EFFECT OF FARMYARD MANURE AND NITROGEN FERTILIZER RATES ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa.* L.) AT JIMMA, SOUTHWEST ETHIOPIA

M.Sc. THESIS

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BY

KOKOBE W/YOHANNES

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APPROVAL SHEET

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

As Thesis research advisors, we hereby certify that we have read and evaluated this thesis prepared, under our guidance, by **Kokobe W/Yohannes**, entitled "**Effect of Farmyard Manure and Nitrogen Fertilizer rates on growth, yield and quality of Onion (*Allium cepa.* L.) at Jimma, SouthWest Ethiopia"** we recommend that it be submitted as fulfilling the thesis requirement.

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DEDICATION

I dedicate this thesis manuscript to my father W/Yohannes Gonose and my mother Lakech Belayneh for nursing me with affections and love and their dedicated partnership for success in my life.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my bonafide work and all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M. Sc. degree in Horticulture at Jimma University and is deposited at the University library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The author, Kokobe W/Yohannes was born on September 24, 1986 in Fincha district Horro Guduru Wollega Zone of Oromia Regional State. She attended her primary and junior secondary school education at Junior and Senior Secondary Schools at Fincha, respectively. She also attended at Ambo Preparatory and Technique School from 2004 to 2005. She joined Jimma University College of Agriculture and Veterinary Medicines (JUCAVM) and graduated with a Bachelor of Science degree in Horticulture in 2008.

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ACRONYMS AND ABBREVIATIONS

AVRDC	Asian Vegetable Research and Development Center
BPEDORS	Bureau of Planning and Economic Development of Oromia Regional state
CACC	Central Agricultural Census Commission
CSA	Central Statistical Agency
EARO	Ethiopian Agricultural Research Organization
FAO	Food and Agricultural Organization
MARC	Melkassa Agricultural Research Center
MoARD	Ministry of Agriculture and Rural Development

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EFFECT OF FARMYARD MANURE AND NITROGEN FERTILIZER RATES ON GROWTH, YIELD AND QUALITY OF ONION (*Allium cepa.* L.*)*AT JIMMA, SOUTHWEST ETHIOPIA

ABSTRACT

Onion is one of the most important vegetable crops produced in Ethiopia. Among different varieties 'Bombey Red' is the most widely accepted by farmers for its earliness. Onion is heavy feeder and requires more fertilizer than other vegetable crops. However, study on combined application of organic and inorganic fertilization to improve the yield of onion bulb is scarce. Therefore, a field experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine research field from October 2011 to March 2012 under irrigation to assess the response of onion to farmyard manure and nitrogen fertilizer rates. The study consists of four levels of FYM (0, 15, 30 and 45 ton FYM ha^{-1}) and four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}). The experiment was conducted in 4 × 4 factorial arrangements in a randomized complete block design with three replications. Data on growth, yield, and quality parameters were recorded and analyzed using SAS Computer Software version 9.2. Results revealed that interaction of FYM and N fertilizer significantly ($P \leq 0.05$) influenced Plant height, number of leaves, leaf lengh, maturity, average bulb weight, total yield, marketable yield, harvest index, bulb dry matter, TSS and split bulbs. However, leaf diameter, bulb length, bulb diameter and unmarketable yield were not affected by the combined application of FYM and N fertilizer. The findings highlighted that the performance of onion at Jimma area can be enhanced through application of FYM and N fertilizers. The highest bulb yield of onion (36.85 ton ha^{-1}) was obtained when the plots received combined application of 100 kg ha^{-1} of N and 45 ton ha^{-1} of FYM which significantly increased the total bulb yield by about 53% as compared to the unfertilized plot (17.45 ton ha^{-1}). This however was statistically similar with the combination of 150 kg ha^{-1} of N and 30 ton ha^{-1} of FYM and also150 kg ha^{-1} of N and 45 ton ha^{-1} of FYM. In this study, maximum dry bulb yield of onion (33.30 ton ha^{-1}) was obtained when the plots received combined application of 150 kg ha^{-1} of N and 30 ton ha^{-1} of FYM. The highest organic carbon, organic matter, N, P and K were recorded from highest dose of farmyard manure. It can be concluded that organic fertilizer (FYM) can significantly increase the soil nutrient content. Based on these result it can be concluded that farmyard manure improves the soil organic matter, adds soil nutrients, improves soil physical properties and increases the productivity. The above findings indicated that the growth and productivity of onion at Jimma can be improved by using increased farmyard manure and nitrogen fertilizer combination. Therefore, from statistical point of view and labour requirements to prepare and apply FYM, a farmyard manure application at a rate of 30 ton ha^{-1} and nitrogen fertilizer at a rate of 150 kg ha^{-1} can be used as a recommended fertilizer combination for onion production around Jimma area. To develop robust recommendation, it will be good to repeat the experiment on soils of different characteristics, agro-ecological conditions and cost benefit analysis should be done.

1. INTRODUCTION

Onion (*Allium cepa* L.) is a member of Alliaceous family and the *Allium cepa* species are diploid with basic chromosome number of x=8 (2n=16). The primary center of origin of onion is Central Asia with secondary center in Middle East and the Mediterranean region. From these centers, onion has spread widely to many countries of the world (Dahlgren *et al.*, 1985). Onion grows at altitude range of 500- 2400 m.a.s.l with the optimum range of 700-1800 m.a.s.l and the temperature range of 13 to 24^0C. Soil pH (6.5-7), seeding rate (3-4 kg ha^{-1}), maturity period (110-130 days) is not very different among the cultivars (Lemma and Shimelis, 2003).

Onions contribute significant nutritional value to the human diet and have medicinal properties and are primarily consumed for their unique flavor or for their ability to enhance the flavor of other foods (Randle, 2000). In 2000-2005, the world's top producer of onion was China, contributing an average of 31% to the total production, followed by India 10% (FAO, 2005). The highest productivity of onion in world is of Korea Rep (67.25 MT ha^{-1}) followed by USA (53.91 MT ha^{-1}), Spain (52.06 MT ha^{-1}) and Japan (47.55 MT ha^{-1}). India being a second major onion producing country in the world has a productivity of 10.16 MT ha^{-1} only (FAO, 2008).

Over the last 15 years the total surface area dedicated to onion crop in the world has doubled, reaching 2.74 million hectares. Average world yield increased from 12 MT ha^{-1} in the early 1960s to 17 MT ha^{-1} in 2001. Currently the world production of onion is about 3944 million MT per year (FAOSTAT, 2011). In Ethiopia, the total area under onion production reached 15,628 hectares and the production was estimated to be over 148,854.9 ton (MoARD, 2009). In Ethiopia in 2010 onion production was 17,588 ha^{-1} area coverage and 204,900 tons production (FAOSTAT, 2012).

Ethiopia has enormous potential to cultivate vegetables on small as well as commercial scale. The country has high potential to benefit from onion production, and the demand for onion increases from time to time for its high bulb yield, seed and flower production potential (Lemma and Shimelis, 2003).

Quality of onion and shallots can be affected by mineral nutrition, irrigation schedule or rainfall (Chung, 1989), cultivar differences and the use of growth regulators such as maleic hydrazide (sprout inhibitor) (Hussien, 1996). The productivity of tropical onion is around 9.6 tons ha^{-1}, which is very low, compared to the average bulb yield in temperate countries, which is about 19.5 tons ha^{-1}. The world average yield is about 17.3 tons ha^{-1} (FAO, 1999). Ethiopia has a great potential to produce onion every year for both local consumption and export with an average yield 13.3 tons ha^{-1} (CSA, 2001/02).

Nitrogen is the principal plant nutrient required in much greater quantities. It is the important component of proteins, enzymes and vitamins in plants and is a central part of essential photosynthetic molecule, chlorophyll (Marschner, 1995). Plants demand for N can be satisfied from a combination of soil and fertilizer N to ensure optimum growth. While exogenous N application is known to increase yield of onions and many researchers found that high levels of nitrogenous fertilizer resulted in reduced onion storage life (Kato *et al*., 1987). Inadequate N has been reported as major constraints to increased onion production. N is essential to growth and yield of onion but excessively high doses cause delay in bulb maturity and encourages bolting, which is undesirable characteristic (Aliyu *et al.*, 2008).

Farmyard Manure (FYM) is prepared basically using animal dung, urine, waste straw and other dairy wastes. It is highly useful and some of its properties are it is rich in nutrients, a small portion of N is directly available to the plants while a larger portion is made available as and when the FYM decomposes, when cow dung and urine are mixed, a balanced nutrition is made available to the plants, availability of Potassium and Phosphorus from FYM is similar to that from inorganic sources and application of FYM improves soil fertility (www.vanashree.in/fym.htm, 2009).

According to Jeyathilake *et al*. (2006) integrated use of bio fertilizer, organic manure and chemical fertilizers resulted in onion yield increase in comparison with the exclusive application of chemical fertilizers. For the research and the extension activities, the nationally recommended Nitrogen fertilizer rate (100 kg N ha^{-1}) is being used (Olani and Fikre, 2010) and a general recommendation for organic manure is 25 to 40 ton ha^{-1} is recommended to obtain high bulb yield (Shanmugasundaram and Kalb, 2001).

However, chemical fertilizers alone generate several deleterious effects to the environment and human health and they should be replenished in every cultivation season because, the synthetic N, P and K fertilizer are rapidly lost by either evaporation or by leaching in drainage water and causes dangerous environmental pollution (Aisha *et al*., 2007). Onions are more susceptible to nutrient deficiencies than most crop plants because of their shallow and un branched root system; hence they require and often respond well to addition of fertilizers (Brewester, 1994). Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers as reported by Naeem *et al*. (2006) for improving soil structure (Dauda *et al*., 2008) and microbial biomass (Suresh *et al*., 2004).

With the increased cost of inorganic fertilizers, application of recommended dose is difficult to be afforded by the small and marginal farmers. Hence renewable and low cost sources of plant nutrients for supplementing chemical fertilizers should be substituted which can be affordable to the majority of farming community. In this context, integrated nutrient management would be a viable strategy for advocating judicious and efficient use of chemical fertilizers with matching addition of organic manures and bio fertilizers (Tandon, 1987). Farmyard manure is a conspicuous organic component of an integrated nutrient supply system, which improves soil health, increases the productivity and releases macro and micronutrients (Kale *et al*., 1992).

Farmers in the study area are aware of the response of onion and other related crops to applied nutrients and raise the crop in homesteads using farmyard manure, household wastes etc. However, the rate of farmyard manure and its combined effect with inorganic fertilizers for high production of the crop is not well understood. Currently little research has been done on integrated use of organic and inorganic fertilizers application pertaining to yield and yield related components of onion. In view of this fact, a systematic investigation into the effect of using commercial fertilizer like nitrogen and locally available, accessible and affordable farmyard manure is of paramount importance for increasing yield and yield components of onion.

Keeping all this critical issues in view, this experiment was initiated with the objective of assessing the effects of combined use of different levels of Farmyard manure and Nitrogen fertilizer on growth, yield and quality of onion and finding out suitable proportion (ratio) of farmyard manure and Nitrogen fertilizer which could give an economic yield of onion.

Objectives

General objective

The study was conducted to investigate the combination of Farmyard manure and Nitrogen fertilizer for optimum growth, yield and quality of onion.

Specific objectives

- To determine combined effect of FYM and Nitrogen fertilizer on growth, yield and quality of onion and accordingly identify the best combination
- To study the effect of Farmyard Manure and Nitrogen on soil properties

2. LITERATURE REVIEW

2.1 The Economic Importance of Onion

Onions are naturally packed vegetables consisting of fleshy connective scales, which are enclosed, in paper like wrapping leaves. The stem from which the roots arise is very short. Leaves are produced from the apical moisten. They are still physiologically long day plants but ones, which respond to days, which are short. Short day cultivars can initiate and form bulbs under photoperiods of thirteen hours or less. Onions therefore could be classified as short day or day neutral.

A global review of major vegetables show that onion ranks second to tomatoes in area under cultivation. According to FAO (1999), over 40 million tons of onion was produced worldwide in 1998, covering about 4.5 million hectares. Tropical countries, having about 45% of the world's arable land, grow about 35% of the world's onions (Pathak, 1993). About 8% of the total area was in Africa in 1995.

Irrigation development is part of the strategy designed to ensure food security and alleviate poverty in Ethiopia including Jimma Zone. In 2009/10 production season there was about 79.52 ha^{-1} of land covered by onion production in the zone. There are 9, 146 holders, who took part in the development activities. The total yield obtained was 659.986 tons with average yield of 8.3 ton ha^{-1} (BoARD, 2010).

Onion is the most popular vegetable grown in Ethiopia next to tomatoes (Lemma and Shimeles, 2003). It is relatively recently introduced but rapidly becoming popular among producers and consumers. The crop is widely produced by small farmers and commercial growers throughout the year for local use and export market. Onion is valued for its distinct pungency and form essential ingredients for flavoring varieties of dishes, sauces, soup, sandwiches, snacks as onion rings etc. It is popular over the local shallot because of its high yield potential per unit area, availability of desirable cultivars for various uses, ease of propagation by seed, high domestic (bulb and seed) and export (bulb, cut flowers) markets in fresh and processed forms (Lemma and Shimelis, 2003).

Onion used to be an indispensable crop used as a condiment in most traditional Ethiopian cuisine. It is hardly possible to get a dish without this vegetable in every meal of a day. Per capita consumption is said to be 1.7 kg in rural areas and 5.9 kg in the towns (Currah and Proctor, 1990). This figure may not be very exact since shallot and onions are found mixed in production, marketing and consumption. Shallots and onions are cultivated in every corner of the country with an estimated production area of 10,488.5 ha^{-1} (CACC, 2002).

Onion bulb is rich in phosphorous, calcium, and carbohydrates; it also contains protein and vitamin C (Ali *et al*., 2007). Along with this, a medium onion (50 g in weight) contains 60 calories, 1g proteins, 16g carbohydrate, no fat, 5mg sodium, 200mg potassium, dietary fiber 3 grams (Khan *et al*., 2005). The optimal level of any agronomic practice such as fertilization, plant population and harvesting date of the crop varies with environment, production system, purpose, and varieties. Moreover, these agronomic practices affect the expression of the full potential of the varieties under use (Shimeles, 2004).

2.2 Onion Growth

Bulb onion is a shallow rooted, biennial plant that is grown as an annual. It has long, hollow leaves with widening, overlapping bases. The tubular leaf blades are flattened on the upper surface, and the stem of the plant also is flattened. Roots arise from the bottom of the growing bulb. Leaf initiation stops when the plant begins to bulb. The base of each leaf becomes one of the “scales” of the onion bulb, so the final bulb size depends in part on the number of leaves present at bulb initiation. The leaf base begins to function as a storage organ at bulb initiation, so the size of the leafy part of the plant also influences bulb size (Randall, *et al*. 1999).

Onion dry bulb can be produced throughout the year if dependable irrigation water, and diseases and insect pests control measures are available. However, the yield and quality of dry bulbs seem to vary from season to season due to diverse climatic conditions prevailing in the production areas. Findings of the research done by Melkassa Agricultural research center at the upper Awash rift valley revealed that 20 cm between rows on the bed and 10 cm between plants with 333,300 plants per hactare gave high yield (150 quintal ha^{-1}) and was easy to manage the plant. This is suitable for small-scale hand operated production system for the Melkassa and other areas with similar agro-ecologies. The spacing could be adjusted depending on the availability of facilities especially for tractor operated large scale production (Lemma, 2004).

2.3 Farmyard Manure

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. Manures are the organic materials derived from animal, human and plant residues which contain plant nutrients in complex organic forms (Reddy, 2005). Naturally occurring or Synthetic chemicals containing plant nutrients are called fertilizers. Manures with low nutrient content per unit quantity have longer residual effect besides improving soil physical properties compared to fertilizer with high nutrient content (Reddy, 2005).

Manures are an excellent source of plant nutrients. Approximately 70-80% of the nitrogen, 60-85% of the phosphorus and 80-90% of the potassium in feeds are excreted in the manure (Stephen, 2005). The amount of nutrients available for recycling to plants varies widely upon the composition of the feed ration, the amount of bedding and water added or lost the method of manure collection and storage, the method of land application, and characteristics of the soil, crop and climate. Manure contains all the plant nutrients needed for crop growth including trace elements (Stephen, 2005).

Organic manures are most used in maintaining the fertility of cultivated soil in those areas where livestock and Arable farming are carried on side by side or at least in the same area (Aim, 1993). The intensive utilization of chemical fertilizers, cultivation of short seasonal crops particularly in absence or lack of organic manure and the removal of plant residues from the land, all of these practices adversely affect the soil fertility status (Shaheen, 2011).

Vegetable crops like potato, tomato, sweet-potato, carrot, radish, onion etc., respond well to the Farmyard manure. The other responsive crops are sugarcane, rice, Napier grass and orchard crops like oranges, banana, mango and plantation crop like coconut (Reddy, 2005).The entire amount of nutrients present in farmyard manure is not available immediately. About 30 % of nitrogen, 60 to 70 % of phosphorus and 70 % of potassium are available to the first crop (Reddy, 2005).

2.4 Farmyard Manure Preparation

Before the widespread use of chemical fertilizers, animal manures were used as a primary source of nutrients in crop production. In addition to supplying nutrients to the soil, manure also improves soil health by increasing soil organic matter and promoting beneficial organisms. Incorporating manure into a field will help to reduce water and wind erosion by improving soil structure (Lombin and Abdullahi, 1977; Hermanson, 1996; Ojeniyi, 2000). Livestock and chicken manures contain a broader range of nutrients than most commercial fertilizers. This is because a large portion of the plant nutrients initially ingested by the animals and chicken. Generally 80% of the phosphorus, 90% of the potassium and 75% of the nitrogen are still present in the manure. Chicken manure tends to be high in nitrogen (N) and phosphorus (P), while dairy manure tends to be high in potassium (K).

Cow dung which is obtained in abundance is collected after cleaning cowshed in a pit close by and is allowed to decompose over a period of time (www.vanashree.in/fym.htm, 2009). Every month this manure (compost) is applied to the plants or the field to enrich the soil since it is highly composted and extremely rich. The manure becomes ready for use in about four to five months after plastering (Reddy, 2005).

2.5 Time of Application

Timing and method of manure application determine the efficiency of nutrient recycling. Incorporating manure immediately minimizes odors and ammonia loss. If manure supplies more N than needed then some ammonia loss is unimportant. However, it is better to apply manure to more hectares than to apply an excess to fewer hectares. To save money and to protect the environment avoid over applications (Stephen, 2005).

Partially rotten farmyard manure has to be applied three to four weeks before sowing while well rotten manure can be applied immediately before sowing. Generally 10 to 20 ton ha^{-1} is applied, but more than 20 ton ha^{-1} is applied to fodder grasses and vegetables. In such cases farmyard manure should be applied at least 15 days in advance to avoid immobilization of nitrogen (Reddy, 2005). The existing practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. These losses can be reduced by spreading the manure and incorporating by ploughing immediately after application. The reasons of high yield of applying organic fertilizers can be explained by the greater capacity of treated soils with chicken and/or animal manures to retain the nutrients in forms that can easily be taken up by plants onion plants over a long period of time. Conversely, the lower performance of mineral fertilizers could be attributed to the fact that nutrients released from mineral fertilizers are for short period of time because of leaching problems (Antoun *et al.*, 1985; Carol *et al*., 1999).

Moreover, applying of organic manure fertilizers was reported to increase the uptake of N, P, K, Ca, and Mg contents in the soil and, therefore, organic manure are considered to be a good source for soil fertility (Nyathi and Campbll, 1995; Adenyian and Ojeniyi, 2003). The application of organic manure to the soil whether alone or in combination with mineral fertilizers has been a successful practice to improve the physical, chemical and biological properties of the soil as well as its productivity (Clark *et al.*, 1999; Abd-Allah *et al.*, 2001; Poudel *et al.*, 2002).

2.6 Availability of the Nutrients

Approximately 40-50% of the stable organic N will be available the first year, 12-15% of the N remaining the year after, 5-6% in the third year and lesser amounts in each subsequent year. These figures are approximations and could vary in different locations due to variations in the rate of microorganism breakdown and climate. The decay series is only for the stable organic N and does not include the urea or ammonium N which is 100% available the first year if not lost as ammonia (Stephen, 2005).

When manure is applied at a rate to supply the N need of a crop, the P and K will likely be in excess of the crop requirement. Essentially most of the K is available for plant growth the year manure is applied. However, some of the P may be in the form of insoluble inorganic compounds or as organic P and, like stable organic N must be mineralized before it is available. Nutrient availability, however, is determined by the manure handling system, as well as by climate and soil characteristics. Nutrient values also vary with different types of livestock and the animal feed rations, which vary with the season (Antoun *et al.*, 1985; Drinkwater *et al.*, 1995).

2.7 Role of Nitrogen

Plants respond quickly to increased availability of Nitrogen, their leaves turning deep green in color. Nitrogen increases the plumpness of cereal grains, the protein content of both seed sand foliage, and the succulence of such crops as lettuce and radishes. It can dramatically stimulate plant productivity (Sopher and Baird, 1982). Nitrogen is also essential for carbohydrate use within plants. A good supply of nitrogen stimulates root growth and development as well as the uptake of other nutrients (Brady and Weil, 2002).

Nitrogen uptake levels by onion crops may vary from less than 50 kg to more than 300 kg per hectare, depending on cultivar, climate, plant density, fertilization and yield levels (Hegde, 1986; Sørensen, 1996; Suojala *et al.*, 1998 and Salo, 1999). High yielding varieties usually require more N than low yielding. Results from different climatic regions of the world also show varying responses of onions to applied N. On a sandy loam soil in a semi-arid region of Ethiopia, irrigated onion plants benefited from application of 90 to120 kg ha^{-1} N compared to unfertilized crops (Aklilu, 1997).

Onions are heavy feeders and require more fertilizer than is used in most vegetable crops. They respond well to additional fertilizer applied 40 to 60 days after seeding or transplanting (Boyhan *et al*., 2001). It is among the high N demanding vegetables, its productivity depends on use of optimum fertilizer rates and if not adequately fertilized, considerable yield losses are apparent (Balemi *et al*., 2007). The amount to be applied depends on the type and fertility status of the soil. However, the best combination levels for a particular locality or soil type have to be determined for economic production of dry bulb (Link, 1966 cited by Lemma and Herath, 1994).

Nitrogen plays an important role to reach the optimum yield of onion and is found essential to increase the bulb size and yield. Patel and Patel (1990) reported that N-level had significant effect on bulb yield. Murata (1969) reported that nitrogen plays an important role in plant photosynthesis by improving leaf area index. He also stated that higher dose of nitrogen application caused reduction in photosynthetic rate by mutual leaf shading due to excessive plant growth. In contrast, the low level of nitrogen application caused reduction in photosynthetic rate due to reduction in chlorophyll contents of plant cells, an effect of that is reversible Girarden *et al.* (1985). It is, therefore, obvious that application of nitrogen at a suitable rate can lead to increase of leaf area and chlorophyll contents thus resulting in higher photosynthetic rate and higher plant yield.

2.8 Effect of different combination level of FYM and Nitrogen fertilizer

Inorganic fertilizer is considered a major source of plant nutrients (Naeem *et al.*, 2006). Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield (Stewart *et al.*, 2005) and maximum value of growth (Badr and Fekry, 1998; Arisha and Bardisi, 1999; Dauda *et al*., 2008). However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Arisha and Bardisi, 1999).

Mineral fertilizers are considered to be an important source of major and minor elements in crop production. Continuous application of mineral fertilizers may adversely affect soil chemical composition, nutrient imbalance, soil degradation and crop yield (Obi and Ebo, 1995; Ojeniyi, 2000). Cultivating with persistent application of mineral fertilizers increases soil acidity and soil physical degradation which may reduce crop yield (Adeinyan and Ojeniyi, 2003; Ojeniyi *et al*., 2007).

Nutrients have paramount importance in boosting productivity and quality of onion which is a heavy feeder of mineral elements and continuous use of inorganic fertilizers resulted in deficiency of micronutrients, imbalance in soil physicochemical properties and unsustainable crop production (Jeyathilake *et al*., 2006). Farmers spend greater portion of their capital for purchasing fertilizers. Generally excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield (Stewart *et al*., 2005).

Farmyard manure release nutrients slowly and steadily and activates soil microbial biomass (Ayuso *et al*., 1996; Belay *et al*., 2001). Organic manures can sustain cropping systems through better nutrient recycling and improvement of soil physical attributes (El-Shakweer *et al*., 1998). The use of inorganic fertilizer has not been helpful under intensive agriculture because of its high cost and it is often associated with reduced crop yields, soil degradation, nutrient imbalance and acidity (Kang and Juo, 1980; Obi and Ebo, 1995).

The complementary use of organic and inorganic fertilizers has been recommended for sustenance of long term cropping in the tropics (Ipimoroti *et al*., 2002). Fuchs *et al*. (1970) reported that nutrients from mineral fertilizers enhance the establishment of crops while those from mineralization of organic manures promoted yield when both fertilizers were combined. In several studies, the effects of fertilization on yield and quality of onion were investigated. Kumar *et al*. (2001) found that application of 120 kg N ha^{-1} increased onion yield to 30%. Sharma *et al*. (2003) have found that addition of animal manure resulted in higher onion yield compared to NPK fertilizer. 0, 50 and 150% of the recommended amounts of NPK fertilizers (125:33:50 kg ha^{-1}) with 0, 10, 20 ton ha^{-1} manure combination increased onion yield and nutrient uptake.

Gambo *et al.* (2008) find out that the increasing rates of FYM tended to increase bulb yield of onion with the highest values at 30 tons ha^{-1}. The results show that there is the tendency for higher onion bulb yield with higher application of FYM. Lombin and Abdullahi (1977) in long term fertility studies in Northern Nigeria showed that 5 tons ha^{-1} of animal dung annually combined with 100 kg N and 50 kg P_2O_5 will maintain yield under continuous cropping.

Similarly, Bababe *et al*. (1998) showed that organic manure is a supplier of N, P and K in the soil, which also increase the phosphate solubulising bacteria in the rhizosphere. Akoun (2004) confirmed that organic manure increases the nutrient status of a soil which leads to increase in onion yield. The application of varying levels of nitrogen also had a significant effect on the bulb yield of onions. Increasing the level of nitrogen applied led to an increase in yield with highest yields obtained from the highest N rate of 75 kg ha^{-1}.

3. MATERIALS AND METHODS

3.1 Description of the study area

The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine research field in the year 2011/2012 in the offseason under Irrigation. Jimma University College of Agriculture and Veterinary Medicine is geographically located 346 km southwest of Addis Abeba at about 7^0, 33'N latitude and 36^0, 57' E longitude at an altitude of 1710 meter above sea level (m.a.s.l). The mean maximum and minimum temperatures are 26.8^0C and 11.4^0C, respectively and the mean maximum and minimum relative humidity are 91.4% and 39.92%, respectively (BPEDORS, 2000). The mean annual rainfall of the area is 1500-1800mm (Melaku, 2008). A physicochemical property of the soil of the experimental area and FYM before setting up of the experiment is given in table 1 below.

Table 1. Physical and chemical analysis of soil and FYM used as organic fertilizer in the experiment before planting.

Properties	Soil sample	FYM Sample
Chemical properties		
pH (water 1:1)	6.7	6.99
Electrical conductivity(mS/cm)	0.28	0.67
Organic matter (%)	5.06	12.12
Organic carbon (%)	2.93	7.02
Total nitrogen (%)	0.25	0.61
Available phosphorus (ppm)	13.08	36.47
Available potassium (ppm)	2.61	7.29
Physical properties (%)		
Sand	12	-
Silt	44	-
Clay	44	-
Texture class	Silty Clay	

Note: The soil physical and chemical properties of experimental site were determined at Jimma University College of Agriculture and Veterinary Medicine soil laboratory

3.2. Experimental Material

Onion cultivar ’Bombay Red’ was obtained from Melkassa Agricultural Research Center (MARC) for this study. The variety is widely accepted by farmers for its earliness and higher bulb yield. It is thick, flat shaped, light red and light pungent. The cultivar was released in 1980, well adapted to areas of 700-2000m. It matures within 110-120 days (EARO, 2004). Yields up to 40 tons for Bombay red were observed on farmer’s fields in Central Rift Valley areas (Olani and Fikre, 2010). The urea fertilizer was used as Nitrogen source and the Farmyard manure used in the experiment was collected from the nearby animal production station of the college which is fully decomposed manure.

3.3 Experimental Design and Treatments

The experiment consisted of four levels of Farmyard manure (0, 15, 30 and 45 tons ha^{-1}) and four levels of Nitrogen (0, 50, 100 and 150 kg N ha^{-1}). The trial was set up in a randomized complete block design (RCBD) in 4 X 4 factorial arrangements with three replications. Each treatment combination was assigned randomly to experimental units within a block.

There were 16 treatments in the field experiment. Unit plot size of the experiment was 1m x 1.2m (1.2 m^2). The blocks were separated by 1 m width whereas the space between each plot within a block was 0.5 m. In each plot, there were six rows, and in each rows there were 10 plants. Totally, there were 60 plants in a plot with spacing of 20cm between rows and 10cm between plants within the row.

3.4 Cultural Practices

A seed bed of 1x 5m was well prepared for seedling development. The soil was harrowed or cultivated to a fine tilth before sowing and transplanting. Seeds were sown on October, 2011 in well pulverized seed bed. Sowing was at 10cm between rows and then lightly covered with soil and mulched with grasses or straws until seedling emerged (2-5cm) from the soil.

Healthy and vigorous seedlings of 12-15cm height or 3-4 true leaf stages were carefully uprooted for transplanting. The selected seedlings were transplanted in December 2011 with recommended spacing 20cm×10cm between rows and plants respectively. After transplanting important cultural practices such as uniform application of water, weeding, and cultivation was done manually and equally for all treatments as required.

Different levels of N were applied in the form of urea (46% N) in two split doses of equal amounts, 50% of urea at time of transplanting and the other 50% at one and a half month after transplanting. The well decomposed manure was carefully weighed and thoroughly applied as a single application into the experimental plot. The beds were watered and left for one week before the transplanting to enable carbon dioxide escape thus preventing burning and scorching on the tender seedlings (Olufolaji 1990). At maturity, onion bulbs from the central four rows were manually harvested at the end of March, 2012.

3.5 Data collection

Measurements on the following growth parameters and bulb characters were recorded at physiological maturity and harvesting time, respectively.

3.5.1 Growth parameters

1. **Plant height (cm):** was measured using ruler from the soil surface to the tip of the longest mature leaves at physiological maturity.
2. **Leaf number per plant:** the total count of leaves per plant at maturity.
3. **Leaf length (cm):** the length of the longest leaf was measured using ruler from the sheath to tip of the leaf at physiological maturity.
4. **Leaf diameter (mm):** the maximum diameter of the longest leaf measured using ruler at the widest point of the leaf.
5. **Days to physiological maturity:** the actual number of days from transplanting to a day at which more than 50% of the plants in a plot have shown fallen tops (IPGRI, 2001).

3.5.2 Yield parameters

1. **Bulb length (cm)**: refers to the height of the bulb measured at harvest using a vernier caliper from the bottom to the top of the matured bulb.

2. **Bulb diameter (cm):** was measured at harvest using a vernier caliper at the widest point in the middle portion of the mature bulb.

3. **Average bulb weight (g):** computed by weighing ten marketable bulbs together and calculating the average.

4. **Total bulb yield (ton ha^{-1}):** The sum of total marketable and unmarketable bulbs was computed based on the weight of matured bulbs yield per plot and converted in to hectare base.

5. **Marketable bulb yield (ton ha^{-1}):** was determined after discarding bulbs smaller than 3 cm in diameter, split, thick necked, rotten and discolored.

6. **Unmarketable bulb yield (ton ha^{-1}):** this were determined by categorizing which were under sized (<20g), diseased, decayed, physiological disordered such as thick necked splits and bolted were weighed and expressed as unmarketable bulbs.

7. **Harvest index:** It is the proportion of the crop that is of economic importance. It is the ratio of mature dry bulb weight to total dry biomass yield in gram. The data set is the average of ten randomly taken plants in each experimental plot. This was calculated by:

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}}$$

3.5.3 Bulb quality parameters

1. **Dry matter content (%):** A homogenate (25g) was prepared for determination of percent dry matter content from each plot of bulb samples and oven (DP 203A: P/N 2123LST (A24) China) dried at a temperature of 80^0c for 48 hrs. Then the weight was measured using digital balance and percentage was calculated using the following formula.

$$\text{Dry Matter Content} = \frac{\text{Dry Weight}}{\text{Fresh Weight}} * 100$$

2. **Total soluble solid (TSS ^{o}Brix):** To determine the TSS of the sample mortar was used to crush the bulb and prepare and extract aliquot. This was done in the laboratory of post-harvest management department. The TSS was determined by refractormeter (Bellingham + Stanley 45-02 BS eclipse) by placing 1 to 2 drops of clean juice on the prism. Between samples, the prism of the refractrometer was washed with distilled water and dried before use.

3. **Split bulbs percentage (%):** was determined by counting the number of split bulbs per plot and expressed in percentage in reference to total number of normal bulbs per plot.

3.5.4 Soil parameters

The representative soil sample were collected from 0-30cm depth using an auger from randomly selected sub-samples representing the entire experimental field and composited in to one sample. Then the composited samples were dried and passed through 2.0 mm sieve before laboratory analysis and all the soil parameter data were taken. Moreover, soil samples were taken from each experimental plot at final harvest to determine the basic physico-chemical properties of the soil status.

1. **Soil pH:** Digital pH meter was used to analyze the soil pH using pure water (1:1 ratio).
2. **EC(mS/cm):** The soil was analyzed for EC using EC meter
3. **Organic carbon (%):** organic carbon content of the soil was determined based on oxidation of organic carbon with acid dichromate medium following the Walkley and Black method as described by Dewis and Freitas (1970).
4. **Organic matter (%):** The Walkley and Black (1934) wet digestion method was used to determine soil OM.
5. **Available Phosphorus (ppm):** Available phosphorus was determined using standard procedure of Bray II method.
6. **Potassium (cmol (+)/kg soil):** Potassium was determined using flame photometer (Rowell, 1994).
7. **Total Nitrogen (%):** was analyzed using the Kjeldahl digestion, distillation and titration method as described by Black (1965) by oxidizing the OM in concentrated sulfuric acid solution (0.1N H_2SO_4).

3.6 Data Analysis

The collected data were first checked for meeting all the ANOVA assumption and subjected to analysis of variance (ANOVA) by using SAS computer software version 9.2 (SAS Institute Inc., 2008). When ANOVA showed significant differences, mean separation was carried out using LSD (Least Significant Difference) test at 5% significance level.

4. RESULTS AND DISCUSSION

Data on growth, yield and quality parameters were recorded during the course of study and the results are presented and discussed here under.

4.1. Growth parameters

4.1.1. Plant height

The interaction of Nitrogen and Farmyard manure significantly (*P*<0.05) influenced plant height of onion (Table 2 and Appendix Table 1). Application of 100 kg N ha^{-1} and 15 ton FYM ha^{-1} increased plant height by about 21% compared to the control (41.47 cm) although further application did not cause further significant change. The highest mean plant height was obtained at 100 kg ha^{-1} N and 45 ton ha^{-1} FYM while the lowest was at 0 kg ha^{-1} N and 0 ton ha^{-1} FYM. At physiological maturity, the highest mean plant height (54.16 cm) of onion was achieved at 100 kg ha^{-1} N and 45 ton ha^{-1} FYM which was statistically similar with 100/15, 150/15, 50/30, 100/30, 150/30, and 150/45 kg ha^{-1} of N and FYM combinations, respectively (Table 2). Thus the effects of N on plant height was enhanced when used in combination with Farmyard manure. All the treatments recorded better plant height over the control.

Nitrogen levels with more proportion of FYM fertilizer gave highest plant height as compared to the lower level of FYM fertilizer (and the control). This might be due to the rapid availability of nutrients from the applied N in combination with FYM fertilizers since they provide major elements at the early stage of plant growth and development.

The result is in line with the findings of Gupta *et al* (1999) who reported that application of FYM at 72.0 quintals ha^{-1} along with ammonium sulphate at 565 kg ha^{-1} were effective in increasing the growth and yield in onion. Geetha *et al.* (2000) reported that application of FYM at 25 ton ha^{-1} and 200 kg ha^{-1}K increased the shoot and bulb yields of onion. Yassen and Khalid (2009) also pointed out that the highest values of vegetative growth characters were recorded with 23.8m^3 ha^{-1} farmyard manure plus 47.6m^3 ha^{-1} chicken manure. Organic fertilizers *i.e.* mixture of farmyard and chicken manure, improved the vegetative growth characters of onion plants.

Similar results were observed by Damke *et al.* (1988) enhanced plant height of chilli with application of FYM at 9 ton per ha^{-1} along with 50 kg each of N, P_2O_5 and K_2O. Similarly, Surlekov and Pankov (1989) reported greater plant height, number of branches and number of leaves per plant in chilli with the application of farmyard manure at 20 ton per ha^{-1} along with 100:80:100 kg N, P_2O_5 and K_2O per ha^{-1}. At harvest, application of FYM at 25 ton per ha^{-1} (100%) + PSB + *Azospirillum* recorded numerically higher plant height (81.0 cm) followed by the application of FYM at 12.5 ton per ha^{-1}(50%) + poultry manure at 2.1 ton per ha^{-1} (50%) (79.9 cm) (Suresh, 2007).

Table 2. Interaction effect of farmyard manure and nitrogen fertilizer on mean plant height (cm) of onion at Jimma

Nitrogen (kg ha^{-1})	Farmyard manure (kg ha^{-1})			
	0	15	30	45
0	41.47^{f}	46.29^{cd}	45.21^{de}	47.61^{cd}
50	42.12^{ef}	47.78^{cd}	52.19^{a}	51.72^{ab}
100	48.86^{bc}	52.33^{a}	53.11^{a}	54.16^{a}
150	51.44^{ab}	54.11^{a}	53.29^{a}	54.01^{a}
LSD (0.05) = 3.18				
CV (%) = 3.84				

* *Means followed by the same letter(s) in the same column are not significantly different at 5%*

Plant height was very highly significantly and positively correlated with leaf number per plant (r=0.70***), leaf length (r=0.70***), days to physiological maturity (r=0.77***), average bulb weight (r=0.63***), total bulb yield (r=0.62***), marketable bulb yield (r=0.62***), bulb diameter (r=0.47**), bulb length (r=0.40**), bulb dry matter content (r=0.38**), harvest index (r=0.70***) and split per cent of onion bulbs (r=0.64***) (Appendix Table 7).

4.1.2. Leaf number per plant

Mean number of leaves per plant at physiological maturity was significantly ($P<0.05$) affected by combined application of N and FYM (Figure 1 and Appendix Table 1). The highest mean value (15.44) was obtained from the combined application of 150 kg ha^{-1} N and 45 ton ha^{-1} FYM and the lowest mean value (7.86) was recorded in the control treatment. Combined application of N and FYM at 150 kg ha^{-1}: 45 ton ha^{-1} increased the mean number of leaves by about 49% as compared with the unfertilized plots. This could be attributed to the increase in the vegetative growth of the onion plants through its effect in the synthesis of the different components of protein required for leaf development.

In line with this Bhujbal (1989) recorded that the effect of organic, inorganic and bio fertilizer on growth, yield and storage quality of bulbs reported that the highest plant height and number of leaves per plant were recorded by the treatment of 60 ton FYM + 100:50:50 kg NPK ha^{-1}. Suresh (2007) also reported that FYM at 12.5 ton per ha^{-1} (50%) + vermicompost at 2.1 ton per ha^{-1} (50%) produced maximum of 11.6 and 11.2 leaves per plant at 60 DAT and at harvest, respectively.

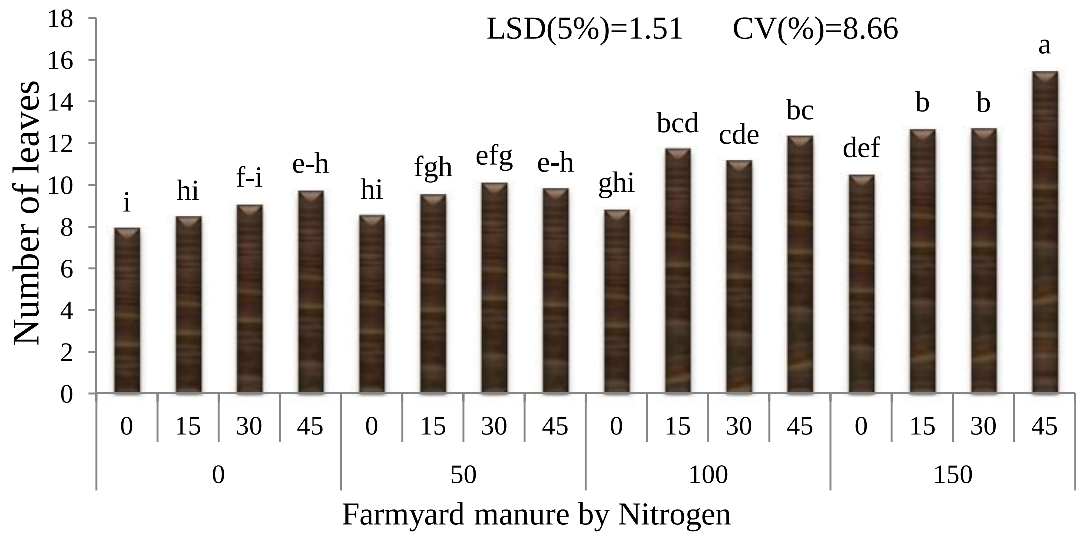

Figure 1. Interaction effect of farmyard manure and nitrogen fertilizer on leaf number per plant of onion at Jimma

Similar results were reported by Nasreen *et al*. (2007) who found that application of 120 kg N ha^{-1} significantly increased the number of leaves per plant and further increased N supply to 160 kg ha^{-1} tended to decrease it. Vachhani and Patel (1993) also found that number of leaves per plant was the highest with the application of 150 kg N ha^{-1}. Knal *et al*. (2002), Aregawi (2006), Abdulsalam and Hamaiel (2004) also reported similar results in onion. The increase in number of leaves per plant with increase in N level can be due to nitrogen that might have contributed in producing new shoots and vigor in vegetative growth which is directly responsible in increasing the leaf number.

4.1.3. Leaf lengh

Application of N and Farmyard manure highly significantly (*P*<0.001) influenced leaf length. However, their interaction was not significant. Increasing the level of FYM application from 0 to 45 ton ha^{-1}, increased the mean leaf length per plant by about 28% when compared with the control (33.60) (Table 3). This might be because it supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition. Indirectly, it improves the physical properties of soil such as aggregation, aeration, permeability and water holding capacity (Chandramohan, 2002).

Similarly, the results of this study revealed that application of N at different levels showed a highly significant (*P*<0.001) effect on the mean leaf length per plant (Table 4 and Appendix Table 1). The plots that were fertilized with the maximum rate of N (150 kg ha^{-1}) showed about 16% increase in mean leaf length per plant over the control which is statistically the same value with (42.05) registered from plots that received only 100 kg of N ha^{-1}. Further application of N above 100 kg ha^{-1} did not bring change on mean leaf length onion. The minimum mean leaf length (35.70cm) was recorded in the control treatment.

The result is in agreement with Bungard *et al*. (1999) who reported that N is the major constituent of proteins and the presence of abundant protein tends to increase the size of the leaves and ultimately increase carbohydrate synthesis. Similarly, Jilani (2004) reported that application of 200 kg N ha^{-1} significantly enhanced the length of onion leaves. Kumar *et al.* (1998) and Singh and Chaure (1999) also indicated that application of N at 150 kg ha^{-1} gave the best result with regard to onion leaf length. Abdissa *et al.* (2011) also reported that N application showed a significant effect on onion leaf length.

4.1.4. Leaf diameter

The level of Nitrogen, Farmyard manure and interaction of the two did not affect leaf diameter significantly (Table 4 and Appendix Table 1).

Table 3 Effect of farmyard manure and nitrogen fertilizer on leaf length and leaf diameter of onion in Jimma

N (kg ha^{-1})	Leaf length (cm)	Leaf diameter (cm)
0	35.70^{b}	0.81^{a}
50	37.46^{b}	0.84^{a}
100	42.05^{a}	0.91^{a}
150	42.50^{a}	1.00^{a}
LSD (5%)	2.45	NS
FYM (ton ha^{-1})		
0	33.60^{d}	0.81^{a}
15	36.85^{c}	0.83^{a}
30	40.88^{b}	0.89^{a}
45	46.38^{a}	1.02^{a}
LSD (5%)	2.45	NS
CV%	7.47	21.2

N=nitrogen, FYM=farmyard manure and Ns = Non significant at 5% level. Means followed by the same letter(s) in the same column are not statistically significantly at 5% level of significancy.

The result disagrees compared to those reported by Kumar *et al*. (1998) in that N application at 150 kg ha^{-1} gave the best result with regard to leaf diameter of the longest leaf. This result is also in contrast with the finding of Suresh (2007) who reported that numerically higher leaf width was observed with treatment receiving FYM at 100 per cent and lowest leaf width, was obtained at Recommended Dose of Fertilizer (control). However, N and FYM fertilization in didn’t influence leaf diameter of onion.

4.1.5. Days to physiological maturity

The interaction effect of nitrogen with farmyard manure application at the rates of 150 kg ha^{-1} and 30 ton ha^{-1} respectively delayed the days to attain physiological maturity by about 14 days compared to the unfertilized plot (98 days). Further application does not affect days to physiological maturity of onion. This indicates that higher application of FYM and N significantly delays days to attain physiological maturity in onion plants (Figure 2 and Appendix Table 2).

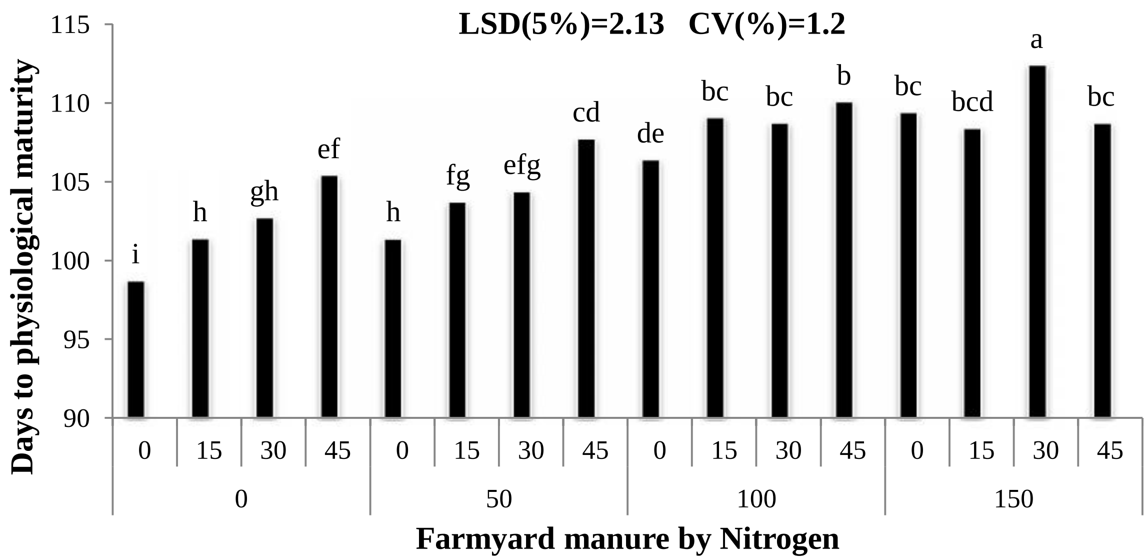

Figure 2. Interaction effect of farmyard manure and nitrogen on days to physiological maturity of onion at Jimma

This result is in agreement with the findings of Brewster (1994), Sorensen and Grevsen (2001) and Abdissa *et al.,* (2011) who reported that too much nitrogen promotes excessive vegetative growth and delayed maturity. Riekels (1979) and Batal *et al*., (1994) also indicated that high nitrogen can result in excessive vegetative growth and delayed maturity of onion. In line with this Kebede (2003) reported that increased nitrogen fertilizer rates enhanced vegetative growth, delayed maturity and reduced bulblet sizes.

4.2. Yield parameters

4.2.1. Bulb length

The level of farmyard manure and interaction with nitrogen had revealed non - significant effect on mean bulb length of onion plant (Appendix Table 3). This is because of the fact that nitrogen is responsible for vegetative growth of plants and later it increases the bulb weight through increasing bulb diameter rather than bulb length (Brewster, 1994). Although FYM fertilization did not affect bulb length in this study. But there are findings disclosing an increased bulb length in response to N fertilization (Yadav *et al*., 2003; Reddy *et al*., 2005).

Separate application of N at different levels illustrated a highly significant (P<0.001) effect on mean bulb length (Table 4 and Appendix Table 3). Of all the levels tested, the maximum rate of N (150 kg ha^{-1}) increased the mean bulb length by about 12% in reference to the control treatments (4.54cm), which was statistically similar with 100 kg ha^{-1} N treatment (Table 4). The result indicates that further application of nitrogen doesn't affect mean bulb length of onion.

4.2.2. Bulb diameter

Nitrogen and Farmyard manure highly significantly (P<0.001) influenced the mean bulb diameter. However, their interaction did not show significant difference (Appendix Table 3). Regardless of the rate of FYM fertilization a highly significant (P<0.001) variation exist in mean bulb diameter of onion. Application of FYM at a rate of 45 ton ha^{-1} gave the highest mean bulb diameter (5.99cm); which was statistically similar with 30 ton ha^{-1} (Table 4). The smallest bulb diameter (5.59cm) was found at control (0 ton FYM ha^{-1}).

In a study of onions it was found that applications of farmyard manure, pelleted manure, neem (*Azadirachta indica*) seed powder, and karanj cake (*Pongamia pinnata*) with 75% of the recommended inorganic fertilizer [100 kg ha^{-1} N, 60 kg ha^{-1} phosphorus (P), and 80 kg ha^{-1} potassium (K)] resulted in increased onion bulb diameter compared with using inorganic fertilizers alone (Mondal *et al*., 2004). Bulb width and the number of storage leaves were observed to be maximum at 60 ton ha^{-1} application of organic fertilizer (Yoldas *et al.*, 2011).

Similarly, N fertilization (150 kg ha^{-1}) increased bulb diameter by about 8% in reference to the control (5.47 cm), which may be linked to the increase in dry matter production and allocation to the bulb. Larger bulb diameter in onion with N application could be associated with promoting nature of nitrogen in cell elongation, above ground vegetative growth and synthesis of more chlorophyll to impart dark green color of leaves which may be linked to the increase in dry matter production and translocation to the bulb (Brady, 1985).

The result is in agreement with Aliyu *et al*. (2008) who reported a significant effect on bulb diameter of onion at 100 kg ha^{-1} N application. Similar results were also reported by Yadav *et al*. (2003) who found that N at 150 kg ha^{-1} enhanced the formation of bulbs with larger diameters. Khan *et al*. (2002) and Maier *et al*. (1990) also reported similar result for onion. The increase in bulb diameter corresponds to its effect on shoot dry weight.

Table 4. Main effect of FYM and N on onion bulb length, diameter and mean bulb weight

N (kg ha^{-1})	Bulb length (cm)	Bulb diameter (cm)	Average bulb weight (g)
0	4.54^{c}	5.47^{b}	40.37^{c}
50	4.77^{bc}	5.77^{a}	49.85^{b}
100	5.03^{ab}	5.93^{a}	58.98^{a}
150	5.18^{a}	5.94^{a}	64.34^{a}
LSD (5%)	0.35	0.23	5.67
FYM (ton ha$^{-1)}$			
0	4.73^{a}	5.59^{b}	48.92^{b}
15	4.85^{a}	5.73^{b}	49.20^{b}
30	4.87^{a}	5.80^{ab}	54.01^{b}
45	5.06^{a}	5.99^{a}	61.42^{a}
LSD (5%)	NS	0.23	5.67
CV%	8.83	4.9	12.74

N=nitrogen, FYM=farmyard manure and Ns = Non significant at 5% level. Means followed by the same letter(s) are not significantly different at 5% level of significancy.

4.2.3. Average bulb weight

A significant ($P<0.05$) interaction effect of nitrogen with farmyard manure was observed for mean bulb weight of onion (Appendix Table 3). Mean bulb weight increased by about 43% in response to application 150 kg ha^{-1}N and 30 ton ha^{-1} FYM as compared to the control; although further application did not bring significant change. Likewise, mean bulb weight of onion was highly and significantly affected by farmyard manure alone, where in application of 45 ton ha $^{-1}$ registered the maximum mean value (61.42g) which was increased by about 20% as compared to the control (Table 4 and Appendix Table 3).

This result is in agreement with the findings of Abbey and Kanton (2003) who found that application of farmyard manure (FYM), inorganic fertilizer (IF) or a combination of manure and inorganic fertilizer (FYM + IF) resulted in onion bulb weight increase by FYM+IF in subsequent years. Suresh (2007) also observed highest bulb dry weight by the application of FYM at 25 ton ha^{-1} (94.5 g) followed by the Recommended Dose of Fertilizer (93.3 g).

Average bulb weight of onion was found to be highly significantly ($P < 0.001$) affected by N application (Appendix Table 3). The highest bulb weight (64.34g) was recorded at 100 kg ha^{-1} of nitrogen which was 37% higher compared to the control. Bulb weight increased with increased nitrogen rate up to 150 kg ha^{-1} N doses (Table 4). Mean bulb weight improvement in response to N could be attributed to the increase in number of leaves produced, leaf length, and extended physiological maturity in response to the fertilization all might have increased assimilate production and allocation to the bulbs.

The result is in accordance with the findings of Knal *et al*. (2002) and Kumer *et al*. (1998) who reported a significant increase in bulb weight of onion with increasing N level up to 100 kg ha^{-1}, but a decline beyond this rate was observed. Similarly Kashi and Frodi (1998), Greenwood *et al*. (2001) and Abdissa *et al.* (2011) also reported significant increase in bulb weight due to increased N application.

Mean bulb weight was strongly and positively correlated with plant height (r = 0.63***), number of leaves (r = 0.69***), leaf length (r = 0.69**), leaf diameter (0.47**) and days to physiological maturity (r = 0.72***). It was also positively and strongly correlated with bulb length (r = 0.50***) and diameter (r = 0.55***) signifying that FYM and N fertilization increased bulb weight by improving these parameters (Appendix Table 7).

4.2.4 Total bulb yield

The analysis of variance for the interaction effect of nitrogen and farmyard manure showed significant (*P*<0.05) difference on dry bulb yield of onion (Table 5 and Appendix Table 4). Increasing the combination level from 0 to 100 kg ha^{-1} of N and 0 to 30 ton ha^{-1} of FYM resulted in progressive increase in bulb yield of onion. Further increase in nitrogen and farmyard manure fertilizer to 150 kg ha^{-1} and 45 ton ha^{-1} respectively did not significantly increase the yield. The highest bulb yield of onion (36.85 ton ha^{-1}) was obtained when the plots received combined application of 100 kg ha^{-1} of N and 45 ton ha^{-1} of FYM which was statistically similar with the levels of 150 kg ha^{-1} of N ; 30 ton ha^{-1} of FYM and 150 kg ha^{-1} of N ; 45 ton ha^{-1} of FYM. This increased the total bulb yield by about 53% as compared with the unfertilized plot (17.45 ton ha^{-1}). This is due to the fact that farmyard manure applied along with mineral fertilizers tremendously increased the yield of onion bulbs and the magnitude of the increase was about 130 and 140 % over control (no FYM and no- NPK fertilizer) when 10 ton ha^{-1} and 20 ton ha^{-1} farmyard manure were used with NPK fertilizers, respectively (Ezekiel, 2010).

This is in agreement with Rumpel (1998) who researched the effect of 20, 40, 60 ton ha^{-1} animal manure doses, NPK (75: 50:100 kg ha^{-1}) and their combination. The result indicated that the addition of animal manure resulted in higher onion yield as compared to NPK fertilizer. In another study of organic amendments in onion production, it was found that an integration of organic amendments (farmyard manure or vermicompost) and biofertilizers with inorganic fertilizers resulted in higher yields and greater growth than the inorganic fertilizer alone (Jayathilake *et al*., 2002). Similarly, Selvakumari *et al*. (2001) found in a study of nutrient rates on various crops, including onions, that the inclusion of organic manures and biofertilizers reduced the required amounts of inorganic N, P, and K.

Kropisz, (1992) reported that organic fertilizers improved cropping with the highest average yields, 28.3 ton ha^{-1} obtained on plots receiving FYM + NPK. Integrated application of recommended dose of NPK + FYM improved the growth parameters as well as yield and yield components in chilli (Mallangouda *et al*., 1995). Vinay Singh and Singh (1995) observed the highest bulb yield (50.6 g/pot) from plants fertilized with FYM (10 ton ha^{-1}) + 40 kg ha^{-1}N + 60 kg ha^{-1} P. Similarly, Warade *et al.* (1996) reported that the highest bulb yield (27.7 ton ha^{-1}) was obtained with 40 ton ha^{-1} FYM + NPK (100, 50 and 50 kg ha^{-1}). Lombin and Abdullahi (1977) in long term fertility studies in Northern Nigeria showed that 5 tons ha^{-1} of animal dung annually combined with 100 kg N and 50 kg P_2O_5 maintains yield under continuous cropping. Similarly, Bababe *et al*. (1998) showed that organic manure is a supplier of N, P and K in the soil, which also increase the phosphate solubilizing bacteria in the rhizosphere.

Table 5. Interaction effect of farmyard manure and nitrogen fertilizer on total and marketable bulb yield of onion at Jimma

FYM ton ha^{-1}	N kg ha^{-1}	Total bulb yield (ton ha^{-1})	Marketable bulb yield (ton ha^{-1})
0	0	17.45^{e}	15.83^{e}
	50	21.70^{cde}	20.16^{cde}
	100	23.40^{bcd}	21.97^{bcd}
	150	26.62^{bc}	25.05^{bc}
15	0	18.96^{de}	17.66^{de}
	50	22.71^{bcd}	21.45^{bcd}
	100	23.41^{bcd}	21.95^{bcd}
	150	26.98^{b}	25.38^{b}
30	0	18.97^{de}	17.55^{de}
	50	23.11^{bcd}	21.78^{bcd}
	100	23.29^{bcd}	21.82^{bcd}
	150	33.30^{a}	32.50^{a}
45	0	26.70^{bc}	25.16^{bc}
	50	25.84^{bc}	24.25^{bc}
	100	36.85^{a}	36.32^{a}
	150	34.78^{a}	33.52^{a}
LSD (5%)		5.01	5.01
CV%		11.89	12.58

N=nitrogen, FYM=farmyard manure. Means followed by the same letter(s) within the same column are not significantly different at 5% level of significancy.

4.2.5. Marketable bulb yield

The analysis of variance for the interaction of nitrogen with farmyard manure fertilizer showed highly significant (*P*<0.01) difference on marketable yield (Table 5 and Appendix Table 4). The highest marketable bulb yield (36.32 ton ha^{-1}) was recorded from 100 kg ha^{-1} of nitrogen and 45 ton ha^{-1} of farmyard manure followed by 150 kg ha^{-1} of N; 45 ton ha^{-1} of FYM and 150 kg ha^{-1} of N; 30 ton ha^{-1} of FYM which gave 33.52 and 32.50 ton ha^{-1} marketable yield per hectare respectively. From all the fertilizer combination treatments that had more amount of farmyard manure fertilizer gave highest yield.

4.2.6. Unmarketable bulb yield

The level of nitrogen, farmyard manure and interaction of the two revealed non – significant effect on unmarketable yield of onion (Appendix Table 4). However, the highest unmarketable yield was recorded from the control plot (Table 6). Accordingly the results indicate that higher application rate of N and FYM decreased the unmarketable bulb yield per hectare. Among all treatments combinations the highest unmarketable bulb yield was recorded in the unfertilized plots. Low levels of nitrogen as well as farmyard manure have been associated with early bulb formation, plants can be severely stunted, with bulbs size and marketable yields reduced in onion.

Table 6. Interaction effect of farmyard manure and nitrogen fertilizer on unmarketable bulb yield and harvest index of onion at Jimma

FYM ton ha^{-1}	N kg ha^{-1}	Unmarketable bulb yield (ton ha^{-1})	Harvest index
0	0	1.61^{a}	0.58^{g}
	50	1.53^{a}	0.65^{f}
	100	1.42^{ab}	0.72^{ef}
	150	1.57^{a}	0.75^{cd}
15	0	1.29^{ab}	0.61^{fg}
	50	1.26^{ab}	0.74^{d}
	100	1.45^{ab}	0.73^{de}
	150	1.60^{a}	0.81^{bc}
30	0	1.42^{ab}	0.63^{fg}
	50	1.33^{ab}	0.66^{ef}
	100	1.47^{ab}	0.74^{d}
	150	1.26^{ab}	0.87^{ab}
45	0	1.54^{a}	0.64^{fg}
	50	1.59^{a}	0.67^{ef}
	100	1.28^{ab}	0.84^{ab}
	150	1.26^{ab}	0.90^{a}
LSD (5%)		NS	0.06
CV(%)		21.78	5.61

N=nitrogen, FYM=farmyard manure and Ns = Non significant at 5% level. Means followed by the same letter(s) are not significantly different at 5% level of significancy.

4.2.7. Harvest index

Highly significant (P<0.01) interaction effect of nitrogen with farmyard manure was observed with respect to the harvest index (Table 6 and Appendix Table 2). The highest harvest index (0.90) was recorded from treatment with 150 kg ha^{-1} N and 45 ton ha^{-1} FYM, which is not significantly differ from plots received 100 kg ha^{-1} N; 45 ton ha^{-1} FYM and 150 kg ha^{-1} N; 30 ton ha^{-1} FYM. Increasing the combination level of nitrogen and farmyard manure application from 0 to 150 kg ha^{-1} and 0 to 45 ton ha^{-1} highly and significantly increased the harvest index by about 36% over the respective check.

At harvest, onion bulb weight increased as the above ground shoot decreased and the respective bulb dry weight is higher, while the shoot dry weight is lower; this make the onion to have a high harvest index (Brewster, 1994). The plants receiving 50% N of RDF through VC (T5) and through FYM (T4) in combination with chemical fertilizers recorded significantly higher HI (65.6 and 64.7%, respectively) than the control (63.1%) as reported by Jayathilake *et al*. (2006).

4.3. Quality parameter

4.3.1. Bulb dry matter content

Regarding the dry matter contents, combined application of N and FYM resulted to the significant increase in dry matter (Figure 3 and Appendix Table 5). The increasing levels of N and FYM encouraged bulbs with a significantly higher dry matter contents as compared to the unfertilized plot. The maximum dry matter contents of onion bulbs (17.37%) were recorded with application of 100 kg $ha^{-1}$of N and 45 ton $ha^{-1}$of FYM. However, further increase in the rate did not bring significant increase except at the highest rate (150 kg $ha^{-1}$of N and 45 ton $ha^{-1}$of FYM) that caused 29% bulb dry matter content over the control. Whereas, the minimum dry matter contents (12.08%), were detected in the controls plot (Figure 3 and Appendix Table 5).

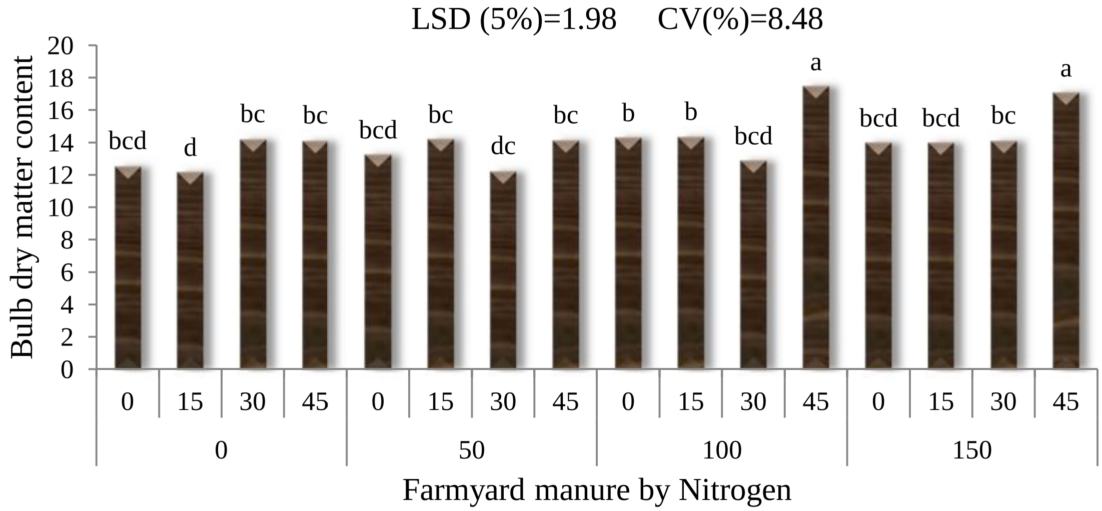

Figure 3. Dry matter contents (%) of onion bulbs as affected by FYM and N fertilizers

4.3.2 Total soluble solids

Total soluble solid (TSS), was found to be highly significantly (*P*< 0.01) affected by N, FYM and the interaction of the two treatments (Table 7 and Appendix Table 5). The highest TSS value (15.43^{o} Brix) was recorded as a result of the combined application of N-FYM at the rate of 100 kg ha^{-1}:45 ton ha^{-1}; while the minimum TSS value (9.00 ^{o}Brix) was recorded from the control one. More explicitly, the maximum TSS which was registered from the combined application of N-FYM (100 kg ha^{-1}:45 ton ha^{-1}) was greater than the control by about 42%. The results in Table 7 and Appendix Table 5 revealed that combined application of N and FYM had shown a highly significant effect on the TSS of onion bulbs. Regardless of the levels of Nitrogen applied at 150 kg ha^{-1} increased the TSS by about 15% as compared to control (10.12 ^{o}Brix).

Table 7. Total soluble solid and split % of onion bulbs as influenced by combined application of farmyard manure and nitrogen fertilizer

FYM ton ha^{-1}	N kg ha^{-1}	Total soluble solid	Split bulbs (%)
0	0	9.00^{h}	1.20^{h}
	50	10.00^{g}	1.24^{gh}
	100	11.00^{e}	1.88^{de}
	150	11.00^{e}	1.79^{f}
15	0	10.00^{g}	1.32^{g}
	50	10.50^{f}	1.81^{ef}
	100	11.00^{e}	1.90^{d}
	150	11.00^{e}	1.31^{a}
30	0	11.50^{d}	2.21^{b}
	50	10.50^{f}	1.79^{f}
	100	10.50^{f}	2.20^{b}
	150	12.00^{c}	2.23^{ab}
45	0	10.00^{g}	1.23^{h}
	50	10.50^{f}	1.81^{ef}
	100	15.43^{a}	2.30^{a}
	150	15.00^{b}	2.00^{c}
LSD (5%)		0.21	0.08
CV (%)		1.14	2.77

N=nitrogen, FYM=farmyard manure. Means followed by the same letter(s) are not significantly different at 5% level of significancy.

4.3.3. Split bulbs

Application of N, FYM and their interaction significantly affect the formation of number of splitted bulbs in onion (Table 7). Both Nitrogen and Farmyard manure fertilization at a rate of 100 kg ha^{-1} and 45 ton ha^{-1} increased the development of splitted bulbs by about 48% over the check plot. However, further increase in the rate did not bring significant increase splitted bulb formation. Steer (1980) reported that bulb splitting as a result of multiple growing points is under genetic control with shallots being at the extreme in this respect. Growth in high temperatures and short days increases lateral shoot production in some cultivar.

4.4 Soil Parameters after harvest

Soil chemical analysis after harvest from the experimental field shows that soil chemical properties such as organic carbon (OC), organic matter (OM), total nitrogen, available phosphorus and available potassium of the soil showed increasing as compared with the value of before planting as shown in Table 8 below.

Table 8. Chemical properties of soil after harvest of the experimental site

Treatments	pH	EC(mS/c)	%OC	%M	%TN	P(ppm)	K(cmol (+)/kg soil)
FYM0,N0	6.85	0.15	1.94	4.32	0.24	10.40	2.98
FYM0,N50	6.91	0.15	2.93	4.76	0.25	10.75	3.05
FYM0,N100	6.97	0.15	3.12	5.09	0.26	11.78	3.25
FYM0,N150	7.03	0.19	3.27	5.34	0.25	11.58	3.21
FYM15,N0	6.88	0.16	2.82	5.58	0.28	12.80	3.46
FYM15,N50	6.92	0.17	2.74	4.43	0.27	12.75	3.45
FYM15,N100	6.98	0.14	3.15	5.13	0.28	13.94	3.68
FYM15,N150	7.05	0.15	3.01	4.90	0.28	13.09	3.52
FYM30,N0	6.89	0.16	3.68	6.04	0.30	15.63	4.02
FYM30,N50	6.95	0.16	3.57	5.86	0.30	15.93	4.27
FYM30,N100	7.00	0.19	3.15	5.13	0.28	15.11	3.92
FYM30,N150	7.09	0.17	3.82	4.57	0.29	15.63	4.02
FYM45,N0	6.90	0.17	3.55	5.83	0.32	16.86	4.38
FYM45,N50	6.96	0.15	3.23	5.27	0.32	17.40	4.47
FYM45,N100	7.01	0.16	3.07	4.99	0.33	17.86	4.59
FYM45,N150	7.09	0.21	3.40	6.30	0.34	18.47	4.47
Mean	6.97	0.16	3.15	5.22	0.29	14.37	3.80

EC = electrical conductivity, OC = organic carbon, OM = organic matter, TN = total nitrogen,P = phosphorus and K = potassium

4.4.1 Total Nitrogen

The total N in soil were recorded from highest application dose of FYM (45 ton ha^{-1}) while recording maximum (0.34%) in combination with nitrogen fertilizer which was on a par with (30 ton ha^{-1}) application of farmyard manure. The lowest level of total N (0.24%) was recorded from the control plot (FYM 0) which was significantly lower to the other farmyard manure treatments combinations.

4.4.2 Available Phosphorus

The available phosphorus in soil increased with application of farmyard manure in combination with nitrogen fertilizer. Significantly higher available phosphorus (18.47ppm) in soil was observed with the application of FYM 45 ton ha^{-1}in combination with 150 kg ha^{-1} N. The lowest value of available P (10.40ppm) in the soil after harvest was registered from the treatment containing no FYM.

4.4.3 Available Potassium

The maximum available amount of potassium in the soil (4.59 cmol (+)/kg soil) was registered from the combined application of (45 ton ha^{-1} FYM and 100 kg ha^{-1}N) which was significantly superior to the unfertilized plot (2.98cmol (+)/kg soil). The plots supplied with the highest application dose of farmyard manure were recorded significantly higher values of K over the lowest levels and the (control) treatments.

4.4.4 Organic Carbon

All fertilized plots with FYM showed significant differences over the control treatment. Higher organic carbon content (3.82%) of soil was recorded from 30 ton ha^{-1} of FYM, 150 kg $ha^{-1}$of N treatment combination. The lowest organic carbon content (1.94%) on the other hand was recorded from the control. Generally plots having more amount of farmyard manure fertilizer showed higher percentage of organic carbon over the control. This result is in line with Reza and Jafar (2007) who indicated that the additions of organic fertilizer resulted in increased total OC. Maheswarappa *et al.* (1997) observed that, organic carbon content was increased to a greater extent with FYM and vermicompost application than other sources. Javariaa and Khana (2011) also reported that an increase in organic C is obvious in soils receiving combined application of organic manures and inorganic fertilizers compared to soils receiving inorganic fertilizers alone.

4.4.5 Organic Matter

Higher organic matter content of the soil was recorded from the combination of 45 ton ha^{-1} FYM and 150 kg ha^{-1} N. The lowest amount of organic matter content (4.32%) on the other hand was recorded from the control treatment. All other treatments were in between these two results but greater than that of the control and the initial value. From all the treatments, those having more proportion of FYM gave higher soil organic matter. Generally, all fertilized plots showed significant differences over the control treatment. This result is in line with the result of Reza and Jafar (2007) who reported that addition of organic fertilizer resulted in increased total organic matter than that of inorganic fertilizer.

5. SUMMARY AND CONCLUSION

Onion is relatively recently introduced vegetable crop and is rapidly becoming popular among producers and consumers. It is widely produced by small farmers and commercial growers throughout the year for local use and export market. Onions are heavy feeders and require more fertilizer than is used in most vegetable crops. The amount to be applied depends on the type and fertility status of the soil. However, the best combination levels for a particular locality or soil type have to be determined for economic production.

Continuous usage of inorganic fertilizer alone affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers as for improving soil structure and microbial biomass. Similarly with the increased cost of inorganic fertilizers, application of recommended dose is difficult to be afforded by the small and marginal farmers. Hence renewable and low cost sources of plant nutrients for supplementing and complementing chemical fertilizers should be substituted which can be affordable to the majority of farming community. In this context, integrated nutrient management would be a viable strategy for advocating judicious and efficient use of chemical fertilizers with matching addition of organic manures. Farmyard manure is a conspicuous organic component of an integrated nutrient supply system, which improves soil health, increases the productivity and releases macro and micronutrients.

Integrated use of organic manure and chemical fertilizers result in onion yield increase in comparison with the exclusive application of chemical fertilizers. Keeping this fact in view this research was carried out to determine the comparative benefits of using farmyard manure and nitrogen fertilizers in combination or alone in respect of yield and quality of onion at Jimma. The results of the study showed that main effect of FYM and N as well as their interactions had considerable influence on different parameters.

The interaction of FYM and N fertilizer revealed significant effect on plant height, number of leaves, maturity date, average bulb weight, marketable yield, total yield of onion, bulb dry matter content, total soluble solids, harvest index and split bulbs, but did not affect leaf length and diameter, bulb length and diameter, unmarketable bulb yield. Increased combined application of farmyard manure and nitrogen delayed maturity of onion by 14 days compared to the control. The highest bulb yield of onion (36.85 ton ha^{-1}) was obtained when the plots received combined application of 100 kg ha^{-1} of N and 45 ton ha^{-1} of FYM which was statistically similar with the levels of 150 kg ha^{-1} of N ; 30 ton ha^{-1} of FYM and 150 kg ha^{-1} of N ; 45 ton ha^{-1} of FYM.

The result showed that appication of farmyard manure at different level significantly affect plant hieght, number of leaves, leaf length, maturity day, average bulb weight, marketable bulb yield, total bulb yield, bulb diameter, bulb dry matter content (%), total soluble solid, harvest index and split bulbs; but it had no significant effect on leaf diameter, unmarketable bulb yield andbulb lenght. Maximum application of FYM levels at 45 ton ha^{-1} increased the marketable bulb yield by about 30% as compared with the control treatments.

Similarly, applied N fertilizer revealed significant effect on plant hieght, number of leaves, leaf length, maturity day, average bulb weight, marketable bulb yield, total bulb yield, bulb diameter, bulb lenght, bulb dry matter content (%), total soluble solid, harvest index and split bulbs; but it had no significant effect on leaf diameter and unmarketable bulb yield. In this study, the maximum dry bulb yield of onion (33.30 ton ha^{-1}) was obtained when the plots received combined application of 150 kg ha^{-1} of N and 30 ton ha^{-1} of FYM.

The highest organic carbon, organic matter, N, P and K were recorded from highest dose of farmyard manure. It can be concluded that organic fertilizer (farmyard manure) can significantly increase the soil nutrient content. Based on these result it can be concluded that farmyard manure is very important combination for sustainable agriculture. It improves the soil organic matter, adds soil nutrients, improves soil physical properties and increases the productivity.

The above findings indicated that the growth and productivity of onion at Jimma can be improved by using increased farmyard manure and nitrogen fertilizer combination. Therefore, from statistical point of view and labour requirements to prepare and apply FYM, a farmyard manure application at a rate of 30 ton ha^{-1} and nitrogen fertilizer at a rate of 150 kg ha^{-1} can be used as a recommended fertilizer combination for onion production around Jimma area. To develop robust recommendation, it will be good to repeat the experiment on soils of different characteristics, agro-ecological conditions and cost benefit analysis should be done.

6. REFERENCES

Abbey. L, and RAL Kanton, 2003. Fertilizer type, but not time of cessation of irrigation, affect onion development and yield in a semiarid region. *Journal of Vegetable Crop Production, **9 (2)**:41-48.*

Abd-Allah, A.M., Safia, M. Adam and A.F. Abou-Hudia, 2001. Response of some tomato hybrids to the organic fertilizer under newly reclaimed soil conditions. *Egypt Journal of Horticulture*, **28**: 341- 353.

Abdissa, T. Tekalign and L. M. Pant, 2011. Growth, bulb yield and quality of onion (*Allium cepa* L.) as influenced by nitrogen and phosphorus fertilization on vertisol. Growth attributes biomass production and bulb yield. *African Journal of Agricultural Research,* **6(14)**: 3252-3258.

Abdulsalam, M.A. and A.F. Hamaiel. 2004. Effect of Planting Dates and Compound Fertilizers on Growth, Yield and Quality of Hassawi Onion Under Al-Hassa Oasis Conditions. *Scientific Journal of King Faisal University (Basic and Applied Sciences,)* **5(1):** 1425.

Adeinyan, O.N. and S.O. Ojeniyi 2003. Comparative effectiveness of different level of poultry manure with NPK fertilizer on residual soil fertility, nutrient uptake and yield of maize. *Moor J. Agric. Res*. **4**: 191-197.

Aim P. M. 1993. Tropical soils and fertilizer use. U.K. pp147 –148

Aisha, A.H., Rizk, F. A., Shaheen, A.M. and Abdel-Mouty, M. M. 2007. Onion plant growth, bulbs yield and its physical and chemical properties as affected by organic and natural fertilization. *Research Journal of Agriculture and Biological Sciences*, **3(5)**: 380-388.

Aklilu, S.1997. Onion research and production in Ethiopia. *Acta Horticulturae,* **433**: 95-97.

Akoun, J. 2004. Effect of plant density and manure on the yield and yield components of the common onion (*Allium cepa* L.) var. nsukka red. *Nigerian Journal of Horticultural Science*, **9**: 43-48.

Ali, M.K., M.F. Alam, M.N, Alam and S.M.AT. Khandaker. 2007. Effects of Nitrogen and Potassium level on yield and quality seed production of onion. *Jour. of Appl. Science Research*, **3(2)**: 1989-1999.

Aliyu, U., A.U. Dikko, M.D. Magaji and A. Singh. 2008. Nitrogen and Intra-row Spacing effects on Growth and Yield of Onion (*Allium cepa* L.). *Online, J. Plant scie. Research,* **3(2)**:188-193.

Antoun, H., S. A Visser,M.P Cescas. Joyal 1985. Effect of liquid hog manure application rates on silage corn yield and nutrient uptake. *Canadian J. Plant Science*, **65**:63-70.

Aregawi Tesfay. 2006. effect of Nitrogen and phosphorus on yield and dry mateer Accumulation of Garlic (*Allium sativum*) at Bule wereda, southern Ethiopia, M.Sc. Thesis, Hawassa Universisty, Awassa Ethiopia. 42 p.

Arisha H.M. and A. Bradisi, 1999.Effect of mineral fertilizers and organic fertilizers on growth, yield and quality of potato under sandy soil conditions. *Zagazig J. Agric. Res*., **26**: 391–405.

Ayuso MA, JA. Pascal, Garcia C, Hernandez .T 1996. Evaluation of urban wastes for urban agricultural use. *Soil Sci. Plant Nutr*. **42:**105- 111.

Bababe, B., K.M.Sandabe, and A. Ibrahim, 1998. The use of organic wastes and compost as an alternative source of fertilizers in Borno State. Paper presented at a workshop on soil Fertility Management and utilization of organic wastes at the Borno state Agricultural Development Programme (BOSADP) Maiduguri, pp 81-88.

Badr, L.A.A. and W.A. Fekry, 1998. Effect of intercropping and doses of fertilization on growthand productivity of taro and cucumber plants.1-vegetative growth and chemical constituents of foliage. *Zagazig J.Agric. Res.*, **25**: 1087–101.

Balemi.T., N. PAL and A. K Saxena. 2007. Response of onion (*Allium cepa L.*) to combined application of biological and chemical nitrogenous fertilizers. *Acta agriculturae Slovenica,* **89 (1)**: 107 – 114.

Batal, K.M., K. Bondari, D.M. Granberry and B.G. Mullinix. 1994. Effects of source, rateand frequency of N application on yield, marketable grades and rot incidence of sweet onion (*Allium cepa L*. cv. Granex-33). *Journal of Horticultural Science,* **69**:1043-1051.

Belay A, Classens AS, Wehner FC, De Beer JM 2001. Influence of residual manure on selected nutrient elements and microbial composition of soil under long term crop rotation. *S. Afr. J. Plant Soil*, **18**:1-6.

Bhujbal PK. 1989. Effect of organic, inorganic and biofertilizers on growth, yield and storage quality of onion bulbs cv. N-2-4-1.M.Sc.Thesis submitted to Mahatma PhuleKrishi Vidyapeeth, Rahuri, Maharashtra, India.

Black, C.A.1965. Methods of soil analysis. Part I, American society of Agronomy. Madison, Wisconsin, USA.1572p.

Boyhan, G., T. Kettey, D. Granberry, W.M. Randle and R.L. Torrance. 2001. Variety Selection and Characteristics. Bulletin 1198.

BPEDORS. 2000. Physical and socio economical profile of 180 District of Oromia Region. Bureau of Planning and Economic Development of Oromia Regional state, Physical planning Development. Finfinne, Ethiopia. Pp.248-251.

Brady, N. C. 1985. The Nature and Properties of Soils, 9th Edn. New Delhi.

Brady, N.C. and R.R. Weil, 2002. The nature and properties of soils. Thirteenth edition. Pearson Education Asia. Delhi, India. 960p.

Brewester JL 1994. Onions and other vegetable *Alliums*. CAB International, Wallingford, UK,p. 236.

Bungard RA, Wingler A, Morton JD, Andrews M, 1999. Ammonium can stimulate nitrate and nitrite reductase in the absence of nitrate in Clematis vitalba. Plant Cell Environ. **22**: 859-866.

CACC, 2002. (Central Agricultural Census Commission Part I): Report on the preliminary results of area, production and yield of temporary crops. Addis Ababa. 200p.

Carol, M., C. Tanya and F. Tamera 1999. From end to begging: A Manure Resource Guide for farmers and gardeners in western Washington. King Conservation District 935 Powell Ave SWRenton, WA 98055, pp 206.

Chandramohan, S., 2002, Organic farming in cotton + black gram intercropping system. *M.Sc. (Agri.) Thesis*, Tamil Nadu Agricultural University, Coimbatore (India).

Chung, B., 1989. Irrigation and bulb onion quality. *Acta Horticulture* **247**: 233-237.

Clark, M.S., W.R. Horwath, C. Shennan, K.M. Scow, W.T. Lantna and H. Ferris, 1999.Nitrogen, weeds and water as yield limiting factors in conventional, low-input and organic tomato systems; Agric. *Ecosyst. and Environ*. **73**: 257-270.

CSA Report of Federal Democratic Republic of Ethiopia, 2001/02.Statistical Report on Socio-Economic Characteristics of the Population in Agricultural Households, Land Use, Area and Production of Crops. Addis Ababa: CSA, Pp.193-211.

CSA (Central Statistical Agency), 2002. Agriculture sample survey. Central Statistical Agency, Addis Ababa, Ethiopia.

Currah, L. and F.G. Proctor. 1990. Onions in Tropical Regions. *Natural Resource Institute*. Bulletin **35**:20-23

Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F. 1985. The Families of the Monocotyledons: Structure, Evolution, and Taxonomy. Springer. 520 pp.

Damke, M. M., Kawarkhe, V. J. and Patil, C. V., 1988, Effect of phosphorus and potassium on growth and yield of chilli. *Punjab Agric. Uni. J. Res*., **12:** 110-114.

Dauda, S. N., Ajayi, F. A and Ndor, E. 2008. Growth and yield of water melon (*Citrulluslanatus*) as affected by poultry manure application. *Journal of Agriculture and Social Science*, **4**: 121-124.

Dewis, J. and P. Freitas, 1970. Physical and Chemical Methods of Soil and Water Analysis. *FAO Bull*. No.**10**, Rome. 271p.

Drinkwater, L. E, D.K. Letoumeau, F. Worker, A. H.C. Van Bruggen and C. Shennan 1995. Fundamental differences between conventional and organic tomato agro systems in Ecological Modeling **35**: 1098-1112.

EARO. 2004. Directory of Released Crop Varieties and their Recommended Cultural Practices. Ethiopian Agricultural Research Organization, Addis Abeba, Ethiopia.

El-Shakweer MHA, El-Sayad EA, Ewees MS 1998. Soil and Plant analysis as a guide for interpretation of the improvement efficiency of organic conditioners added to different soils in Egypt. *Communication in soil science and plant analysis*, **29**:2067-2088.

Ezekiel T., N, 2010. Effect of combined application of organic manure and chemical fertilizers on soil properties and crop yields. *Nigerian Journal of Science, Technology and Environmental Education (NIJOSTEE)*, **3(1)**: 28-32.

FAO, 1999. Production Year Book, vol, 53, Food and Agricultural Organization of the United Nation., Rome. pp.78-80

FAO, 2005. Food and Agricultural organization. Production year book.(http://www.fao.org).

FAO, 2008. Food and Agricultural organization, Production Year book. Food and Agricultural Organization Statistics Series No 176, Vol. **56**. Rome, Italy

FAOSTAT, 2011. Statistics division. Accessed on 08 June 2011.http://faostat.fao.org

FAOSTAT, 2012. Statistics division. Accessed on 07 August 2012. http://faostat.fao.org
Fuchs W, Rauch K, Wiche HJ, 1970. Effect of organic fertilizer and organo mineral fertilizing on development and yield of cereals. Abrecht- *Thaer. Arch*., **14**:359-366.

Gambo, B. A., Magaji, M. D., Yakubu, A. I.and Dikko, A. U. 2008. Effects of Farmyard Manure, Nitrogen and Weed Interference on the Growth and Yield of Onion *(Alliumcepa l.)* at the Sokoto Rima Valley. *J. of Sustainable Development in Agriculture &Environment, **3(2)**:87-92.*

Geetha, A., Sreenivasaraju, P., Chandrasekhar Rao and Suryanarayan Reddy, M., 2000. Effect of individual and combined application of FYM and potash fertilizer on yield and potash nutrition of onion in Alfisol *Journal Research ANGRAU*, **28(4)**: 34-39.

Girarden, P., Tollenaar, M. and Muldoon, J.F, 1985. Photosynthetic Rate and Chlorophyll Content. *Canadian Journal of Plant Science*, **65:** 491-500.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural research. 2nd. ed. John wily & Sons, New York.

Greenwood, D.J., D.A. Stones and A. Barnes, 2001. Root development of vegetable crops. *Plant Soil,* **68**: 75-96.

Gupta, R. P., Sharma, V. P., Singh, D. K., Srivastava, K. J., 1999. Effect of organic manuresand inorganic fertilizers on growth, yield and quality of onion variety Agrifound DarkRed. *News Lett Nation. Hortic. Res. and Dev. Found.,* **19(2/3)**: 7-11.

Hegde, D.M. 1986. Effect of irrigation and nitrogen fertilization on water relations, canopy temperature, yield nitrogen uptake and water use of onions. *Indian Journal of Agricultural Sciences,* **56**: 858-867.

Hermanson, R. E. 1996. Manure Sampling for Nutrient Analysis with Worksheets for Calculating Fertilizer Values. WSU Extension Bulletin No. 1819.

http://www.vanashree.in/fym.htm,last updated 05-Aug-2009

Hussien, J., 1996. Influence of nitrogen and maleic hydrazide on the keeping quality and subsequent establishment of shallot. M.Sc thesis. pp. 11-13.

Ipimoroti RR, Daniel MA, Obatolu CR 2002. Effect of organic mineral fertilizer on tea growth at Kusuku Mabila Plateau Nigeria. *Moor J. Agric. Res*., **3**: 180-183.

IPGRI, ECP/GR, AVRDC. 2001. Descriptors for Allium (*Allium* spp.). International Plant Genetic Resources Institute, Rome, Italy; European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR), Asian Vegetable Research and Development Center, Taiwan ISBN 92-9043-506-2

Jayathilake, P.K.S., I.P. Reddy, D. Srihari, G. Neeraja, and R. Ravinder. 2002. Effect of nutrient management on growth, yield and yield attributes of rabi onion (*Allium cepa* L.). *Vegetable Science*, **29**:184–185.

Jayathilake, P.K.S., I.P. Reddy, D. Srihari, and K.R. Reddy. 2006. Productivity and soil fertility status as enfluenced by integrated use of N-fixing biofertilizers, organic manures and inorganic fertilizers in onion. *The Journal of Agricultural Sciences*, **2 (1)** 46-58.

Javaria, Sadaf and Khan, M. Qasim, 2011. Impact of integrated nutrient management on tomato yield quality and soil environment, *Journal of Plant Nutrition*, **34**(**1**)**:**140-149.

Jilani MS, 2004. Studies on the management strategies for bulb & seed production of different cultivars of onion (*Allium cepa* L.). PhD thesis, Gomal University, Dera Ismail Khan.

Kale, R.D. B.C. Mallesh, K Bano, and D.J. Bagyaras, 1992. Influence of vermicompost application on the available micronutrients and selected microbial population. *Soi Biology and Biochemistry,* **24(12)**: 1317 – 1320.

Kang BT, Juo ASR 1980. Management of low activity clay soils in tropical Africa for food crops production pp129-133 In: Terry ER, KA Oduro and S Caveness (eds.) Tropical Roots crops. Research strategies for the 1980s.Ottawa, Ontario IDRC.

Kashi, A. and B.R. Frodi, 1998. Effect of nitrogen on the yield, quality and storability of edible onion cultivars (*Allium cepa* L.) *Iran Journal of Agricultural Science*, **29**: 589-597.

Kato, T., M. Yamagata and S. Tsukahra, 1987. Nitrogen nutrition, its diagnosis and post harvest bulb rot in onion plant. *Bulletin of the Shikoku National agricultural. Experiment station*, **48**:26-49.

Kebede, Woldetsasik, 2003. Shallot (*Allium cepa var. ascalonicum*) responses to plant nutrients and soil moisture in a sub-humid tropical climate. Doctoral thesis, Swedish University of Agricultural Sciences, Acta Universitas Agriculturae Sueciae, Agraria 367p.

Khan, H.I., I. Muhammad, G. Abdul and K. Waseem. 2002. Effect of various plant spacing and different nitrogen levels on the growth and yield of onion (*Allium cepa* L.). *Online Journal of Biological Sciences* **2(8)**: 545 – 547.

Khan, M.H., I Muhammad and T. H. Chattha. 2005. Effect of Irrigation Intervals on Growth and Yield of Onion Varieties Swat–1 and Phulkara. *Journal of Applied Sciences Research* **1(2)**: 112-116.

Kropisz, A., 1992, Influence of fertilization with compost on yield of vegetables and their content of mineral elements. *Ann. of Warsaw Agric. Univ.*, **16:** 9-13.

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

Kumar, H., J.V. Singn, K. Ajav, S. Mahak, A. Kumar and M. Singn. 1998. Studies on the influence of nitrogen on the growth and yield of onion cv. Parna red. *Indian J. Agric. Res*., **32**: 88-92.

Lemma Dessalegn and E. Herath. 1994. Agronomic studies on *Allium.* In: Herath, E and Lemma Dessalegne.Eds. Proceeding of the second National Horticultural workshop of Ethiopia. Pp, 139-141.

Lemma D. and Shimeles, A. 2003. Research experiences in onion production. Research report No. 55, EARO, Addis Abeba Ethiopia, p. 52.

Lemma D. 2004. Onion Production Pamphlet (Amharic version). EARO, Melkassa Research Center.

Lombin L.G and Abdullahi A. 1977. Long term fertility studies at Samaru, Nigeria. Effect of Farmyard manure on Monocropped cotton, sorghum and groundnuts and a rotation of the three crops under continues cultivation. *Samaru Misc* paper No. **72** IAR/ABU pp 14.

Maheshwarappa, H. P., Nanjappa and M. R. Hegde, 1997, Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as an intercrop in coconut garden. *Ann. Agric. Res.*, **20(3)**: 318-323.

Maier, N.A., A.P. Dahlenburg and T.K. Twigden. 1990. Effect of nitrogen on the yield and quality of irrigated onions (*Allium cepa* L.) cv. Cream Gold grown on siliceous sands. *Australian Journal of Experimental Agriculture*, **30(6):** 845 – 851.

Mallanagouda, B., Sulikeri, G. S., Murthy, G. B. and Prathiba, N. C., 1995, Effect of NPK, FYM and companion crop on growth, yield and yield components of chilli. *Adv.of Agric. Res. Ind.*, **3:** 58-69.

Marschner, H., 1995. Mineral Nutrition of Higher Plants, 2nd ed. Academic press. London. 196p.

Melaku Tegegn. 2008. Household solid waste generation rate and physical composition analysis, in Jimma town Ethiopia. A Thesis presented to the School of Graduate Studies of Addis Ababa University. Addis Ababa, Ethiopia.

MoARD. 2009. Crop Variety Register. Crop Development department, Issue No.9, June 2009, Addis Ababa, Ethiopia.

Mondal, S.S., A. Debabrata, G. Arup, and U. Thapa. 2004. Integrated management of organic and inorganic sources of nutrient to improve productivity and qualitative characters of rice and onion in rice-onion cropping sequence. *Environ. Ecol*. **22**:125–128.

Murata, Y. (1969). Physiological responses to nitrogen in plants. In physiological aspects of crop yield, eds J.D. Eastin, F.A. Haskins, C.Y. Sullivan and C.H.M. van Bavel, ASA and CSSA, Madison, Wisconsin, p. 235-259.

Naeem, M., Iqbal, J. and Bakhsh, M.A.A. (2006). Comparative study of inorganic fertilizers and organic manures on yield and yield components of mungbean (*Vigna radiate* L.) *Journal of Agriculture and Social Science*, **2**: 227-229.

Nasreen, S., M. M. Haque, M. A. Hossain and A. T. M. Farid. 2007. Nutrient Uptake and Yield of Onion as Influenced by Nitrogen and Sulfur Fertilization. *Bangladesh J. Agril. Res*. **32(3)**: 413-420.

Nyathi, P. and B.M. Campbell 1995. The effect of tree litter, manure, inorganic fertilizerandtheir combinations on above ground biomass production and grain yield of maize. *African Crop Sci. J*. **3**: 451-456.

Obi ME, Ebo PO 1995. The effect of different management practices n the soil physical properties and maize production in severely degraded soil in /Southern Nigeria. *Biol. Res. Technol*., **51**: 117-123.

Ojeniyi, S. O., 2000. Effect of goat manure on soil nutrients content and okra yield in arain forest area of Nigeria. *Applied Tropical Agric*. **5**: 20-23.

Ojeniyi, S.O., M.A. Awodun and S.A. Odedina, 2007. Effect of Animal Manure Amended Spent Grain and Cocoa Husk on Nutrient Status, Growth and Yield of Tomato. *Middle-East Journal of Scientific Research,* **2 (1)**: 33-36.

Olani Nikus and Fikre Mulugeta, 2010. Onion seed production techniques. A Manual for Extension Agents and Seed Producers. FAO-Crop Diversification and Marketing Development Project. Asella, Ethiopia. p. 8

Olufolaji A.O., 1990. Effect of different planting dates on the performance of amaranthlines. -National Horticultural Research Institute, Ibadan.

Patel, J.J. and A.T. Patel, 1990. Effect of nitrogen on growth and yield of onion (*Allium cepa* L.) cultivar, pusa red. *Gujrat Agriculture University Res. J*., India, **15**: 1–5

Pathak, C. S., 1993. *Allium* improvement for the tropics: Problems and AVRDC strategy.

Poudel, D.D., W.R. Horwath' W.T. Lanin, S.R. Temple and A.H. Van Bruggen, 2002. Comparoson of soil N availability and leaching potential, crop yield and weeds in organic, low input and conventional farming system in Northern California *Agric.Ecosyst.Environ*., **90**: 125-137.

Randall T. Hamasaki Hector R. Valenzuela Robin S. Shimabuku, 1999. Bulb Onion Production in Hawaii University of Hawaii at Manoa, Honolulu, Hawaii 96822.

Randle, W.M., 2000. Increasing nitrogen concentration in hydroponic solutions affects onion flavour and bulb quality. *Journal of the American Society for Horticultural Science*, **125**: 254-259.

Reddy KC, Reddy KM, 2005. Differential levels of vermicompost and nitrogen on growth and yield in onion (*Allium cepa* L.) – radish (*Raphanus sativus* L.) cropping system. *J.Res. ANGRAU*, **33(1)**: 11- 17.

Reddy, S.R., 2005. Principles of Agronomy.Kalyani Publisher, Ludhiana.

Reza, M. T., and K. Jafar. 2007. Influence of organic and chemical fertilizers on growth and yield of tomato (*Lycopersicon esculentum* L.) and soil chemical properties. Annual Report. Shahid Beheshti University. Tehran, Iran.

Riekels, J.W., 1979. Nitrogen water relationships on onions grown on organic soils, *Journal of the American Society for Horticultural Science*, **202**: 139.

Rowell, D.L.,1994. Soil science: Methods and applications. Addison Wesley Longman Singapore publishers. England, UK.350pp.

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

Salo, T. 1999. Effect of band placement and nitrogen rate on dry matter accumulation, yield and nitrogen uptake of cabbage, carrot and onion. *Agricultural and Food Science in Finland*, **8**: 157-232.

SAS Institute Inc. 2008. SAS/STAT®9.2 User's Guide. Cary, NC: SAS Institute. Inc Cary, USA.www.support.sas.com/documentation/cdl/PDF; (Accessed on October/10/2011).

Selvakumari, G., R. Santhi, R. Natesan, and K. Sathiyabama. 2001. Soil test and vegetable crop response under integrated plant nutrition system for optimization of fertilizer doses. *South Indian Hort.* **49**:130–136.

Shaheen A.M., Fatma A. Rizk, Faten S. Abdel-Aal, Hoda A. M. Habib, 2011. Production of safe and economic onion bulbs. *International journal of academic research*, **3(1)**: 527.

Shanmugasundaram.S and T. Kalb, 2001. Onion Cultivation and Seed Production. (AVRDC) Asian Vegetable Research and Development Center. Training guide suggested cultural practices for onion. p 3

Sharma R.P. Datt N and P.K. Sharma, 2003. Combined Application of Nitrogen, Phosphorus, Potassium and Farmyard Manure in Onion Under High Hills, Dry Temperate Conditions Of North-Western Himalayas. *Indian J. Agr. Sci*., **73:(4)**: 225-227.

Shimeles Aklilu. 2004. Onion production. In: training manual of Horticulture and spice crops. Joint publication of MARC, EARO and World vision Ethiopia 21 - 29 Jan 2004. Melkassa, Ethiopia.

Singh, J. and N.K. Chaure, 1999. Effect of age of seedling and nitrogen levels on growth and yield of onion (*Allium cepa* L.). *Adv. Hortic. For*., **6**: 73-77.

Sopher, C. D. and J. V. Baird, 1982. Soils and soil management.2nd edition.Prentice hall. *New Jersey*. 312p.

Sørensen J.N. 1996. Improved N efficiency in vegetable production by fertilizer placement and irrigation. *Acta Horticulturae,* **428**: 131-140.

Sorensen JN, Grevsen K. 2001. Sprouting in bulb onions (*Allium cepa* L.) as influenced by nitrogen and water stress. *J. Hort. Sci. Biotech*., **76**: 501-506.

Soujala, T., Salo, T, & Pessala, R. 1998. Effect of fertilization and irrigation practices onyield,maturity and storability of onions. *Agricultural and Food Science in Finland,* **7**: 477-489.

Stephen J. Herbert, 2005. Dept. of Plant and Soil Sciences University of Massachusetts Amherst Crops, Dairy, Livestock News. Adapted from various Northeast Publications

Steer , B.T. ,1980. The bulbing response to day length and temperature of some Australiacultivars of onion (*Allium cepa*L.). Aust. J. Agri. Res., **31**: 511-518.

Stewart, M. W., Dibb, W.D., Johnston, E.A. and Smyth, J.T. 2005. The contribution of commercial fertilizer nutrients to food production. *Agronomy Journal*, **97**: 1-6.

Suresh C. Bendegumbal., 2007, Studies on effect of organics on seed yield and quality in onion (*Allium cepa*L.) *M. Sc. (Agri.) Thesis*, Uni. Agri. Sci., Dharwad (India).

Suresh, K.D., Sneh, G., Krishn, K.K and Mool, C.M. 2004. Microbial biomass carbon and microbial activities of soils receiving chemical fertilizers and organic amendments .*Archives Agronomy Soil Science*, **50**: 641-647.

Suresh, V. V., 2000. Effect of nitrogen and potassium on yield and quality parameters of Byadagichilli (*Capsicum annuum* L.). *M. Sc. (Agri.) Thesis*, Uni. Agri. Sci., Dharwad (India).

Surlekov, P. and Pankov, V., 1989. The effect of fertilization on capsicum productivity and soilagro – chemical and biological properties in monoculture. *Pochvozanie Agrokhimiya*, **24**: 17– 23.

Tandon, H.L.S., 1987. Fertilizer recommendation for horticultural crops. A guide book, Fertilizer Development and Consultation Organization, New Delhi, pp. 10-14.

Vachhani MU, Patel ZG 1993. Growth and yield of onion (*Allium cepa*, L.) as influenced by levels of nitrogen, phosphorus and potash under South Gujarat conditions. *Progressive Hort.*, **25(3)**: 166-167.

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

Walkley, A. and I.A. Black, 1934. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil sci* **37**:29-38

Warade, S D., Desale, S B. and Shinde, K G., 1996. Effects of organic, inorganic and biofertilizers on yield of onion bulbs cv. B 780. *J. Maharashtra Agric. Univ.*, **20(3)**: 467 468.

Yadav RL, Sen NL, Yadav BL 2003. Response of onion to nitrogen and potassium fertilization under semi-arid condition. *Indian J. Hort*., **60(2)**: 176-178.

Yassen A.A. and Kh. A. Khalid, 2009. Influence of organic fertilizers on the yield, essential oiland mineral content of onion Department of Cultivation and Production of Medicinal and Aromatic Plants, National Research Centre, Dokki, Cairo, Egypt *Int.Agrophysics*, ***23**:183-188.*

Yoldas Funda, Safak Ceylan, Nilgun Mordogan and Bihter ColakEsetlili, 2011. Effect of organic and inorganic fertilizers on yield and mineral content of onion (*Allium cepa* L.) *African Journal of Biotechnology*, **10(55)**: 11488-11492.

7. APPENDICES

Appendix Table 1. Mean square values for plant height, leaf number per plant, leaf length and leaf diameter as affected by main and interaction effect of farmyard manure and nitrogen fertilizer application rates for onion

Source of variation	Degree of freedom	Mean squares			
		Plant height	Number of leaves	Leaf length	Leaf diameter
Replication	2	15.080	1.458	76.193	0.058
N	3	161.995***	38.390***	136.251***	0.086^{ns}
FYM	3	81.447***	17.261***	364.149***	0.101^{ns}
N*FYM	9	8.342*	1.851*	12.271^{ns}	0.036^{ns}
Error	30	3.659	0.828	8.681	0.063

N=nitrogen, FYM=farmyard manure, N*FYM=interaction between nitrogen and farmyard manure, ns = non significant*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.

Appendix Table 2. Mean square values for days to physiological maturity and harvest index of onion as affected by main and interaction effects of nitrogen and farmyard manure fertilization at Jimma, south west Ethiopia 2011/12.

Source of variation	Degree of freedom	Mean squares	
		Days to physiological maturity	Harvest index
Replication	2	0.083	0.002
N	3	154.854***	0.111***
FYM	3	50.020***	0.015***
N*FYM	9	3.613*	0.004**
Error	30	1.638	0.001

N=nitrogen, FYM=farmyard manure, N*FYM=interaction between nitrogen and farmyard manure, ns = non significant*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.

Appendix Table 3: Mean square values for bulb length, bulb diameter and average bulb weight of onion as affected by main and interaction effects of nitrogen and farmyard manure fertilization at Jimma, south west Ethiopia 2011/12.

Source of variation	Degree of freedom	Mean squares		
		Bulb length	Bulb diameter	Average bulb weight
Replication	2	0.285	1.628	208.127
N	3	0.970**	0.576***	1332.587***
FYM	3	0.225^{ns}	0.334**	409.672***
N*FYM	9	0.047^{ns}	0.079^{ns}	109.262*
Error	30	0.186	0.08	46.296

N=nitrogen, FYM=farmyard manure, N*FYM=interaction between nitrogen and farmyard manure, ns = non significant*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.

Appendix Table 4: Mean square values for total bulb yield, marketable and unmarketable bulb yield of onion as affected by main and interaction effects of nitrogen and farmyard manure fertilization

Source of variation	Degree of freedom	Mean squares		
		Total bulb yield	Marketable bulb yield	Unmarketable bulb yield
Replication	2	32.271	25.575	0.398
N	3	219.865***	229.057***	0.156^{ns}
FYM	3	190.502***	201.249***	0.239^{ns}
N*FYM	9	20.428*	25.449**	0.314^{ns}
Error	30	9.028	9.049	0.186

N=nitrogen, FYM=farmyard manure, N*FYM=interaction between nitrogen and farmyard manure, ns = non significant*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.

Appendix Table 5: Mean square values for dry matter content, total soluble solid and split bulbs % of onion as affected by main and interaction effects of nitrogen andfarmyard manure fertilization

Source of variation	Degree of freedom	Mean squares		
		Dry matter content	Total soluble solid	Split bulbs %
Replication	2	10.301	0.016	0.002
N	3	7.826**	8.596***	1.207***
FYM	3	14.456***	14.063***	0.248***
N*FYM	9	3.194*	7.235***	0.282***
Error	30	1.41	0.016	0.002

N=nitrogen, FYM=farmyard manure, N*FYM=interaction between nitrogen and farmyard manure, ns = non significant*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.

Appendix Table 6. Chemical properties of soil before planting and after harvest of the experimental site

Properties	Before planting	After harvest
pH (water 1:1)	6.7	6.97
Electrical conductivity (mS/cm)	0.28	0.16
Organic matter (%)	5.06	5.22
Organic carbon (%)	2.93	3.15
Total nitrogen (%)	0.25	0.29
Available phosphorus (ppm)	13.08	14.37
Available potassium (ppm)	2.61	3.8

Appendix Table 7. Simple correlation (r) among growth, yield and yield components of onion.

Parameter	PH	LNPP	LL	LD	MD	BD	BL	ABWT	TBY	MBY	UMY	DMC	HI	TSS	Split%
PH	1														
LNPP	0.70**	1													
LL	0.70**	0.64**	1												
LD	0.27ns	0.39**	0.39**	1											
MD	0.77**	0.76**	0.68**	0.30*	1										
BD	0.47**	0.51**	0.60**	0.39**	0.45**	1									
BL	0.40*	0.42*	0.45**	0.28*	0.56**	0.28*	1								
ABWT	0.63**	0.69**	0.69**	0.47**	0.72**	0.55**	0.50**	1							
TBY	0.62**	0.68**	0.76**	0.47**	0.72**	0.54**	0.53**	0.92**	1						
MBY	0.62**	0.68**	0.75**	0.49**	0.72**	0.53**	0.55**	0.91**	0.99**	1					
UMY	-0.20ns	-0.16ns	-0.16ns	-0.36*	-0.26ns	-0.06ns	-0.36**	-0.25ns	-0.30*	-0.37*	1				
DMC	0.38**	0.53**	0.51**	0.31*	0.49**	0.42**	0.22ns	0.53**	0.57**	0.58*	-0.30*	1			
HI	0.70**	0.80**	0.61**	0.54**	0.76**	0.57**	0.60**	0.78**	0.75**	0.75*	-0.32*	0.53**	1		
TSS	-0.09ns	0.02ns	-0.19ns	0.14ns	-0.07ns	0.14ns	0.10ns	0.22ns	0.12ns	0.13ns	-0.15ns	-0.08ns	0.18ns	1	
Split%	0.64**	0.56**	0.44**	0.27*	0.67**	0.28*	0.41**	0.57**	0.47**	0.48*	-0.25ns	0.39**	0.67**	0.09ns	1

PH = plant height, LNPP = leaf number per plant, LL = leaf length, LD = leaf diameter, MD = days to physiological maturity, BD= bulb diameter, BL= bulb length, ABWT= average bulb weight, TBY= total bulb yield, MBY= marketable bulb yield, UMY= unmarketable bulb yield, DMC= dry matter content, HI= harvest index, TSS=total soluble solid, Split%=split bulb %. Ns= non significant,*, **, and *** indicate significant difference at probability level of 5%, 1% and 0.1%, respectively.