00	289.00	281.00	12.05	11.49	11.77	129.21	203.15	166.18	2.18	2.14	2.16	5.38	5.22	5.30
T_7-50% RDF + 50% FYM	198.20	289.05	243.62	12.73	14.60	13.66	182.50	196.00	189.25	2.30	2.35	2.32	5.30	5.24	5.27
T_8-50% RDF + 50% pig manure	289.70	308.14	298.92	13.43	15.09	14.26	230.09	250.15	240.12	2.20	2.60	2.40	5.33	5.26	5.29
T_9- 50% RDF + 50% poultry manure	291.00	301.00	296.00	13.11	13.85	13.48	236.00	254.70	245.35	2.25	2.31	2.28	5.34	5.28	5.31
T_{10} - 50% RDF +50% vermicompost	269.18	219.17	244.17	13.65	14.77	14.21	215.00	222.03	218.51	2.18	2.13	2.15	5.30	5.25	5.27
T_{11}-50% RDF + *Azotobacter*	276.00	202.00	239.00	12.73	13.89	13.31	176.15	215.47	195.81	2.19	2.18	2.18	5.28	5.19	5.23
T_{12}-50% RDF + *Azospirillum*	190.15	219.17	204.66	11.10	13.39	12.24	211.04	231.20	221.12	2.16	2.14	2.15	5.18	5.13	5.15
T_{13}-50% RDF + Phosphotika	247.66	235.00	241.33	11.36	13.51	12.43	212.71	253.21	232.96	2.16	2.13	2.14	5.36	5.26	5.31
T_{14}- 75% RDF + *Azotobacter*	174.14	273.18	223.66	13.20	12.20	12.20	182.10	205.02	193.56	2.21	2.20	2.20	5.23	5.17	5.20
T_{15}- 75% RDF + *Azospirillum*	271.00	250.10	260.55	12.27	13.58	12.92	220.04	256.33	138.18	2.18	2.14	2.16	5.26	5.20	5.23
T_{16}- 75% RDF + Phosphotika	276.00	290.00	283.00	13.30	13.60	13.45	205.30	225.00	215.15	2.22	2.17	2.19	5.20	5.16	5.18
CD at 5%	25.61	18.64	-	4.30	4.07	-	20.87	27.73	-	1.28	1.04	-	0.89	1.20	-

whereas, minimum mean physiological weight loss during storage (14.16%) was noticed with application of poultry manure @10MT/ha (T_5) in both the years.

4.7 Economics of the treatment

4.7.1 Cost of cultivation

The economics of different INM based treatments are presented in Table 15. The cost of cultivation of onion per hectare varied under different treatments. The maximum cost of cultivation was incurred in treatment receiving 6 MT Vermicompost/ha (T_6) followed by application of 50% RDF + 50% vermicompost (T_{10}). Application of organic manures alone or in combination recorded higher cost of cultivation over combined application of inorganic fertilizers and biofertilizers.

4.7.2 Net return

Net monetary return also varied due to different treatments. The maximum net return (Rs. 136175 ha $^{-}$1) was received in the treatment T_9 (50% RDF +50 % Poultry manure) followed by application of 50% RDF +50 % FYM (Rs. 125885 ha $^{-1}$) and T_8 (50% RDF +50 % Pig manure) with net value Rs. 118845 ha $^{-1}$). Combined application of organic manures and fertilizers caused better net return than individual application. It was calculated minimum (Rs. 57090 ha^{-1}) in control plot (T_1).

4.7.3 Benefit cost ratio

It is rate of profit over each rupee of investment and also expressed as profitability.

The data revealed from the Table 16 that among the different treatments, the lowest profit ratio (1:1.71) was obtained in control plot (T_1). The treatment combination of 50% RDF +50 % Poultry manure (T_9) resulted in higher benefit : cost ratio (1:3.10) followed by T_7 (50% RDF + 50% FYM) with 1:2.80 and T_8 (50% RDF + 50% pig manure) with 1:2.65.

Table 14: Effect of integrated nutrient management on storage of onion

Treatment	Rotting loss (%)		Pool Mean	Sprouting loss (%)		Pool Mean	Physiological weight loss (%)		Pool Mean
	2007	2008		2007	2008		2007	2008	
T_1- Control	16.56	16.14	16.35	4.96	4.43	4.69	15.31	14.76	15.03
T_2- 100 % RDF	18.52	18.05	18.28	6.72	6.31	6.51	18.72	18.07	18.39
T_3- FYM @ 30 MT/ha	16.82	16.16	16.22	5.03	4.86	4.94	15.85	14.93	15.39
T_4- Pig manure @ 20 MT/ha	17.03	16.23	16.63	5.15	4.92	5.03	16.17	15.82	15.99
T_5- Poultry manure @ 10 MT/ha	16.05	15.38	15.71	4.32	4.16	4.24	14.68	13.64	14.16
T_6- Vermicompost @ 6 MT/ha	17.15	16.72	16.93	5.28	5.00	5.14	16.37	15.98	16.17
T_7-50% RDF + 50% FYM	17.08	16.48	16.78	5.60	5.18	5.39	17.03	16.56	16.79
T_8-50% RDF + 50% pig manure	17.32	16.86	25.75	5.73	5.49	5.61	17.16	16.60	16.88
T_9- 50% RDF + 50% poultry manure	16.48	15.64	16.06	5.46	5.09	5.27	16.84	16.36	16.60
T_{10} - 50% RDF +50% vermicompost	17.46	17.00	17.23	5.96	5.51	5.73	17.28	16.81	17.04
T_{11}-50% RDF + *Azotobacter*	18.11	17.65	17.88	6.48	6.03	6.25	18.09	17.35	17.72
T_{12}-50% RDF + *Azospirillum*	18.05	17.39	17.72	6.31	5.74	6.02	17.84	17.10	17.47
T_{13}-50% RDF + Phosphotika	17.96	17.45	17.70	6.10	5.65	5.87	17.52	17.05	17.28
T_{14}- 75% RDF + *Azotobacter*	18.50	17.73	18.11	6.68	6.27	6.47	18.43	17.78	18.10
T_{15}- 75% RDF + *Azospirillum*	18.42	17.81	18.11	6.56	6.17	6.36	18.56	17.86	18.21
T_{16}- 75% RDF + Phosphotika	18.38	17.65	18.01	6.60	6.18	6.39	18.29	17.65	17.97
CD at 5%	4.27	4.32	-	0.36	0.48	-	3.86	4.08	-

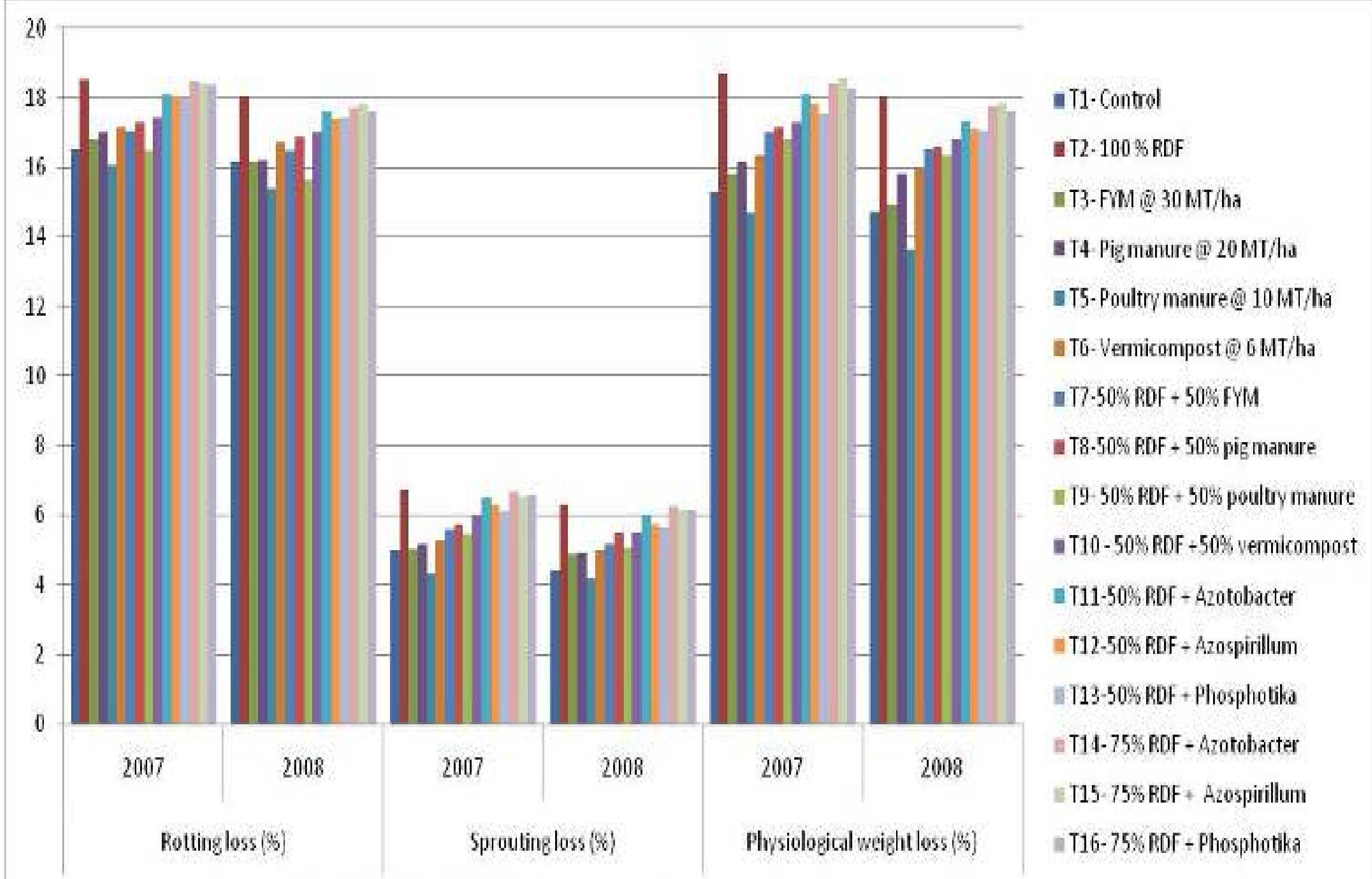

Fig. 27. Effect of integrated nutrient management on storage of onion

Table: 15: General cost of cultivation of onion (Rs. ha^{-1})

a) Fixed cost		
i	Cost of bulblets 1500 kg ha^{-1} @ Rs.10 kg^{-1}	Rs. 15000/-
ii	Cost of ploughing 3 times (tractor @Rs. 1000 per ploughing)	Rs. 3000/-
iii	Cost of land preparation, 20 men @ Rs.120/men	Rs. 2400/-
iv	Cost of planting, 15 men @ Rs. 120/men	Rs. 1800/-
v	Hoeing, weeding and earthing up upto 3 times 15 x 3 =45 men @ Rs.120/men	Rs. 5400/-
vi	Cost of irrigation 2 times @ Rs. 500/irrigation	Rs. 1000/-
vii	Cost of plant protection measures	Rs. 1200/-
viii	Cost of harvesting, 20 men @ Rs. 120/men	Rs. 2400/-
ix	Miscellaneous	Rs. 1000/-
Total		Rs.33200/-
b)Treatment cost		
T_1	Control	0.00
T_2	100 % RDF (120:60:60: kg ha^{-1}) Cost of N through urea @ Rs.15/kg = Rs.3750 Cost of P_2O_5 through SSP @ Rs. 12/kg = Rs.4500 Cost of K_2O through MOP @ Rs. 25/kg = Rs.3000	Rs.11250/-
T_3	FYM (30 t) @ Rs.400/t	Rs.12000/-
T_4	Pig manure (20 t) @ Rs.600/t	Rs.12000/-
T_5	Poultry manure (10 t) @ Rs.1000/t	Rs.10000/-
T_6	Vermicompost (6 t) @ Rs.3000/t	Rs.18000/-
T_7	50% RDF + 50% FYM	Rs.11625/-
T_8	50% RDF + 50% pig manure	Rs.11625/-
T_9	50% RDF + 50% poultry manure	Rs.10625/-
T_{10}	50% RDF +50% vermicompost	Rs.14625/-
T_{11}	50% RDF + *Azotobacter*	Rs. 5675/-
T_{12}	50% RDF + *Azospirillum*	Rs. 5675/-
T_{13}	50% RDF + *Phosphotica*	Rs. 5675/-
T_{14}	75% RDF + *Azotobacter*	Rs. 8487/-
T_{15}	75% RDF + *Azospirillum*	Rs. 3425/-
T_{16}	75% RDF + *Phosphotica*	Rs. 3425/-
Azotobacter @ Rs. 25/kg *Azospirillum* @ Rs. 25/kg *Phosphotika* @ Rs. 25/kg		

Table 16: Economics of cultivation of onion under various treatments

Treatment	Cost of cultivation			Fresh bulb yield (q/ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
	Fixed cost	Treatment cost	Total				
T_1- Control	33200	0.00	33200	90.29	90290	57090	1:1.71
T_2- 100 % RDF	33200	11250	44450	156.23	156230	111780	1:2.51
T_3- FYM @ 30 MT/ha	33200	12000	45200	134.09	134090	88890	1:1.96
T_4- Pig manure @ 20 MT/ha	33200	12000	45200	138.26	138260	93060	1:2.05
T_5- Poultry manure @ 10 MT/ha	33200	10000	43200	146.67	146670	103470	1:2.39
T_6- Vermicompost @ 6 MT/ha	33200	18000	51200	156.92	156920	105720	1:2.06
T_7-50% RDF + 50% FYM	33200	11625	44825	170.71	170710	125885	1:2.80
T_8-50% RDF + 50% pig manure	33200	11625	44825	163.67	163670	118845	1:2.65
T_9- 50% RDF + 50% poultry manure	33200	10625	43825	180.00	180000	136175	1:3.10
T_{10} - 50% RDF +50% vermicompost	33200	14625	47825	161.98	161980	114155	1:2.38
T_{11}-50% RDF + *Azotobacter*	33200	5675	38875	129.22	129220	90345	1:2.32
T_{12}-50% RDF + *Azospirillum*	33200	5675	38875	126.09	126090	87215	1:2.24
T_{13}-50% RDF + Phosphotica	33200	5675	38875	125.17	125170	86295	1:2.21
T_{14}- 75% RDF + *Azotobacter*	33200	8487	41687	133.83	133830	92143	1:2.21
T_{15}- 75% RDF + *Azospirillum*	33200	8487	41687	136.97	136970	95283	1:2.28
T_{16}- 75% RDF + Phosphotica	33200	8487	41687	138.72	138720	97033	1:2.32

Chapter 5

Discussion

DISCUSSION

Allium species are rich in neutraceuticals including flavonoids, sulphur and selenoium-containing compounds. In addition to their role in flavouring, there has been an increasing awareness of both consumers and researchers to the health benefits of *Allium*, as well as for their potential as ornamentals. To meet the fast increasing consumption and exorbitant demand, emphasis is being laid on growing onion in kharif season (Saraf, 2007)

Understanding how to grow onion and develop is a key part of developing strategy to supply nutrients for optimum bulb yield and quality. Onion being a heavy feeder of nutrients, the goal of nutrient management is to provide nutrients in a timely manner to harvest maximum crop yield and improve quality. But in reverse case, an adverse effect of sub optimum supply of nutrients affects both yield and quality of onion (Randle, 2000).

Integrated nutrient management approach for the crop by judicious use of organic manures along with inorganic fertilizers and biofertilizers has a number of agronomical and environmental benefits (Ahmed and Reddy, 2000). This approach is not only reliable for obtaining fairly higher productivity with substantial fertilizer use efficiency but also adds a concept of ecological soundness leading to sustainable production system. It relies on nutrient application and conservation, new technologies to increase nutrient availability to plants, and the dissemination of knowledge between farmers and researchers (Palm *et.al*. 2001)

Integrated nutrient management is basically an open system with soil, plant, animal and the immediate environment as component of the system and nutrient from various source of supply as flow to the system (both inflow and outflow).

Practically very less research work has been done on various sources of organic manures, inorganic fertilizers and biofertilizers on onion under Nagaland condition. So, the present effort was therefore, carried out to evaluate the various sources of organic manures, inorganic fertilizers, biofertilizers and their combined application on the growth, yield, nutrient uptake, quality and storage of onion cv. Agrifound Dark Red. The results of the present investigation thus obtained, are discussed with respect to growth, yield, quality aspect, nutrient uptake by the crop, nutrient balance, storage and economics.

5.1 Growth parameters

The number of leaves and plant height constitute the growth of the plant. It is evident from the present investigation that the morphological growth observations recorded periodically have exhibited interesting variation due to different treatments. Among the various treatments, treatment T_9 (50% RDF +50 % Poultry manure) exert better growth of the onion crop in all the stages of observations in terms of number of leaves, leaf area index and height of plant. Application of poultry manure in combination with inorganic fertilizers have more profound effect on the growth of the plant. This might be attributed to the release of appropriate quantity of nutrients from poultry manure, which was readily available to the plant. The present findings are in close conformity with Yadav *et al.* (2006) where better growth of plant was recorded by application of poultry manure in combination with urea in okra

In an integrated nutrient management study on onion cv. Agrifound Dark Red under Nagaland condition, it had been observed that FYM @ 30 t ha^{-1} was better source of manuring with regard to increasing the height of plant, number of leaves and neck thickness followed by pig manure @ 20 t ha^{-1} and vermicompost 5 t ha^{-1} (Ngullie *et. al.*2009) whereas, Thanunathan *et. al.* (1997) reported that among various amendments with mine spoil, coirpith, vermicompost + mine spoil + soil in 1: 1: 1 ratio recorded maximum height and more number of leaves of onion. Lal *et. al.* (2002) also observed taller plants with more leaves per plant with application of FYM @ 100 t ha^{-1}. Gradual availability of organics throughout the growth phase may be the probable cause for better growth and development.

Yeledhalli and Ravi (2008) observed that combined application of FYM and inorganic nitrogen source significantly recorded higher value of plant growth, leaves number and neck diameter of onion which further confirm the findings of present investigation. The expression of growth characters is genetically controlled and affected by the environmental factors *i.e.,* temperature, humidity and nutrient status of the soil and their effective utilization by the plants. The chemical fertilizers contain nutrients in bulk and in readily available form, which impart great impetus to growth parameters. The application of organic manure is advocated not only for reducing the cost of fertilizer but also to improve the soil structure.

In the present investigation, application of biofertilizers along with 75% RDF was found equally effective to 100% RDF with regard to growth of plant *viz.*, number of leaves, height of plant and leaf area index. Similar observation was made by Thilakavathy and Ramaswamy (1998), Mathuramalingan *et.al*. (2002), Jayathilake *et.al*. (2002) and Jha *et.al.* (2006). This beneficial effect on plant growth was observed due to biofertilizer application as biofertilizers helps in mobilizing unavailable sources of elemental nitrogen and bound phosphate and at the same time enriching the rhizospheric soil by addition of growth promoting substances.

5.2 Yield parameters

The result of present investigation showed beneficial effect of organic manures, inorganic fertilizers and biofertilizer over control with regard to yield attributing characters and yield of onion per plot as well as per hectare. Application of 50% RDF +50% Poultry manure has resulted into more beneficial effect on increasing the yield attributes like size of the bulb and weight of the bulb which was at par with T_7 (50% RDF + 50% FYM). The application of organic manures in combination with inorganic fertilizers were also found to have a significant increase in yield attributing characters over control. It seems that poultry manure and FYM along with inorganic fertilizers had improved the soil condition for better growth and ready availability of nutrients to the plants. Better growth of leaves caused increase in the size of bulbs as well as more nutrient accumulation which resulted in better yield by combined application of poultry manure and inorganic fertilizers.

Abbey (2000) also achieved the higher yield of onion bulbs by application of poultry manure @ 12.4 t ha^{-1} in combination with NPK fertilizers. The present investigation are in close conformity with the work carried out by Khalif *et. al.* (2002) who recorded that chicken manure was more effective in comparison to FYM in increasing the growth, bulb yield, marketable yield and P content. Favourable impact of poultry manure in increasing the growth and productivity of different horticultural crops has been observed by Hochmuth (1993) in cabbage, Stirling and Nikulin (1998) in ginger and Yadav *et. al.* (2006) in okra. It shows that poultry manure is the better source of manuring in comparison to other source of manures. Similar remark was made by Amanullah and Somasundaran (2007) that application of poultry manure increased the yield of many crops due to the ability to supply all the nutrients required.

The beneficial effect of farmyard manure on bulb yield of onion was also reported by Singh and Singh (1995) and Singh *et. al.* (2001). Additional increase in yield over 50% NPK treatment in onion with application of 10 t FYM + *Azotobacter* inoculation was also reported by Warde *et. al.* (1995). This might be due to organic fertilization which improved the soil organic matter, structure, moisture retention and nutrient release capacity. Some of these may affect plant vigour, cell size or content thereby increasing the size and weight of the bulb. Mallanagouda *et. al.* (1995) reported that the higher yield of garlic, onion and coriander were obtained with application of recommended dose of NPK and FYM @ 500 kg ha^{-1}. Singh *et.al.* (1997) recorded highest gross and marketable yield of onion from farmyard manure along with inorganic fertilizers in comparison to other sources of organic manures. Bhattarai and Subedi (1996), Rumpel (1998) and Ngullie e*t.al.* (2009) observed that FYM alone gave better growth and yield of onion which proved that it can purely be cultivated under organic farming. Whereas, Jayathilake *et. al.* (2002) reported that significant higher bulb weight and bulb diameter were recorded with application of *Azospirillum* in combination with 50% of chemical fertilizers. The higher rhizome yield with application of FYM followed by poultry manure was observed by Sanwal (2007) in turmeric. Contrary to this, higher fresh yield of ginger (294.1 q ha^{-1}) was obtained by application of pig manure, which was significantly superior to FYM and poultry manure under agro climatic condition of Nagaland. Santhi *et. al.* (2005) suggested the favourable influence of organics, inorganics and biofertilizers on chemical, physical and biological properties of soil under IPNS, resulted into maximum bulb yield of onion. Deepika *et.al*. (2010) reported that integrated use of organic and inorganic fertilizers proved better in improving the growth, yield and quality than using organic or inorganic fertilizers alone. The increase in the yield may be due to favourable effect of organic manures in combination with biofertilizers which supplies all essential nutrients in balance ratio, increase water holding capacity in the soil. Another reason may be that it mixed with the soil quickly and liberated nutrients that enhances the yield of the crop by increasing the level of soil fertility. Often the role of biofertilizers is perceived as growth regulators besides biological nitrogen which is collectively leading to much higher response on various growth attributing features and productivity indices (Jayathilake *et. al.* 2002)

The yield level during 2008-09 season was higher than that in 2007-08. This variation was mainly due to rainfall received during crop growth. Rainfall distribution was generally more favourable for growth and development of the crop during 2008-09 as compared to 2007-08, leading to higher yield. Similar remark was also made by Narseen and Hossain (2004) during 3 years of field trial in onion.

5.3 Quality parameters

Significant higher dry matter percentage was observed in the treatment T_7 (50% RDF + 50% FYM) followed by T_{13} (50% RDF + Phosphotica). Geetha *et. al.* (1999) reported that combined application of farmyard manure and muriate of potash at 25 t ha^{-1} and 200 kg K_2O ha^{-1} respectively gave significant higher dry matter yield and K content and uptake by the crop at various stages of growth. Biofertilization also greatly improve the quality of onion bulbs. The higher dry-matter production by biofertilizers inoculated plants might be because of the fact that root inoculation with *Azospirillum* and Phosphotica might have augmented the uptake of nitrogen, phosphorus and potassium, helping in acquiring higher dry weight (Devi and Ado, 2005). Due to the supplementation with half of recommended rates of N, P and dual inoculation proved the best in improving the TSS content of the bulb to the extent of 13.11% as well as higher dry matter production with *Azospirillum* treatment was reported by Mengistu and Singh (1999). Rathor *et. al.* (2003) reported that *Azotobacter* inoculation in onion also recorded maximum dry matter content of leaves, dry matter content of bulbs and Total Soluble Solids. Pachauri *et. al.* (2005) also observed that FYM @ 10 t ha^{-1}, N and P significantly reduced inflorescence scapes (bolting) and increased protein, ascorbic acid, reducing, non-reducing and total sugar content of bulbs as compared to the lower dose of FYM (5 t ha^{-1}).

75% RDF + *Azospirillum* treatment exerted better impact on protein content of bulb in comparison to other biofertilizer treatment which is in close conformity with findings of Singh and Pandey (2006) who recorded maximum value of protein content (7.74%) at 75% NPK + FYM + *Azotobacter* treatment. Total

Soluble Solids (TSS), reducing, non-reducing and total sugar was significantly higher with 50% RDF + 50% poultry manure. However, combined application of 50% RDF with 50% of organic manures yielded higher sugar content. Pachauri *et.al. (*2005) reported higher reducing, non-reducing and total sugar with 10 t FYM as compared to lowest dose (5 t FYM ha $^{-1}$)

Higher concentration of nitrogen in both leaf and bulb was recorded from treatment T_9 (50% RDF +50% Poultry manure). Whereas, maximum phosphorus content in leaf was recorded from treatment T_8 (50% RDF + 50% Pig manure) followed by treatment T_6 (Vermicompost @6 MT/ha). Similarly, maximum potassium content (1.76%) in leaf was noticed with the treatment T_{10} (50% RDF + 50% Vermicompost) but higher potassium content in bulb was recorded in treatment T_5 (Poultry manure @10 MT/ha). Thilakavathy and Ramaswamy (1998) reported the favourable effect of *Azospirillum* and *Phosphobacteria* in nutrient accumulation of onion. Whereas, Khalif *et. al.*(2002) also recorded higher phosphorus content in onion with application of chicken manure. The result obtained by Singh and Singh (2007) opined that application of poultry manure was found to improve the quality of ginger under Nagaland condition. Chuda *et.al*.(2009) also observed highest content of dry matter (12.85%) and TSS (12.11°Brix) in onion cv. Agrifound Dark Red by application of 50% NPK + 50% FYM in an INM experimentation. Similarly, highest TSS was recorded by combination of FYM + *Azotobacter*. However, maximum protein content was noticed with treatment combination of poultry manure + *Azotobacter* but remained at par with (FYM + *Azotobacter*).

5.4 Nutrient uptake by the crop

Uptake of N, P and K increased significantly with the application of various organic manures in combination with inorganic fertilizers and biofertilizer as compared to control. From the present investigation, it was found that maximum N uptake was recorded from the treatment T_7 (50% RDF + 50% FYM). Whereas P and K uptake was maximum with treatment T_9 (50% RDF +50% Poultry manure). Significantly higher uptake of N, P and K from organic manures resulted in increasing the bulb size and weight, which ultimately leads to increase in yield of onion bulb. Nutrient released from poultry manure can be readily absorbed by the plants. Hence, better uptake of these nutrients are obtained. The present findings are in close conformity with experiment conducted by Singh and Singh (2007), where poultry manure caused maximum uptake of N and K, while pig manure caused highest accumulation of P in ginger. Sharma and Thakur (2001) reported that application of natrin (*Azotobacter*) resulted in significant improvement in nitrogen uptake at flowering stage and root biomass in tomato. Mallanagouda *et. al.* (1995) and Singh and Singh (1995) reported that increase in uptake of these nutrients with NPK fertilization and farmyard manure. Increase uptake of N, P and K with increasing level of fly ash and FYM was also reported by Patil *et. al.* (2005). Poultry manure along with *Azotobacter* caused maximum uptake of N, P and K in off season onion production under Nagaland condition (Yeptho *et.al*. 2009).

Most of the treatments caused significant influence on accumulation of sulphur in bulbs to control. According to Randle *et.al*.(2000) the accumulation of $SO4^{2-}$ and total sulphur in bulbs increased linearly as the concentration of $SO4^{2-}$ in the nutrient solution increased. Jha *et.al*.(2002) opined that increased sulphur uptake accomplished out of synergistic effect between phosphorus and sulphur uptake led to increment in concentration of allyl propyl disulphide, in pungency factor which was observed to be linked with shelf life of onions. The application of 100% NPK + biofertilizer + FYM recorded maximum sulphur content (0.96%) which maybe due to increase in application of single super phosphate and inoculation with phosphate solubilising bacteria, which has resulted in increased uptake of sulphur and its accumulation in bulbs (Gowda *et.al.* 2007).

5.5 Fertility status of soil after harvest

It is evident from the data analysis that pH and potassium content of soil was recorded maximum by application of 50% RDF + 50% Poultry manure. Similarly, available nitrogen and phosphorus was recorded higher in treatment T_8 (50 % RDF + 50% Pig manure). The organic carbon content was maximum in T_3 (FYM @30MT/ha). Most of the treatments had significant residual effect on enhancing soil fertility level in comparison to control. In present experiment, most of organic manures in combination with inorganic fertilizers supplied adequate amount of nutrients for optimum growth and yield of onion. Besides, they also enhanced the soil contents of major plant nutrients and organic carbon.

The present findings are in close conformity with work carried out by Chaudhary *et. al.* (2003) where slight increase in available N, P and K content of the soil and its pH after harvest of tomato and cabbage due to combined application of vermicompost and FYM was observed. Pachauri and Singh (2005) found greater increase in phosphorus status in the plot supplied with FYM, also application of 75% NPK + FYM showed significant increase in status of available nutrients over control. Addition of organic manures to the soil with biofertilizer improves biofertilizer efficiency and ultimately nutrient status of the soil (Subbian, 1994). The present findings are in close conformity with view of Sanyal, 2001 who remarked that application of organic manures also helped in building the soil organic matter. This organic matter also contributed tremendously to cation exchange capacity that enables the soil to buffer nutrient concentrations in soil solution, apart from helping storage of plant nutrients such as nitrogen, phosphorus, sulphur and micronutrients in soil. Fertility status of soil after harvest of onion crop was found to improve significantly by application of various sources of organic manures and their impact was further enhanced along with *Azotobacter* (Yeptho *et.al.*2009). Jamir *et.al*. (2013) reported that application of 50% NPK + 50% pig manure @ 10 t ha^{-1} was found to be better in terms of availability of P, K and organic carbon along with enhancing the pH level of the soil.

Storage

It was found that the application of 50% recommended dose of fertilizer + 50% Pig manure recorded the maximum rotting loss (25.75%) whereas, the sprouting loss (6.51%) and physiological weight loss (18.39%) was recorded by the application of 100% recommended dose of fertilizer. Weather conditions also had a marked effect on bulb quality at its harvest and its behaviour during storage, with wet weather during harvest causing the greatest damage. Bulbs harvested early had a lower respiration rate during the storage period than bulbs harvested late in the season. Hile *et al.*(2008) observed that with delay in harvesting, the bulb yield rose but the bulb quality deteriorated, resulting in greater storage losses. Satyendra Kumar *et. al.* (2006) observed that the higher sprouting as well as physiological loss in weight was found in fertigation level (100 kg N – 50 kg P – 50 kg K ha^{-1}) in which maximum nutrients were applied amongst all fertigation treatments. Tumbare and Pawar (2003) reported that the rotting losses of onion bulbs due to different sources of fertilizer were 15.4 – 16.71% and 14.23-16.58% during 2000-2001 respectively. The rotting loss of onion bulbs during the second year was less than during the first year. The minimum loss of bulb due to rotting was observed in inorganic fertilizer in which 25% nitrogen substituted through farmyard manure, it was followed by inorganic fertilizer+*Rhizobium*+Phosphate-solubilizing bacteria. This might have increased Total Soluble solids, organic constituents and total sugar which made onion bulbs resistant to rotting.

Onion crop harvested for bulbs, bolting does not generally occur. But bolting and doubling in onion under north eastern region is a common feature when raising during kharif season which causes deterioration of storage quality. These problem are often as ascribed to optimum fertilization, besides unfavourable meteorological conditions (Ngullie *et.al.* 2009).

Economics

From the present study, it was found that the cost of cultivation was maximum in the treatment T_4 (Pig manure @ 20MT/ha). The maximum net return and benefit:cost ratio was obtained in T_9 (50% RDF + 50% Poultry manure) followed by T_7 (50% RDF + 50% FYM). Singh *et al.* (1997) reported that when farmyard manure was combined with 100 kg N + 25 kg P + 25 kg P ha^{-1}, gross and marketable yields were increased to 323.1 and 313.6 q ha^{-1}, respectively, and the highest net return (32,651 Rs ha^{-1}) was obtained. While Yeledhalli and Ravi (2008) reported that application of 75% recommended dose of nitrogen (RDN) through FYM gave higher (85.20%) exportable onion followed by application of 100% RDN through FYM and 50% RDN through KNO_3. The lowest values were obtained (60.3%) from 100% RDN through urea application alone. Jayathilake *et.al.* (2002) revealed higher value of net returns and cost:benefit ratio when FYM was used as an organic source replacing the 50% of the recommended dose of inorganic nitrogen. Whereas, Yeptho *et.al*.(2009) observed highest net returns (Rs. 1,54,055/ha) and cost:benefit ratio (1:4:13) from pig manure (20 t/ha) + *Azotobacter* in comparison to other treatment under Nagaland condition in off season. Singh *et.al*.(2001) reported that the response of onion cv. N 53 to application of 150 kg N ha^{-1} and FYM at 10 t ha^{-1} observed maximum net returns and benefit: cost ratio. Similarly, Jamir *et.al.* (2013) reported highest gross income (Rs.1,80,670/-), net return (Rs.1,29,260/) and benefit: cost ratio (1:3.51) was obtained from the combined application of 50% NPK + 50% FYM @ 20 t ha^{-1}. In another experiment, Chumei *et.al*. (2013) revealed that maximum yield (38.88 t ha^{-1}) was recorded with 50% NPK + 50% FYM + biofertilizers, which also produced the highest net return of Rs.1,27,978/- with cost:benefit ratio of 1:1.92. It was followed by 50% NPK + 50% pig manure + biofertilizers and 50% NPK + 50% FYM for achieving more returns than other treatments. Similarly, Nchang *et.al*.(2012) reported that maximum yield (194.70 t ha^{-1}) was recorded with 50% NPK + 50% FYM + biofertilizers, which also produced the highest net return of 3,16,338 with cost:benefit ratio of 1:4.33. It was followed by 50% NPK + 50% vermicompost + biofertilizers and 50% NPK + 50% pig manure + biofertilizers for achieving more returns than other treatments.

Chapter 6

Summary & Conclusion

SUMMARY

The present investigation entitled "Effect of integrated nutrient management on growth, yield, nutrient uptake and storage life of onion" cv. Agrifound Dark Red was carried out at Horticulture Research farm, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during the period from August to December 2007-08 and 2008-09, with the following objectives:

i. To study the effect of nutrient management on growth and yield of onion.
ii. To study the effect of nutrient management on nutrient uptake (N,P,K).
iii. To study the effect of management on fertility status of soil after harvest.
iv. To study the effect of nutrient management on storage life of onion.

The results obtained have been summarized as below:

1. The growth attributing characters *viz.* plant height (4.11cm), number of leaves (8.78) and leaf area index (2.632) per plant were recorded maximum with the treatment T_9 (50% RDF + 50% Poultry manure) while maximum neck thickness (2.70 cm) was noticed by application of FYM @30 MT/ha (T_3).

2. The effect of treatment combination on yield and yield attributing characters also observed significantly superior over control. As like growth characters, the treatment T_9 (50% RDF +50% Poultry manure) proved superiority with regard to bulb size (6.26 cm) and weight of the bulb (114.330 g) which ultimately leads to increase in yield per plot (4.00 kg) and projected yield per hectare (180.00 q).

3. The quality of the crop also improved significantly with the combined application of manures, inorganic fertilizers and biofertilizers. The treatment T_7 (50% RDF + 50% FYM) recorded highest dry matter (11.25%). The combined application of 50% RDF and 50% Poultry manure (T_9) recorded maximum TSS (12.61°Brix), reducing sugar (2.93%), non

reducing sugar (5.89%) and total sugar (8.82%).The application of pigmanure @ 20 MT/ha (T_4) recorded highest protein content (6.40%)

4. Similarly, maximum accumulation of N (1.26% in leaves and 1.16% in bulb) was recorded with treatment T_9 (50% RDF + 50% Poultry manure). However, phosphorus accumulation in leaves (0.49%) and in bulb (0.58%) was found higher in treatment T_8 (50% RDF + 50% pig manure) and T_6 (Vermicompost @ 6 MT/ha) while potassium accumulation in leaves (1.76%) and in bulb (2.48%) was recorded maximum in T_{10} (50% RDF + 50% Vermicompost) and T_5 (Poultry manure @10 MT/ha)

5. Uptake of P and K (12.64 and 57.63 kg ha^{-1}) nutrients was recorded maximum with treatment combination of T_9 (50% RDF + 50% Poultry manure) whereas N uptake was found maximum in T_7 (50% RDF + 50% FYM) while maximum sulphur uptake was recorded with T_6 (Vermicompost @6MT/ha) and T_9 (50% RDF + 50% Poultry manure).

6. Various treatments and their combination exerted significant influence on the soil fertility. Application of FYM @ 30 MT/ha (T_3) recorded maximum organic carbon (3.22%). However, available N (298.92 kg ha^{-1}) and available P (14.26 kg ha^{-1}) were recorded maximum from treatment T_8 (50% RDF + 50% pig manure) while available K (245.35 kg ha^{-1}) and pH (5.31) was recorded from the treatment T_9 (50% RDF + 50% Poultry manure).

7. Combined application of 50% RDF and 50% pig manure (T_8) recorded maximum rotting loss (25.75%) and by application of 100% RDF (T_2), maximum sprouting loss (6.51%) and physiological weight loss (18.39%) was recorded. While treatment T_5 (Poultry manure @ 10 MT/ha) recorded minimum rotting loss, sprouting loss and physiological weight loss.

8. It is evident from the economics of the treatment given in Table 16 that application of 50% RDF along with 50% poultry manure (T_9) was found to be more beneficial in increasing the profitability in terms of gross return, net return and benefit cost ratio.

Conclusion

On the basis of two years data, it may be concluded that 50% RDF (60:30:30::N:P:K) + 50% Poultry manure (5MT/ha) is considered the best treatment in terms on growth, yield, Total Soluble

Solids (TSS), reducing sugar, non reducing and total sugar content and better nutrient uptake. Integrated application of different organic manures, inorganic fertilizers and biofertilizers showed profound residual effect on soil fertility status after harvest over initial plot and control. Application of poultry manure recorded minimum rotting loss, sprouting loss and physiological weight loss.

The findings of the present investigation suggested an application of 50% RDF + 50% Poultry manure for obtaining higher net monetary return and benefit:cost ratio in onion cv. Agrifound Dark Red under the existing agro-climatic conditions of Nagaland.

References

REFERENCES

Abbey, L. (2000). Effect of poultry manure and post production application of fungicides on the shelf life of onion cv Bawker Red. *Crop Res.* **20**:87-92.

Abu-Rayyan, Azmi M. and Nazir A. Al-Hadidi (2005). Onion production and nitrogen uptake in response to different doses of urea fertilizer at two different plant populations. *J.King Saud. Univ. Agric. Sci.,* **18**(1):19-37.

Ahmed, S.R. and Reddy, K.V. (2000). Effect of inorganic fertilizers in conjunction with organic manures to onion (*Allium cepa* L.) grown on alfisol in Andhra Pradesh. *Nat. Symp. on onion-garlic production and post-harvest management-challenges and strategies,* Nov. 19-21, Nasik, pp.87-95.

Aisha, A.H., Fatma A. Rizk, Shaheen, A.M. and Mona M. Abdel-M. (2007). Onion plant growth, bulbs yield and its physical and chemical properties as affected by organic and natural fertilization. *Res. J. Agric. & Biol. Sci.* **3**(5):380-388.

Alkaff, H. A., Saeed, O. S. and Salim, A. Z. (2002). Effect of biofertilizer, inorganic, organic and foliar application of power 4 on the productivity of onion. *University of Aden J. of Natural and Appl. Sci.* **6**(1):1-14.

Amanullah, M.M., somasundran, E., Vaiyapuri, K. and Sathymoorthi, K. (2007). Poultry manure to crops- *A review. Agric. Rev.* **28**(3):216-222.

Anonymous (2000). Annual report NHRDF, Nashik, pp.62.

Anonymous (2003). Annual Report (1999-2000), NRCOG, Rajagurunagar, Maharashtra, India, p.60.

A.O.A.C.(1984). Official methods of Analysis of the Association of Official Analytical Chemist. Washington, D.C., USA

Ayed Abdelrazzag (2002).Effect of chicken manure and inorganic fertilizer on yield and nutrient uptake by onion. *Pakistan J. of Biol. Sci.*, **5**:266-268

Aziz Qureshi, Sankar, V., Lawande, K.E. and Tripathi, P.C. (2003). Effect of granulated ammonium sulphate on yield and quality of rabi onion. *Indian J. Hort.* **60**(3):273-276.

Aziz Qureshi, A. and K.E. Lawande (2006). Response of onion (*Allium cepa*) to sulphur application for yield, quality and its storability in S-deficient soils. *Indian J. Agric. Sci.* **76**(9):535-537.

Bagali, A.N.,Patil, H.B., Chimmad, V.P., Patil, P.L. and Patil, R.V. (2012). Effect of inorganics and organics on growth and yield of onion (*Allium cepa* L). *Karnataka J. Agric. Sci.* **25**(1):112-115.

Boff, P, Debarba, J.F, Silva, E. and Werner, H. (2000). Increase onion helath by Thermophilic compost, IFOAM.

Banafar, R. N. S., Namdeo, S. L. and Asati, K.P. (2004). Effect of organic manures in combination with chemical fertilizers on growth, yield and quality of garlic. *Nat. Sem. on opportunities of spices for crop diversification,* Pp.145-148.

Bhattarai, S. P. and Subedi, P. P. (1996). Normal season onion variety, nutrition and management trial at outreach research sites during 1993-1994 season. *Working paper, Lumle Regional Agri. Res. Centre*. **96** (10):48-49.

Bhonde, S.R., Sharma, S.B. and Choughule, A.B. (1997). Effect of bio-fertilizer in combination with nitrogen through organic and inorganic sources on yield and quality of onion. *Newsletter – Nat. Hort. Res. Develop. Found.* **17**(2): 1-3.

Black, C.A., (1965). Methods of soil analysis part I and II. American Society of Agronomy. Inc., Publishers, Madison, Wisconsin, U.S.A. pp 171-175.

Bray, R.H. and Kurtz, L.T.(1945). Determination of total organic and available forms of phosphorus in soils. *Soil Sci*., **59**: 39-45.

Brewster, J.L. and Butler, H.A. (1989). Effects of nitrogen supply on bulb development in onion *Allium cepa* L. *J. Expt. Bot.* **40**:1155-1162.

Brown, B.D. (1997). Soil test N for predicting onion N requirements: an Idaho perspective. pp.43-48. In: *Proc 26th Annual NW fertilizer Conference*, July 15-17, 1985, Salt Lake City, UT.

Calbo, M.E.R., Monnerat, P.H. and Shimoya, C. (1986). Characterization of boron deficiency symptoms in onions (*Allium cepa* L.) at the production stage. *Revista Ceres* **33**(187):174-280. (Hort. Abst. 1987. vol. 57, pp. 568).

Chadha, S., Rana, S.S. and Chaudhury, D.R. (2006). Nutrient management in summer onion (*Allium cepa* L.) under cold desert conditions of northwest Himalayas. *In. J. Agric. Sci.* **76**(10):629-631.

Chapman,H.D. and Pratt,P.F.(1961).Method of analysis for soil and water.University of California pp. 6.

Chattoo, M. A., Ahmed, N., Nuranjan, S., Narayan, R. and Mir, S. A. (2003). Response of garlic (*Allium sativum* L.) to biofertilizer application. *Nat. Sem. on organic products and their future prospects, SKUAST (K), Srinagar*, pp-93.

Chaudhary, B., Chakrabarti, A.K. and Singh, C. (2003). Effect of nitrogen and phosphorus on seed production of onion (*Allium cepa* L.). *Seeds Res*., **8**:1-4.

Chee, L. C., Garcia, C. R. and Ferrera, C. R. (1998). Onion bio-fertilization with vermicompost and arbuscular mycorrhizae. *ASAE Annual Int. Meeting*, Orlando, Florida, USA 12-16 July, pp-8.

Chesnin, L. and Yien, C.H. (1951). Turidimetric determination of available sulphur in soil. *Proc. Soil Sci. Soc. America,* **15**:149-154.

Chuda, K., Kanaujia, S.P., Singh, V.B. and Singh, A.K.(2009). Effect of integrated nutrient management on growth, yield and quality of Kharif onion under terraced conditions of Nagaland. *Environ. & Eco*., **27**(4):1511-1513.

Chumei, Y., Kanaujia, S.P. and Singh, V.B. (2013). Integrated nutrient management in brinjal. *Prog. Agri.-An International Journal*, **13**(1):106-113.

Deepika, A., Singh, A.K., Kanaujia, S.P. and Singh, V.B. (2010). Effect of integrated nutrient management on growth, yield and economics of capsicum (*Capsicum annum* L.) cv. California Wonder. *J.of Soil and Crops,* **20**(1):1-9.

Deho, N.A., Wagan, M.R., Baloach M.K., Rajpar I. and Keerio, M.I. (2002). NPK trial on onion (*Allium cepa* L.). *Pakistan J. Applied Sci.* **2**(8) 820-821.

De Laune, P.B., Moore P.A. Jr. and Lemunyon, J.L. (2006) Effect of chemical and microbial amendment on phosphorus runoff from composted poultry litter. *J. Environ. Qual.* **35**(4):1291-1296.

Devi and Ado (2005). Effect of fertilizers and biofertilizers on physiological growth parameters of multiplier onion (*Allium cepa* var. aggregatum). *Indian J. Agric. Sci.* **75**(6):352-354.

Dimri, D.C. and Singh, V.P. (2005). Response of FYM, N and row spacing on bulb weight and yield of onion cv VL-3. *Prog Hort.* **37**(1):185-187.

Dixit, S.P. (1997). Response of onion (*Allium cepa*) to nitrogen and farmyard manure in dry temperate high hills of Himachal Pradesh. *Indian J. Agric. Sci.* **67**(5):222-223.

El-Desuki, M., Asmaa, R.M. and Hafiz, M.M. (2006). Rsponse of onion plants to minerals and biofertilizers application. *Res.J. Agric. & Biol. Sci.* **2**(6):292-298.

FAO (2010). Food and Agriculture Organization, Italy Rome.

Galbiatti, J.A. and Castellane, P.D. (1990). Effect of irrigation and of mineral and organic fertilization on the onion cultivars Piralopes. *Horti. Brasileira* **8**(1):24.

Geetha, K., Raju, A.S. and Shanti, M. (1999). Effect of farmyard manure and potassium on K nutrition on yield of onion at different stages of growth. *J. Res.* ANGARU **27**(1&2): 18-23.

Greenwood, D.J., Gerwitz, A., Stone, D.A. and Braners, A. (1982). Root development of vegetable crops. *Plant & Soil*. **68**:75-96

Gupta, A.P., Antil, A.N. and Gupta, V.K. (1999). Effect of integratred nutrient management on yield and nutrient uptake by onion and soil fertility. *J. of the Indian Soc. of soil Sc*. Vol.54, No.3 pp.366-367.

Gurubatham, J.R.J., Thamburaj, S. and Kandasamy, D. (1989). Studies on the effect of biofertilizers on the bulb yield and quality of onion. *Annal. Agric. Sci. Fac.Agric. Ain Shams Univ. Cairo, Egypt.* **31**: 365-371

Gowda, M.C.,Vijayakumar, M. and Gowda, A.P.M.(2007). Influence of integrated nutrient management on growth, yield and quality of garlic (*Allium sativum* L.) cv. G-282. *Crop Res*. **33**(1,2 &3):144-147.

Halverson A.D., Ronald F.F., Michael E.B. and Schweissing, F.C. (2002). Nitrogen fertilizer use efficiency of furrow-irrigated onion and corn. American Soc. of Agronomy *Agronomy J.* **94**:442-449.

Hile, R.B., Chauhan, M.R., Bagul, R.S. and Pardeshi, H.P. (2008). Analysis of storage cost of rabi onion in Pune, India. *Agric. Update* **3**(1/2):189-191.

Hochmuth, R.C., Hochmuth, G.J. and Doneley, M.E. (1993). Responses of cabbage yields, head quality and leaf nutrient status and of second crop squash to poultry manure. *Proc. Soil and Crop Sci. Soc.,* Florida. **52** : 126-130.

Indian Horticulture Database (2012). National Horticulture Board, Ministry of Agriculture, Govt. of India.

Jackson, M.L.(1969). Soil Chemical Analysis. Prentice Hall, New Delhi.

Jayathilake, P.K.S., Reddy, I.P., Srihari, D., Neeraja, G. and Reddy, R. (2002). Effect of nutrient management on growth, yield and yield attributes of rabi onion (*Allium cepa* L.). *Indian J. Veg. Sci.* **29**(2):184-185.

Jayathilake, P.K.S., Reddy, I.P., Srihari, D., Reddy, K.R. and Neeraja, G. (2003). Integrated nutrient management in onion (*Allium cepa* L.). *Trop. Agric. Res.* **155**:1-9.

Jamir, S.,Singh, V.B., Kanaujia, S.P. and Singh, A.K.(2013). Effect of integrated nutrient management on growth, yield and quality of onion (*Allium cepa* L.). *Progressive Horticulture* **45**(2):353-358.

Jana, B.K. and Jahangir Kabir (1990). Effect of sulphur on growth and yield of onion cv Nashik Red. *Crop. Res*. (Hisar) **3**(2):5-9

Jha, A.K., Pal N. and Singh, S.K. (2002). Effect of phosphorus on sulphur uptake and storage in onion. *Ann. Agri. Res.* (New series) **23**:503-505.

Jha, A.K., Netra Pal, Saxena, A.K., Singh, D. and Jha, G.K. (2006). Coinoculation effect of VAM and PGPR on growth and yield of onion. *Indian J. Hort.* **63**(1):44-47.

Katwale, T. R. and Saraf, R. K. (1994). Response of onion to varying levels of fertilizer doses during monsoon season in Satpura Plateau. *Orissa J. Hort. 22 (12):13-18.*

Keniseto, C., Kanaujia, S.P., Singh, V.B. and Singh, A.K. (2009). Effect of integrated nutrient management on growth, yield and quality of onion under terraced condition of Nagaland. *Environ.& Eco.* **27** (4):1511-1513.

Khalif, F.A., El-Hamid, A.S.A., Mohammed, E.I. and Hassan, M.A.N. (2002). Response of onion crop var. Shandawed to some source of organic fertilizers. *Assiut J. Agri. Sci.* **33**(5):73-80.

Kumar, A. and Singh, G.N. (1996). Effect of N, P and K on growth, yield and quality of garlic (*Allium sativum* L.). *Recent Hort.***3** (1):118-121.

Kumar, A., Singh R. and Chillar, R.K. (2001). Influence of nitrogen and potassium application on growth, yield and nutrient uptake of onion (*Allium cepa*). *Indian J. Agron.* **46**(4):742-746.

Lancaster, J.E., Farrant, J., Shaw, M., Bycroft, B, Brash, D. and Armstrong, J. (2001). Does sulphur supply to the bulb affect storage of onions. *Acta. Hort.* **555**:111-115.

Lane, J.H. and Eynon, L. (1923). Determination of reducing sugars by means of Fehling's solution with methylene blue as internal indicator. *J. Soc. Chem. Ind. Lond*. **42**(1):15-28

Lal, S., Yadav, A.C., Mangal, I.L., Singh, Avtar and Batra, V.K. (2002). Effect of FYM and irrigation levels on growth and yield of onion cv. Hisar-2. *Haryana J. Hort. Sci.* **31**(1):8-10.

Lee, J.T., Kim, H.D. and Kim, W.I. (2006). Effect of liquid pig manure on growth, nutrient uptake of onion, and chemical properties of soil. *Korean J. Hort. Sci. & Technol*. **24**(2):148-156.

Lester, G.E. and Jifon, J.L. (2007). Foliar application of potassium on onion. *Acta Hort.* 731:115-120.

Mahanthesh, Harshvardhan, B., Thippeshappa, M., Sajjan, G.N. and Lakshmana, M.R.P. (2008a). Nutrient uptake and yield of onion as influenced by integrated nutrient management in rainfed onion cv Bellary Red during Kharif season. Enviorn. & Eco. **26**(1):29-34.

Mahanthesh, B, Harshavardhan, M., Janardhan, G. and Sajjan, M.RP, (2008b). Cost:benefit ratio as influenced by bio-fertilizers along varied levels of NPK in onion (cv Bellary Red) in central zone of Karnataka. *Environ. & Eco.* **26**(1):29-34.

Mallanagouda, B., Sulkeri, G.S., Hullamani, N.C., Murthy, B.C., and Madalgeri, B.B. (1995). Effect of NPK and FYM on groth parameters of onion. *Current Res*. **24**:212.

Mathuramalingam, S., Kumaran, S.S., Muthuvei,I., and Sathiyamurthy, V.A. (2002). Influence of plant densities and applied nutrients on uptake of NPK in seed propagated aggregatum onion (*Allium cepa* L. var *aggregatum*) Gnanamedu local type. *Crop Res.* **23**(3):481-485.

Mengistu, F. and Singh, N. (1999). Effect of biofertilizers on growth, yield and nutrient uptake of onion (*Allium cepa* L.). Veg. Sci.**26**:193-195.

Mishra and Mishra (2005). Organic farming – an analysis system. *Intensive Agric.*pp.4.

Mohanty, B.K., Hossain, M.M. and Prusti, A.M. (2002). Performance of onion cultivars on kharif season. *Advances Plant Sci*. **15**(2):603-604.

Muzika, L.P. (1986). Productivity of onions in relation to cultural methods and fertilization. *Ovochivnitstvo Bashtannitstvo,* **31**:14-17

Naik, B.H. and Hosamani, R.M. (2003). Effect of spacing and nitrogen level on growth and yield of kharif onion. *Karnataka J. Agric. Sci.* **16**(1):98-102.

Nambiar, K.K.M. and Abrol, I.P.(1992). Long term fertilizer experiments in India-An overview. *Fertilizer New,* **34**(4),11-26.

Nasreen, Shamima and Hussain, A.K.M. (2004). Nutrient uptake and yield of onion as influenced by chemical fertilizers and organic manure. *Indian J. Agric. Res.* **38**(3)164-170.

Nasreen, S., Haque, M.M. and Hussain, M.A. (2007). Nutrient uptake and yield of onion as influenced by nitrogen and sulfur fertilization. *Bangladesh J. Agric. Sci.* **32**(2):413-420.

Ngullie, Ethel, Singh, V.B. and Singh, A, K, (2009). Effect of organic manures and biofertilizers on growth, yield and quality of onion, *Environ. & Eco.* **27**(1A): 313-315.

Pachauri, S.P., Singh, Vinoy and Pachauri, C.P. (2005). Effect of FYM, nitrogen and potassium on growth and quality of onion. *Ann. Pl. Soil Res.* **7**(1):54-56.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch, G. and Giller, K.E.(2001). Organic inputs for soil fertility management in tropical agroecosystem: application of an organic resource database. *Agric., Ecosystem and Environ.,* **83**:27-42.

Pandey, R.P. and Pandey, Ajay. (1994). Storage losses of onion bulbs. *Madras Agric. J.* **81**(11):603-605.

Panse, V. C. and Sukhatme, P. V. (1978). Statistical methods for Agricultural workers. ICAR, New Delhi, pp.199-210.

Patel, K.P., Patel, J.C., Patel, B.S., and Sadaria, S.G. 1992). Yield and nutrient uptake by onion (*Allium cepa* L.) as influenced by irrigation, nitrogen and phosphorus. *Indian J. Agron.* **37**:395-396.

Patel, K. M., Joshi, K. I., Sadaria, D.T., Kilkani, K. P. and Joshi, V. I. (2000). Effect of different source of organic manures v/s chemical fertilizers on yield and quality of onion. *Proc. Nat. seminar on production technology and export potential of potato, onion and garlic*, pp.12-13.

Patil, P.V., Chalwade, P.B., Solanka, A.S. and Kulkarni, V.K. (2005). Effect of fly ash and FYM on nutrient uptake and yield of onion. *J. Soil and Crops* **15**(1):187-192.

Paula, M.B., Pádua, J.G., Fontes, P.C.R. and Bertoni, J.C. (2002). Yield, quality and nutrient content in onion leaf and soil as affected by potassium source and phosphogypsum rates. *Revista Ceres* **49**(283):231-244.

Piper, C.S. (1966). Soil and plant Analysis. Bombay, Hans, Publ., pp.368.

Prabhakar, M., Hebbar, S.S. and Nair, A.K.(2012). Effect of organic practices on growth, yield and quality of rose onion (*Allium cepa*). *Indian J.of Agric. Sc*. Vol.82, No.6.

Raju,S.S.V., Nagre, P.K., Prasanth Naik and Bharathi, N. (2013). Effect of integrated nutrient management on growth, yield and quality of onion (*Allium cepa* L.) Cv. Akola Safed. *Asian Journal of microb. and environ. Sci.* Vol.19, Issue 01,195-215.

Randle, W.M. (2000). Increasing nitrogen concentration in hydroponic solution affects onion flavour and bulb quality. *J. Am. Soc. Hort. Sci.* **125**:254-259.

Rathor, S.A., Ahmed, N. and Chattoo, M.A. (2003). Response of onion to microbial inoculation and chemical nitrogen. *Haryana J.Hort. Sci*.,**32**(3 & 4):270-271.

Reddy, K.V.S. (1985). Influence of placement and rate of phosphorus application on growth and yield of onion grown on alfisol. *South Indian Hort*. **33**(3):163-167

Reddy, P., Srihari, D., Reddy, K.R. and Neeraja, G. (2004). Integrated nutrient management in onion (*Allium cepa* L.). *Proc. of Work Plan* (2000-02), Sri Lanka Council of Agri. Res. And Indian Council of Agric. Res. pp. 91-108.

Rumpel, J. (1997). Effect of long term organic and mineral fertilization on soil properties and development of tomato, carrot and onion. *Int. Sem. Ecological aspects of nutrition and alternatives of herbicides in horticulture,* Warszawa, Poland. 10-15 June, 1997.

Rumpel, J. (1998). Effect of long term organic, mineral and combined organic- mineral fertilization on yield of onion (*Allium cepa* L.) grown from seeds. *Biuletyn Warzywniczy*. **48**:5-15.

Santhi, R., Natesan, R. and Selvakumari, G. (2002). Soil test crop response correlation studies under integrated plant nutrition system for onion (*Allium cepa* L. var. aggregatum) to inceptisols of Tamil Nadu. *Journal of the Indian Society of Soil Science,* **50**(4):593-600.

Santhi, R., Natesan, R. and Selvakumari, G. (2005). Effect of soil fertilizers and integrated plant nutrition system on yield, response and nutrient uptake by aggregatum onion. *Indian J. Agric. Res.* **39**(3):213-216.

Sanwal, S.K., Laxminarayanan. K., Yadav, R.K., Rai, N., Yadav, D. and Bhuyan, M. (2007). Effect of organic manures on soil fertility, growth physiology, yield and quality of turmeric. *Ind. J. Hort.,* **64** (4): 444-449.

Sanyal, S. K. (2001). Colloidal chemical properties of humic substances: A Relook. *J. Indian Soc. of Soil Sci.* **49**(4):567-569.

Saraf, R.K.(2007). Herbicidal weed control in kharif onion. *The Asian J. Hort*.,**2**(1):1-5.

Satyendra Kumar, Ashwani Kumar and Goutam Mandal (2006). Effect of irrigation scheduling and fertigation on storability of onion (*Allium cepa*) under sprinkler irrigation regime. *Indian J. Agric. Sci.* **76(**7):401-404.

Saxena, A.K., Singh, S., Srivastava, A. and Poonam, G. (2008). Yield target approach under integrated nutrient management for assessing fertilizer requiredments of onion in Mollisols of Uttarakhand. *Indian, J. Hort.* **65**(3):302-306.

Shaheen, A.M., Fatma, A. Rizk and Singer, S.M. (2007). Growing onion plants without chemical fertilization. *Res. J. Agric. & Biol. Sci.* **3**(2):95-104.

Sharma Pritam K. and Ajit Raina (1994). Effect of phosphorus on the bulb yield and P use efficiency as influenced by FYM in onion crop in acid soil from western Himalayas. *J. Indian Soc. Soil Sci.* **42** (1):68-72.

Sharma, S.K. and Thakur, K.S. (2001). Effect of *Azotobacter* and nitrogen on plants growth and fruit yield of tomato. *Veg Sci.,* **28** (2): 146-148.

Sharma, R.P., Datt, N. and Pritam Sharma (2003). Combined application of nitrogen, phosphorus, potassium and farmyard manure in onion (*Allium cepa*) under high hills, dry temperature conditions of North Western Himalayas. *Indian J. Agric. Sci.* **73**(4):225-227.

Sharma, Anuraj and Agarwal, A.K. (2004). Organic Farming: *Today's Revolution, Tomorrow's Prosperity. Agrobios Newsletter,* **3** (2):16-18.

Sharma, B. R., Verma, B. K., Shrivastava, R. K., Chaddha, A.P.S. and Verma, A.C. (2004). Effect of inorganic fertilizers and biofertilizers on yield of onion, *Nat. Sem. on opportunities and potentials of spices for crop diversification*, pp.159.

Sharma, R.P. ,Naveen Datt, and Girish Chander (2009). Effect of vermicompost, farymyard manure and chemical fertilizers on yield, nutrient uptake and soil fertility in Okra (*Abelmoschus esculentus*) – Onion (*Allium cepa*) sequence in wet temperate zone of Himachal Pradesh. *J. Indian Soc. Soil Sci.* **57**(3):357-361.

Singh, Dhian and Sharma, R.P.(1991). Effect of soil moisture regimes and nitrogen fertilization on onion. *Indian J.Agron*. **36**(1): 125-126.

Singh, Vinay and Singh, R.K.(1993). Response of onion (*Allium cepa* L.) to N, P, Zn and FYM. *Ann.agric. Res.***16**(1):79-81.

Singh, V. and Singh, R. K. (1995). Response of onion to N, P, Zn and FYM. *Ann. Agric.Res.* **16**(1):79-81.

Singh, L.,Bhonda, S. R. and Mishra, V. K. (1997). Effect of different organic and inorganic fertilizers on yield and quality of Rabi onion. *Newsletter-Nat. Horti. Res. And Dev. Found. Nasik.* **17** (3): 1-3.

Singh, R.P., Jain, N.K. and Poonia, B.L. (2000). Response of kharif onion to N, P and K in eastern plains of Rajasthan. *Indian J. Agric. Sci.* **70**:871-872.

Singh, R.P., Jain, N.K. and Poonia, B.L. (2001). Integrated nutrient management in rainy season onion (*Allium cepa*). *Indian J. Agric. Sci.* **71**(5):310-312.

Singh, D.K., Pandey, A.K., Pandey, U.B. and Bhonde, S.R. (2002). Effect of farmyard manure combined with foliar application of NPK mixture and micro-nutrients on yield, quality and storage of onion variety Agrifound Light Red. *NHRDF*, *Newsletter*, **XXI**(3,4): & **XXII**(1)1-7.

Singh, D.K., Singh, N.B. and Bhonde, B.P. (2005a). Effect of integrated nutrient management in onion variety Agrifound Light Red. *Nat. Conference on Allium'* organised at Institute of Agricultural Sciences, BHU, Varanasi Feb. 24-25, 2005

Singh, Shrawan; Yadav, P.K. and Singh, Balbir (2005b). Effect of nitrogen and potassium on quality of onion (Allium cepa L.) cv.Poona Red in arid region of Rajasthan. *Haryana J. Hort. Sci.,* **34**(3-4): 349-350.

Singh, V.B. (2006). Prospect of onion in Nagaland. *Horticulture Newsletter*. The Horticulture Society of North East India, Medziphema **1**:14-15.

Singh, Vinay and Pandey, Manoj (2006). Effect of integrated nutrient management on yield and nutrient uptake by onion and on soil fertility. *J. Indian Soc. Soil Sci.* **54**(3):365-367.

Singh, V.B. and Singh, A.K. (2007). Effect of types of organic manure and methods of nitrogen application on growth, yield and quality of ginger. *Environ. and Eco.*, **25**(1):103-105.

Srinivasan R., Shanmugam, V., Kamalakannan A. and Sunderan, M.(2002). Influence of fertilizers, host factors and storage conditions in relation to disease severity: a case study of black mould rot of onion. *Acta Phytopatho. et Entomo. Hungarica* **37**(1/3): 119-135

Stevens, R.G. (1997). Nutrient management of winter crops in Washington. pp.104-113. In: *Proc. Western Nutrient Mgmt. Conf.* Vol.2 March 6-7, 1997, Salt Lake City UT, University of Idaho. Moscow, ID.

Stirling, G.R. and Nikulin, A. (1998). Crop rotation organic amendments and nematicides for control of root knot nematodes (*Meloidogyne incognita*) on ginger. *Australian Plant Pathology*, **27**(4):234-243.

Subbian, K. (1994). Effect of N, P and biofertilizers on yield and nutirent uptake of chilli and bellary onion. *Madras Agric. J.* **81**:277-279.

Thamburaj, S. (1991). Biofertilizer for onion crop : Lesser the expenses, healthier the soil. *Indian Hort.* **36**:23-30.

Thanunathan, K., Natarajan, S., Senthilkumar, R., and Arulmurugan, K., (1997). Effect of different sources of organic amendments on growth and yield of onion in mine spoil. *Madras Agri. J.,* **84** (7) : 382 – 384.

Thilakavathy, S. and Ramaswamy, N. (1998). Effect of inorganic and biofertilizers on yield and quality parameters of multiplier onion (*Allium cepa* L) var. Aggregatum. *Veg. Sci.* **26**(1):97-98.

Tilak, K.V.B.R. and Saxena, A.K. (2008). Response of onion (*Allium cepa* L.) to inoculation with Azospirillum brasilense. *J. Eco-friendly Agri.* **3**(1):16-18.

Tumbare, A.D. and Pawar, V.S. (2003). Effect of integrated nutrient management system in soyabean (*Glycine max*)-onion (*Allium cepa*) cropping sequence on yield and keeping quality of winter onion. *Indian J. Agric. Sci*. **73**(7):373-375.

Varu, D. K., Vhora, P. H. and Kikani, K.P. (1997). Effect of organic and inorganic fertilizers on onion. *Gujarat Agricultural University Research Journal,* **22** (2).116-118.

Vimala, P. and Yeong, N.H.(1994). Nutrient content and removal by shallots grown on peat in Malaysia. *Acta Hort* 358:415-418.

Warade, S.D., Desale, S.B. and Shinde, K.G. (1995). Effects of organic, inorganic and biofertilizers on yield on onion bulbs cv B-780. *J. Maharashtra Agric. Univ.* **20**(3):467-468.

Yadav, V. S. and Yadav, B. D. (2001). Effect of NICAST (organic manure) in comparison to recommended dose of manures and fertilizers in onion. *South Indian Hort*. **49**:160-161.

Yadav, R.L., Sen, N.L. and Yadav, B.K. (2003a). Response of onion to nitrogen and potassium fertilization under semi-arid conditions of Rajasthan. *Indian J. Hort.* **60**(2):176-178.

Yadav, R.L., Yadav, B.L. and Dhaka, R.S. (2003b). Nutrient management in onion (*Allium cepa* L.) – A review. *Agric. Rev.* **24**(1):64-69.

Yadav, B.D., Khandelwal, R.B. and Sharma, Y.K. (2005). Use of biofertilizer in onion. *Indian J. Hort.***62**:267-286.

Yadav, P., Singh, P., Yadav, R.L. and Lal, R.(2006). Effect of organic manure and nitrogen levels on growth, yield and quality of okra. *Indain J.Hort.,* **63**:215-217.

Yeledhalli, N.A. and Ravi, M.V. (2008) Effect of FYM and inorganic sources of nitrogen on yield, bulb flaking and quality of onion. *Ann. Pl. Soil Res*. **10**(2):133-136.

Yeptho, Avitoli, Singh, A.K., Kanaujia, S.P. and Singh, V.B. (2009). Effect of organic manures and biofertilizers on yield and nutrient composition of onion. *Enviro. & Eco.*, **27**(4): 1628-1630.