EFFECT OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON GROWTH, YIELD AND QUALITY AND PRE-HARVEST SPRAYS OF GROWTH REGULATORS AND CHEMICALS ON STORAGE LIFE OF GARLIC (*Allium sativum* L.)

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JUNE, 2012

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IN

Plantation, Spices, Medicinal and Aromatic Crops

By
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C E R T I F I C A T E

This is to certify that the thesis entitled **"EFFECT OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON GROWTH, YIELD AND QUALITY AND PRE-HARVEST SPRAYS OF GROWTH REGULATORS AND CHEMICALS ON STORAGE LIFE OF GARLIC (*Allium sativum* L.)"** submitted by **KUMARA, B. R.** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **PLANTATION, SPICES, MEDICINAL AND AROMATIC CROPS** to the University of Horticultural Sciences, Bagalkot is a record of research work carried out by him during the period of his study in this University, under my guidance and supervision, and the thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

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JUNE, 2012 **(KUMARA, B. R.)**

Affectionately dedicated to

My Beloved Parents

and

Dr. Shankargouda Patil

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LIST OF ABBREVIATION

AAS	= Arabhavi *Allium sativum*
B : C	= Benefit cost ratio
DAS	= Days after sowing/ storage
DOGR	= Directorate of Onion and Garlic research
FYM	= Farmyard manure
GLBC	= Ghataprabha Left Bank Command area, Belgaum district, Karnataka
MD	= Man day
MT	= Million tonnes
NPK	= Nitrogen, phosphorus and potassium
NS	= Non significant
PLW	= Physiological loss in weight
RDF	= Recommended dose of fertilizer
RDN	= Recommended dose of nitrogen
VC	= Vermicompost
MH	= Maleic hydrazide
CCC	= Cycocel

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1. INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important and widely consumed bulbous spice crops belonging to the family Alliaceae. West Asia and Mediterranean region is considered to be the centre of origin of garlic. It is cultivated throughout India for its bulb which forms an integral part of Indian culinary. The bulb can be consumed as spice or condiment in the form of garlic paste, pickle, chutney, curried vegetables, curry powders and meat preparation, *etc.* Value added products of garlic are represented by garlic powder, flavours, flakes and volatiles. In *Unani* and *Ayurvedic* systems of medicine, garlic is used as carminative and gastric stimulant. It helps in digestion and absorption of food. Allicin present in the aqueous extract of garlic reduces the cholesterol concentration in human blood. It is used as vermifuge to expel worms and has long been recommended to cure number of ailments *viz.*, wounds, ulcer, pneumonia, bronchitis, dyspepsia and gastrointestinal disorders.

Garlic has higher nutritive value than other Alliums. It is rich in protein, phosphorus, calcium, magnesium, carbohydrates and vitamin C. Garlic bulb contains colourless and odourless water soluble amino acid called allin. On crushing the garlic, the enzyme allinase breaks down allin to produce allicin in which the principle ingredient is the odoriferous diallyl disulphide. Garlic contains 0.1 per cent volatile oil. The chief constituent of the oil are diallyl disulphide (60%), diallyl trisulphide (20%) and allyl propyl disulphide (6%).

Garlic possesses insecticidal, nematicidal, bactericidal and fungicidal properties. Garlic extracts and oil have potential uses as an effective insecticide and fungicide in the present scenario of organic farming.

The area under garlic was 13.71 lakh hectares in the world with an annual production of 222.82 lakh MT in 2011. China, India, Korea, Spain, Egypt and USA are the major garlic producing countries. China ranks first with an area of 7.79 lakh hectares and with a production of 179.68 lakh tonnes. India ranks second with an area of 2.05 lakh hectares and the production of 10.70 lakh tonnes. Garlic export from India in 2010-11 was 17,852 tonnes worth 3,877 lakhs (Anon., 2011). In India, Madhya Pradesh is the leading state in area (54,000 ha) and Gujarat is the leading state in production (275,000 MT), whereas maximum productivity is in Jammu and Kashmir (13.91 MT ha^{-1}). In Karnataka, garlic is cultivated in 42,000 hectares with a production of 30,200 MT and a productivity of 7.19 tonnes per hectare. The average productivity in India is low (5.22 t ha^{-1}) compared to other countries.

The low productivity in India is due to inherent low yield potential of garlic cultivars, susceptibility of cultivars to diseases and pests, non availability of genuine planting material, inadequate irrigation, nutrition and post harvest management.

Continuous use of inorganic fertilizers affects soil health and thus, resulting in lower yield and poor quality. The response of garlic in terms of quality and yield, to organic manures and biofertilizers with reduced level of chemical fertilizers (Shinde *et al.,* 2005) indicates the need to further study.

Use of organic manures in the form of farm yard manure (FYM) and vermicompost (VC) are known to impart multiple benefits to crop growth and soil health (Patil, 1995). The FYM by virtue of its essential nutrient content not only helps to enhance the yield of crops but also improves the physical, chemical and biological properties of soil. Application of organic matter alone or in combination with chemical fertilizers increased the yield in most of the crops (Jambhekar, 1996). Similarly, vermicompost facilitates growth and development of humus forming microbes and nitrogen fixers besides supplementing essential nutrients. Thus, a combination of both organic manures and inorganic fertilizers helps to maintain soil productivity on sustainable basis. Incorporation of organic and inorganic sources of nutrients holds great promise in garlic production.

Garlic is a seasonal crop and has comparatively low storability and bulbs are usually stored until the next planting season and significant losses in quality and quantity of garlic occur during storage. Storage of garlic bulbs has therefore become a serious problem in tropical countries like India.

The post-harvest losses like sprouting, rotting and physiological loss in weight pose great problems. It is reported that annual storage losses of more than 40 per cent occur in garlic. Garlic is mainly grown in *rabi* season in Karnataka and the bulbs need to be stored till the next *rabi* season. Hence, storage of garlic bulbs becomes inevitable.

Some growth regulators, fungicides and chemicals are known to reduce the storage losses in garlic. Among the growth regulators, fungicides and chemicals, maleic hydrazide, cycocel, carbendazim, dithane M-45 and borax are known to be important as pre-harvest foliar applications. They are known to reduce the storage losses either singly or in combination. However, improper application, such as at lower concentration and application at improper stage of plant maturity are not effective in reducing the storage losses.

It is widely accepted that growth retardants such as maleic hydrazide and cycocel when sprayed 2-3 weeks before harvest are known to extend the storage life of garlic and onion. Combining fungicides with growth regulators will be an advantage to reduce the fungal diseases in storage. Certain chemicals like borax are known to enhance the sto*rabi*lity of bulbous crops. Hence, the present investigations were carried out under irrigated conditions of Northern Dry Zone of Karnataka with the following objectives:

1. To study the effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic.

2. To study the effect of growth regulators and chemicals on storage life of garlic.

2. REVIEW OF LITERATURE

Organic manures *viz.*, farmyard manure, vermicompost, poultry manure, *etc.* alongwith chemical fertilizers are known to increase crop yields. They also improve physical, chemical and biological properties of the soil. Organic manures also supplement the secondary and micronutrients to crop plants. The interactive advantages of organic and inorganic sources of nutrients generally prove to be superior. The role of FYM in enhancing the yield and quality of crop plant is well documented, so organic manures make positive contribution to soil environment and human health. In North Eastern Dry Zone, it is reported that the application of nitrogen through inorganic source especially through urea is known to reduce the keeping quality of onion and results in low yield (Patil, 1995).

Pre-harvest factors play a significant role in controlling the post harvest deterioration of garlic to a great extent. Important among them is the pre-harvest application of growth regulators such as maleic hydrazide, cycocel and borax which are known to enhance the post harvest life of onion and garlic. Combining fungicides alongwith growth regulators will reduce the spore load of fungus entering into storage and help reducing the losses due to rotting.

The research findings pertaining to the effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic and onion and are the reviews pertaining to the effect of pre-harvest sprays of growth regulators and chemicals on garlic and onion presented in this chapter.

Garlic responds well to organic and inorganic nutrients. To reduce the inorganic nitrogen application, organic equivalent sources like FYM and vermicompost are substituted for inorganic nitrogen. But there are very few studies on organic substitutes for inorganic nitrogen in garlic. However, some of the related reviews on onion are also presented.

2.1 Effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic (*Allium sativum* L.)

2.1.1 Effects of applied nutrients on growth and growth attributes

Selvaraj *et al.* (1993) observed better vegetative growth of garlic supplied with FYM @ 25 t ha^{-1}. Patil (1995) reported maximum plant height of onion in vermicompost applied plots at 75 and 95 days after planting. He also reported significantly more number of leaves per plant with vermicompost @ 4 t ha^{-1} + 50 per cent RDF compared to control.

Seno *et al.* (1995) reported that the application of farmyard manure in garlic induced a quadratic increase in plant height assessed at 60 days after planting over control. Patil (1995) recorded maximum plant height, number of leaves per plant and neck thickness with the application of vermicompost @ 4 t ha^{-1} alongwith 50 per cent recommended dose of fertilizers in onion.

Suresh (1997) reported maximum plant height of garlic due to the application of RDF + vermicompost @ 2.5 t ha^{-1} at 30 DAS, and at harvest. However, these values were statistically *on par* with treatments that constituted 50 per cent RDF + vermicompost and 50 per cent RDF + farm yard manure. Lal *et al.* (2002) obtained more number of leaves and taller plants in onion with the application of farm yard manure @ 100 t ha^{-1}. Sharma *et al.* (2003) reported that 50 per cent NPK @ 72.5:16.5:25 kg ha^{-1} + farm yard manure @ 20 t ha^{-1}, gave more number of leaves and plant height.

Chattopadhyay *et al.* (2006) reported that the increase in plant height was more pronounced in plants receiving NPK @ 60:60:120 kg ha^{-1} in combination with either mustard cake, neem cake or FYM. Incorporation of neem cake @ 5 t ha^{-1} with NPK @ 60:60:120 kg ha^{-1} was found more effective on retention of green leaves per plant. Chadha *et al.* (2006) reported that application of 100 per cent of recommended NPK @ 120:75:60 kg ha^{-1} + FYM @ 10 t ha^{-1} + mulch @ 8 t ha^{-1} gave higher plant height followed by 100 per cent NPK + FYM. Gowda *et al.* (2007) reported significantly superior plant height, more number of leaves and maximum girth of plant in garlic cv. G-282 with 100 per cent NPK + biofertilizer + vermicompost.

Patil *et al.* (2007) studied the response of garlic cv. Yamuna safed-3 to organic and inorganic fertilizers. The growth parameters like plant height and more number of leaves per plant were recorded in the treatment involving the application of 25 per cent RDF + 75 per cent N through FYM.

Ranjan *et al.* (2010) evaluated the effect of biofertilizers in combination with reduced dose of fertilizers on growth of garlic and observed maximum plant height in plants receiving *Azospirillum sp.* + ½ N and P + full K. Subrata *et al.* (2010) studied the effect of applied nutrients and planting time on growth and growth parameters of garlic which were significantly increased by the application of NPK @ 60:60:120 kg ha^{-1} in combination with FYM @ 30 t ha^{-1} or neem cake or mustard cake @ 5 t ha^{-1}. Verma *et al.* (2011) studied the effect of integrated nutrient management on yield of garlic var. Yamuna safed-4 and recorded the maximum plant height, number of leaves per plant and neck thickness in FYM @ 20 t ha^{-1} + NPK @ 100:50:50 kg ha^{-1} + sulphur @ 50 kg ha^{-1} + $ZnSO_4$ sulphate @ 20 kg ha^{-1}.

Mohd *et al.* (2011) reported that application of 25 per cent RDF + 75 per cent RDF through FYM increased growth parameters like number of leaves per plant and plant height. However, maturity was advanced with the application of 50 per cent RDF + 50 per cent RDF through FYM in garlic cv. GG-1. Pratap *et al.* (2011) reported significantly superior plant height, number of leaves per plant, length and width of leaves, fresh and dry weight of plant and leaf area index in garlic with the treatment, 75 per cent RDF +FYM @ 5 t ha^{-1} + *Azotobacter* + PSB over rest of the treatments.

Mankar *et al.* (2011) studied the effect of combined use of organic and inorganic fertilizers on growth and growth attributes of garlic cv. Yamuna Safed-3. The maximum plant height, number of leaves, least bolting percentage and minimum neck thickness were recorded in 25 per cent RDF + 75 per cent N through FYM. While, earliness in maturity of garlic was observed with 50 per cent RDF + 50 per cent N through FYM compared to all other treatments.

Puttaraju *et al.* (2011a) studied the effect of integrated nutrient management on growth factors in garlic cv. Rajalle Gaddi and observed that NPK @ 100:50:50 kg ha^{-1} + *Azospirillum* +PSB + *Trichoderma viridae* + vermicompost showing the highest plant height, plant girth and number of leaves. Puttaraju *et al.* (2011b) studied the effect of integrated nutrient management on growth of garlic cv. G-282 and observed that application of NPK @ 150:50:50 kg ha^{-1} + *Azospirillum* +PSB + *Trichoderma viridae* + vermicompost recording better plant height, plant girth and number of leaves.

Rohidas *et al.* (2011) studied the response of different proportions of organic manures like poultry manure, vermicompost and FYM in combination with different proportions of RDF on growth parameters of onion cv. N-53. The maximum plant height was recorded in treatment 75 per cent RDF + 25 per cent poultry manure, while, the maximum number of leaves per plant and lowest bolting percentage and earliness in maturity of bulbs was observed in 50 per cent RDF + 50 per cent poultry manure.

Chattoo *et al.* (2011) studied the response of onion cv. Yellow globe to different organic manures and observed that application of poultry manure and vermicompost recording higher plant height and more number of leaves per plant.

2.1.2 Effect of applied nutrients on yield and yield attributes

Kultunov (1984) stated that NPK fertilizers supplemented with organic manures like FYM @ 40 t ha^{-1} resulted in higher yield of garlic bulbs which were suitable for long term storage. Sharma and Raina (1993) obtained higher yield of onion bulb with the application of FYM @ 10 t ha^{-1} over control in silty clay loam soil of Western Himalayas.

Selvaraj *et al.* (1993) observed better yield of garlic supplied with 25 tonnes of FYM. Kumar (1994) reported that increase in yield of garlic was due to direct and indirect effect of FYM. The higher yield was obtained when the crop was supplied with normal dose of chemical fertilizers and FYM @ 15 t ha^{-1}. Warade *et al.* (1994) reported maximum bulb yield with treatment receiving FYM 40 t ha^{-1} + NPK @ 100:50:50 kg ha^{-1} which was *on par* with treatment receiving FYM @ 40 t ha^{-1} + NPK @ 75:50:50 kg ha^{-1} + *Azospirillum*, thereby 25 per cent saving in nitrogen. Warade *et al.* (1995) reported an increase in onion yield by the application of FYM @ 40 t ha^{-1} along with chemical fertilizers. Patil (1995) recorded maximum average bulb weight and bulb yield of onion when vermicompost was applied @ 5 t ha^{-1}.

Jambhekar (1996) recorded the maximum bulb diameter and bulb size index due to application of vermicompost in Agrifound Light Red onion variety. Mallanagouda *et al.* (1995) reported higher yield of garlic bulb when it was applied with FYM alongwith 100 per cent recommended dose of NPK @ 125:65.5:65.5 kg ha^{-1}. Dixit (1996) reported that application of 120 kg N and FYM @ 20 t ha^{-1} to onion crop in silty loam soil in Himachal Pradesh recorded significantly higher bulb yield over control.

Singh *et al.* (2001) found that application of FYM @ 10 t ha^{-1} to sandy loam soils of Rajasthan significantly increased the bulb yield of onion. The per cent increase over the control was 14.2 and the per cent increase over FYM @ 5 t ha^{-1} was 5.2.

Rosen and Tong (2001) observed higher proportion of big sized garlic bulbs with the application of compost manure. Yadav and Yadav (2001) obtained highest bulb yield of onion with the application of recommended dose of NPK @ 100:80:80 kg ha^{-1} alongwith FYM @ 30 t ha^{-1} at Agriculture Research Station, Jaipur. Lal *et al.* (2002) recorded significantly higher bulb size and bulb yield of onion with the application of FYM @ 100 t ha^{-1}. Sharma *et al.* (2003) recorded the highest bulb yield of onion due to application of 100 per cent NPK alongwith FYM @ 20 t ha^{-1} on sandy loam soils of Himachal Pradesh.

Patil *et al.* (2005) reported that application of 50 per cent RDF + vermicompost @ 2.5 t ha^{-1} resulted in maximum bulb weight, diameter, number of cloves per bulb and bulb yield of onion. Chadha *et al.* (2006) reported that application of 100 per cent NPK + FYM @ 10 t ha^{-1} + mulch @ 8 t ha^{-1} resulted in higher yield of onion bulbs followed by 100 per cent NPK + FYM @ 10 t ha^{-1}. Chattopadhyay *et al.* (2006) reported higher garlic bulb yield, bulb length, bulb diameter, which was *on par* with NPK @ 60:60:120 kg ha^{-1} + FYM @ 30 t ha^{-1} by the application of NPK @ 60: 60: 120 kg ha^{-1} + neem cake @ 5 t ha^{-1}.

Mamatha *et al.* (2006) studied the influence of organic and inorganic sources of nitrogen on yield and quality of onion. Application of organic manures, either FYM or vermicompost in different proportions to supplement the recommended dose of nitrogen influenced the bulb yield of onion. Among the combinations of organic and inorganic manures, treatments with 75 per cent and 100 per cent RDN through FYM and vermicompost recorded higher bulb yield.

Gowda *et al.* (2007) studied the effect of integrated nutrient management on yield of garlic cv. G-282 and maximum bulb yield was recorded in treatment combination of 100 per cent NPK + biofertilizer + vermicompost.

Chattoo *et al.* (2007) studied the response of biofertilizers and inorganic fertilizers on garlic and observed that application of *Azotobacter* + Phosphobacteria alongwith 75 kg N + 45 kg P_20_5 ha^{-1} resulted highest bulb yield per hectare. Patil *et al.* (2007) studied the response of garlic cv. Yamuna Safed to organic and inorganic fertilizer. Application of 25 per cent RDF + 75 per cent N through FYM recorded higher mean fresh bulb weight, mean cured weight of bulb, length of clove, diameter of clove, weight of clove per bulb and bulb yield compared to all the other treatments.

Subrata *et al.* (2010) reported maximum bulb yield in garlic with the application of NPK @ 60:60:120 kg ha^{-1} in combination with mustard cake @ 5 t ha^{-1} with early planting. Ranjan *et al.* (2010) observed that application of *Azospirillum sp.* + *Microphos sp.* + ½ NP and full K was found to be superior for better yield and yield attributing characters of garlic.

Mohd *et al.* (2011) recorded the maximum bulb yield of garlic cv. GG-1 with application of 25 per cent RDF + 75 per cent through FYM compared to other treatments. Verma *et al.* (2011) studied the effect of integrated nutrient management on yield of garlic var. Yamuna safed-4 and higher marketable bulb yield and bulb diameter were recorded in FYM @ 20 t ha^{-1} + NPK @ 100:50:50 kg ha^{-1} + sulphur @ 50 kg ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1}.

Dhankhar *et al.* (2011) studied the effect of integrated nutrient management on bulb yield of onion cv. Hisar -2 and observed that application of NPKS @ 110:40:60:40 kg ha^{-1} + FYM @ 7.5 t ha^{-1} or NPKS @ 110:40:60:40 kg ha^{-1} + poultry manure @ 7.5 t ha^{-1} was found to increase marketable bulb yield. Pratap *et al.* (2011) studied the effect of organic, inorganic and biofertilizers on productivity of garlic cv. G-323 and observed that application of 75 per cent RDF + FYM @ 5 t ha^{-1} + *Azotobacter* + PSB resulted in highest weight of bulbs, weight of cloves, number of cloves per bulb and bulb yield.

Mankar *et al.* (2011) reported significantly higher polar diameter and equatorial diameter and yield parameters like mean fresh and cured weight of bulb, number of clove per bulb, bulb length, weight of clove, yield per plot and yield per hectare in combined application of 25 per cent RDF + 75 per cent N through FYM.

Puttaraju *et al.* (2011a) studied the effect of integrated nutrients on yield and yield attributes of garlic cv. Rajalle Gaddi and observed that applications of NPK @ 100:50:50 kg ha^{-1} + *Azospirillum* +PSB + *Trichoderma viridae* + vermicompost was found to enhance number of cloves per bulb and bulb yield.

Puttaraju *et al.* (2011b) evaluated the effects of integrated nutrient management on yield and yield attributes of garlic cv. G-282 and observed that application of NPK @ 150:50:50 kg ha^{-1} + *Azospirillum* + PSB + *Trichoderma viridae* + vermicompost was found to enhance number of cloves per bulb and bulb yield.

Patel *et al.* (2011) studied the efficiency of source of organic manure v/s chemical fertilizers on yield of onion cv. White local and observed that combined application of FYM @ 32.5 t ha^{-1} + NPK @ 37.5:18.75:18.75 kg ha^{-1} gave the highest bulb weight and bulb diameter. Chattoo *et al.* (2011) recorded higher bulb weight and bulb yield in onion cv. Yellow globe in response to application of poultry manure and vermicompost.

Rohidas *et al.* (2011) studied the response of different proportions of organic manures like poultry manure, vermicompost and FYM in combination with different proportions of RDF on yield parameters of onion cv. N-53. The maximum fresh weight of bulb and cured weight of bulb were obtained in treatment 50 per cent RDF + 50 per cent poultry manure. Pugalendhi *et al.* (2011) studied the effect of NPKS with different organic manure *viz.*, FYM, vermicompost and poultry manure in different quantities and compared with local fertilizer recommendation and Directorate of Onion and Garlic research recommendations in onion cv. Arka Niketan and the result revealed that application of NPKS @ 150:50:80:50 kg ha^{-1} + FYM @ 20 t ha^{-1} recorded the highest total and marketable yield.

2.1.3 Effect of applied nutrients on quality parameters.

Mamatha *et al.* (2006) studied the effect of soil application of organic and inorganic sources of nitrogen on sulphur content of onion bulbs. The results revealed that the sulphur content increased with increased dose of FYM and vermicompost. Significantly highest sulphur content was recorded in 100 per cent RDN applied as FYM and was *on par* with 100 per cent RDN applied as vermicompost.

Naruka and Rathore (2005) reported maximum volatile oil content in garlic cv. Jajavar Local with the application of 150 kg nitrogen per hectare followed by 100 kg and 50 kg per hectare.

Shinde *et al.* (2005) studied the effect of combined application of organic manures and RDF on storability of garlic and reported that the loss in weight of bulbs was reduced with the application of 50 per cent RDF + poultry manure @ 10 t ha^{-1}. Qureshi and Lawande (2006) reported that sulphur content in garlic bulbs was increased by 48 per cent due to the application of 75 kg sulphur per hectare.

2.1.4 Uptake of nutrients

Khalaf and Taha (1988) while studying the response of garlic plant to organic manures reported the beneficial effects of it on plant growth, yield, and quality as well as on NPK content in the plant tissues and total NPK uptake by the crop. Duque *et al.* (1989) noted higher demand of onion crop for N and K during the early growth stages of onion and that of P throughout the crop period. Uptake levels were 38.80, 38.60 and 71.30 kg of N, P and K, respectively, for a yield of 2.5 t ha^{-1}.

Sharma and Raina (1993) reported maximum P uptake by onion crop when it was supplemented with 120 kg P ha^{-1} alongwith FYM @ 14.58 t ha^{-1}. Mallanagouda *et al.* (1995) reported maximum NPK uptake by onion crop when it was treated with 155, 50 and 125 kg of N, P and K ha^{-1} respectively, alongwith FYM @ 50 t ha^{-1}, and also reported higher dry matter accumulation in garlic and onion when it was applied with FYM alongwith 100 per cent recommended dose of NPK @ 125:65.5:65.5 kg ha^{-1}.

Patil (1995) reported the superiority of application of vermicompost alongwith chemical fertilizers with respect to NPK uptake and recorded the uptake values of 164.38, 16.52 and 84.56 kg of N, P and K ha^{-1} respectively, in onion**.** Shashidhar *et al.* (2005) studied the effect of different organic manures on nutrient uptake and yield of garlic cv. BLG-1. Results revealed that sunhemp application @ 20 t ha^{-1} resulted in highest NPK uptake and was *on par* with vermicompost @ 5 t ha^{-1} and poultry manure @ 2.5 t ha^{-1}.

Mamatha *et al.* (2006) reported enhancement in available nutrient status of soil due to supplementation of N through FYM and vermicompost and the treatment also resulted in higher available nutrient status after the harvest of onion crop. Gasti *et al.* (2011a) reported maximum NPK uptake by garlic crop when it was applied with vermicompost @ 4 t ha^{-1} + 50 per cent RDF.

2. 1.5 Effect of applied nutrients on soil properties

Khani and More (1984) reported a decrease in the bulk density with increase in organic matter content due to better aggregation with the application of FYM. It had favourable effect on the soil structural properties. Continuous addition of organic manure brings about favourable changes in the total porosity of soils, which in turn influences other physical properties.

Muthuvel *et al.* (1990) opined that the higher available N content of soil with application of FYM could be due to favourable microbial activity and enhanced biomass addition to the soil, probably as a result of improved soil physical properties.

Sharma and Raina (1993) reported that incorporation of FYM alongwith P had a spectacular influence on the maximization of P use efficiency in onion. Patil (1995) observed that application of 50 per cent RDF + 50 per cent vermicompost to onion increased the available nutrient status of soil. Singh and Singh (1995) recorded that application of FYM alongwith 40 kg N and 60 kg P ha^{-1} to onion crop increased the available nitrogen and phosphorus status of the soil. Reddy and Mahesh (1995) reported an increased availability of nitrogen in soil by the application of vermicompost compared to FYM. Vasanthi and Kumaraswamy (1996) observed higher concentration of micronutrients in vermicompost treatments alongwith NPK fertilizer compared to NPK alone.

FYM application at graded levels increased the available P content of soil. The increase in available P was 30.1 and 66.6 per cent with 10 t ha^{-1} and 20 t ha^{-1} of FYM respectively, over no FYM application. The increase in available P may be due to chelating effect of organic manure and organic matter lowered the fixation of Al-P and Fe-P in soil (Saravanapadian, 1998).

Experiment conducted at Kasargod, Kerala revealed that FYM and Vermicompost application decreased the bulk density, increased the soil porosity and water holding capacity to a greater extent (Maheswarappa *et al.*, 1999). Singh *et al.* (2001) opined that FYM has beneficial effect on soil fertility and biophysical properties of the soil which ultimately resulted in higher yield of onion. Mamatha *et al.* (2006) reported significant improvement in physic-chemical properties of soil after the harvest of onion crop due to application of 75 and 100 per cent RDN through either FYM or vermicompost and organics helps to decrease the bulk density and increase the organic carbon content and maximum water holding capacity of the soil.

2.1.6 Economics of cultivation

Bose *et al.* (2008) studied the economics of organic manure as well as inorganic fertilizers in onion cultivation. Maximum net returns were recorded in inorganic fertilizers followed by vermicompost. Pratap *et al.* (2011) observed maximum net returns with 75 per cent RDF + FYM 5 t ha^{-1} + *Azotobacter* + PSB and minimum net returns were recorded with 10 tons FYM + *Azotobacter* + PSB.

Puttaraju *et al.* (2011a) calculated the benefit cost ratio due to application of integrated nutrients in garlic cv. Rajalle Gaddi and obtained the highest benefit cost ratio in 75 per cent N and P + 100 per cent K of 150:50:50 kg ha^{-1} + *Azospirillum* +PSB + *Trichoderma viridae* + Vermicompost. Puttaraju *et al.* (2011b) worked out the benefit cost ratio as influenced by the integrated nutrient management in garlic cv. G-282 and obtained that highest benefit cost ratio in 75 per cent N and P + 100 per cent K of 150:50:50 kg ha^{-1} + *Azospirillum* +PSB + *Trichoderma viridae* + Vermicompost. Verma *et al.* (2011) worked out the benefit cost ratio as influenced by the integrated nutrient management in garlic var. Yamuna safed-4 and recorded the highest benefit cost ratio in FYM @ 20 t ha^{-1} + NPK @ 100:50:50 kg ha^{-1} + sulphur @ 50 kg ha^{-1} + ZnSO4 @ 20 kg ha^{-1}.

2.2 Effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.)

2.2.1 Pre-harvest sprays of growth regulators and chemicals on growth and yield of garlic and onion

Barman *et al.* (1996) recorded the highest yield (0.83 kg/ m^2) with maleic hydrazide (500 ppm) + TIBA (50 ppm) as a pre soaking treatments in garlic compared to other growth regulators. Singh *et al.* (2008) evaluated the effect of growth regulators on growth and yield of garlic and reported that the application of cycocel @ 600 ppm with 60 ppm NAA and 60 ppm ethrel resulted maximum plant height, stem diameter, number of leaves per plant, length and width of leaves, bulb size and bulb yield.

Memane *et al.* (2008) studied the effect of clove weight and plant growth regulators on growth and yield of garlic cv. GG-3. Cloves dipped in cycocel @ 1000 ppm and NAA @ 50 ppm recorded the maximum plant height. Dipping cloves in 1000 ppm of cycocel recorded maximum number of leaves per plant, weight of bulbs, weight of cloves, diameter of bulb, number of cloves per bulb, yield and TSS content compared to control.

Gasti *et al.* (2011b) observed that spraying of garlic with different concentrations of cycocel at full vegetative growth *i.e.* 60 DAS, resulted in highest bulb yield was recorded with mapiquat chloride at 175 ppm. Gasti *et al.* (2011c) studied the effect of pre-harvest sprays of growth retardants on yield of onion. The results revealed that treatment with different concentrations of cycocel and mapiquat chloride sprayed at full vegetative growth *i.e.* 45 DAS. Mapiquat chloride @ 175 ppm gave a maximum bulb yield per hectare over control.

Sankar and Lawande (2011) studied the effect of pre-harvest sprays of growth retardants on growth and yield of garlic var. G-41 and the results revealed that treatment with Cycocel @ 6 ml/l applied as foliar spray at different growth stages though increased yield over control, it was non significant and there was no additional benefit of foliar application of cycocel.

Anbukkarasi *et al.* (2011) studied the effect of pre-harvest foliar sprays of growth regulator and fungicides on growth and yield of onion. The results revealed that treatment with Cycocel @ 200 ppm + Carbendazim @ 1000 ppm sprayed 30 days before harvest recorded more number of leaves per plant, weight of bulb and bulb yield.

2.2.2 Pre-harvest sprays of growth regulators and chemicals on storage life of garlic and onion.

Maleic hydrazide has been used commercially for over 40 years to control sprouting of onion during storage. Its use has extended the marketing seasons from two to eight months and significantly altered the marketing practices and capital investments of onion storage industry. At present, there is no alternative chemical to maleic hydrazide (Isenberg and Ferguson, 1981).

Sinclair (1985) reported that spraying of Maleic hydrazide (Royal MH-30 @ 180 g/l of potassium salt formulation) three weeks before harvest and cold stored up to 9 months resulted in reduced incidence of clove rotting (5% compared to 33% in control) and no sprouting of cloves (compared to 52% in unsprayed control).

Masters *et al.* (1985) studied the effect of maleic hydrazide on cellular structure of the shoot apex of onion. The results revealed that treatment of maleic hydrazide @ 2.2 kg ha^{-1} applied at the top at 50 per cent neck fall reduced the sprouting in storage. Sidhu and Chadha (1986) observed that maleic hydrazide sprays @ 2000 and 4000 ppm in onion cv. N-53 was superior to cycocel 1000 and 2000 ppm in reducing the loss due to sprouting after two months storage.

Pre-harvest foliar sprays of MH @ 6000 ppm had beneficially reduced the post-harvest storage losses with minimum sprout percentage, sprout length, rotting and physiological loss in weight of onion (Abdul, 1988). A red skinned onion was sprayed with maleic hydrazide @ 1000, 1500 and 2000 ppm, two weeks before harvest and was stored for four months at ambient temperature (25-45°C and 50-75% relative humidity). Maleic hydrazide was partially effective in delaying sprouting, rooting and moisture loss (Nawaz *et al.*, 1988). The treatment combination of maleic hydrazide @ 2500 ppm +

difolation @ 0.2 per cent was found to be more effective in reducing storage losses in vegetables (Gopalkrishnarao, 1998). Maleic hydrazide @ 2500 ppm sprayed two weeks before harvest of onion cv. MDU-1 completely inhibited sprouting in storage (Shanti and Balakrishnan, 1989).

Kulval *et al.* (1989) observed that the pre-harvest sprays of maleic hydrazide @ 2000 ppm was found to be effective in onion controlling losses due to sprouting under Akola conditions of Maharashtra. Vijayakumar *et al.* (1989) observed that pre-harvest treatment of maleic hydrazide (MH-40) @ 2000 to 3000 ppm 15 days prior to harvest reduced the storage losses in small onion.

Ray *et al.* (1991) found that pre-harvest sprays with maleic hydrazide @ 3000 mg per liter and ethrel @ 2.5 ml per liter resulted in the lowest percentage of onion bulbs rotting after four months (0.9 and 3.0%) and eight months of storage (2.0% and 5.5%) compared to control (17.0 and 21.3%), respectively. Application of maleic hydrazide 10 to 20 days before harvest was the most effective treatment to prevent sprouting in stored onion bulbs (Mondal and Pramanik, 1992). Pandey *et al.* (1994) observed that foliar spray of maleic hydrazide at 3000 and 3500 ppm 21 days before harvest proved to be beneficial in reducing storage losses of onion bulbs.

Sinha *et al.* (1994) reported that pre-harvest spray of carbendazim at 100, 200 and 400 g per hectare was effective in control of *Aspergillus niger* in onion and did not find residues in the tissues, whereas, the compound moved deep into the tissues when used as post-harvest treatment and residue decreased with passage of storage time.

Combination of maleic hydrazide @ 3000 ppm + Tecto 1200 ppm and maleic hydrazide alone at 3000 ppm proved to be most effective in reduction of sprouting of bulbs and total loss in weight caused by rotting, sprouting and drying, only foliar sprays two and three weeks before harvest were effective in prolonging the storage life of onion bulbs (Singh and Dhankhar, 1995).

Ray *et al.* (1996) reported that Maleic hydrazide was most effective treatment in reducing loss in weight, rotting and sprouting when onion bulbs were stored in wooden baskets at ambient temperature for eight months. Bhalekar *et al.* (1997) revealed that the application of 4000 ppm maleic hydrazide 21 days before harvest significantly reduced the total losses of onion both on number and weight basis by 3.4 and 6.8 per cent, respectively. Singh *et al.* (1998) observed that pre-harvest spray of maleic hydrazide @ 4000 ppm 15 days prior to harvest proved to be most effective in controlling sprouting, rotting and total loss in weight in onion after 160 days of storage compared to untreated bulbs.

Mukeshkumar *et al.* (2000) reported that foliar sprays of 3000 ppm maleic hydrazide 15 days before harvest with 4 days of curing was found to be most effective in controlling the sprouting, rotting and physiological loss in weight of *kharif* onion during storage.

Pre-harvest sprays of maleic hydrazide @ 2000 ppm three weeks before harvest recorded minimum losses caused by sprouting, rotting and physiological loss in weight of bulbs after six months of storage of onion (Shukla and Namadeo, 2000).

Minimum storage loss of bulbs was recorded in Baswant-780 and Agrifound Dark Red var. of onion when they were sprayed with pre-harvest sprays of maleic hydrazide (MH-40) at 2000 ppm + aureofungin @ 150 ppm 15 days before harvest (Waskar *et al.*, 2000).

Pre-harvest sprays of borax and copper oxychloride (250 g /100 litre of water) induced an increase in skin thickness, decreased weight loss and enhanced colour in onion bulbs. Dark red skin cultivars had a better response to pre-harvest treatments in relation to light skin cultivars and firmness was not affected by pre-harvest treatments (Ferreira and Minami, 2000).

The lowest loss due to decay, physiological loss in weight and total loss was obtained with carbendazim at 0.1 per cent applied as pre-harvest spray at 100 and 110 days after sowing of onion cv. Agrifound Dark Red (Singh and Sharma, 2002). Maleic hydrazide sprays @ 2000 ppm sprayed 15 days prior to harvest was found to be comparatively more effective than aureofungin @ 150 ppm and streptocyclin @ 150 ppm for reducing sprouting and rotting losses during storage of onion varieties, *viz.*, Baswant-780 and Agrifound Dark Red (Waskar *et al.*, 2004).

Kukanoor *et al.* (2007) recorded minimum storage losses in onion var. N-53 due to spraying of Carbendazim 1000 ppm + Maleic hydrazide 2500 ppm two weeks prior to harvest. Akhilesh *et al.* (2010) reported that spraying of borax at 1000 ppm two weeks before harvest reduced the physiological loss in weight, sprouting and rotting of onion bulbs in storage.

3. MATERIAL AND METHODS

Field experiments were conducted during *rabi*, 2010 and 2011 at the research farm of Kittur Rani Channamma College of Horticulture, Arabhavi to study the effect of organic and inorganic sources of nitrogen on growth, yield and quality and pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.) under irrigated conditions. The details of materials used and methods adopted during the investigations are described in this chapter.

3.1 Geographical location and climatic condition of the experimental site

Arabhavi is situated in northern dry tract of Karnataka (Zone-3 of Region-2) at 16°15' N latitude and 94°45' E longitude and at an altitude of 612 m above mean sea level.

3.1.1 Climate

Arabhavi which comes under Zone-3, Region-2 of agro-climatic zone of Karnataka is benefitted by both South-West and North-East monsoons. The mean rainfall of the Zone is 530 mm distributed over a period of six to seven months (May to November). The command area receives water from Ghataprabha Left Bank Canal from mid-October to mid-March. During the experimental period, the meteorological data recorded at meteorological observatory of the Agricultural Research Station, Arabhavi is presented in Appendix I.

3.2 Experimental details

The following two experiments were conducted separately to fulfil the objectives of the investigation.

3.2.1 Experiment-I: Effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic (*Allium sativum* L.)

Design : Randomized Block Design (RBD)

Treatments : Nine

Replications : Three

Plot size Gross : 3.0 m x 1.5 m = 4.5 m^2
Net : 2.85 m x 1.43 m = 4.08 m^2

Spacing : 15 cm x 7.5 cm

Cultivar : AAS-2 (Vannur Local)

Seed rate : 500 kg ha^{-1}

Season : *Rabi*, 2010-11

Treatment details

T_1- 25% RDN through FYM + 75% RDN through urea

T_2 - 50% RDN through FYM + 50% RDN through urea

T_3 - 75% RDN through FYM + 25% RDN through urea

T_4- 100% RDN through Farm yard manure (FYM)

T_5- 25% RDN through VC + 75% RDN through urea

T_6 - 50% RDN through VC + 50% RDN through urea

T_7- 75% RDN through VC + 25% RDN through urea

T_8- 100% RDN through vermicompost (VC)

T_9- 100% RDF (control)

Note**:** RDF: 125:62.5:62.5 NPK kg ha^{-1} and FYM 25 t ha^{-1}

Nitrogen was applied as per treatments. The recommended dose of PK was applied in form of single superphosphate and muriate of potash, respectively and FYM @ 25 t ha^{-1} was applied common to all treatments and analytical data of FYM and VC presented in Appendix II.

3.2.2 Cultural operations

The details regarding the various cultural operations carried out during the course of investigations are furnished hereunder.

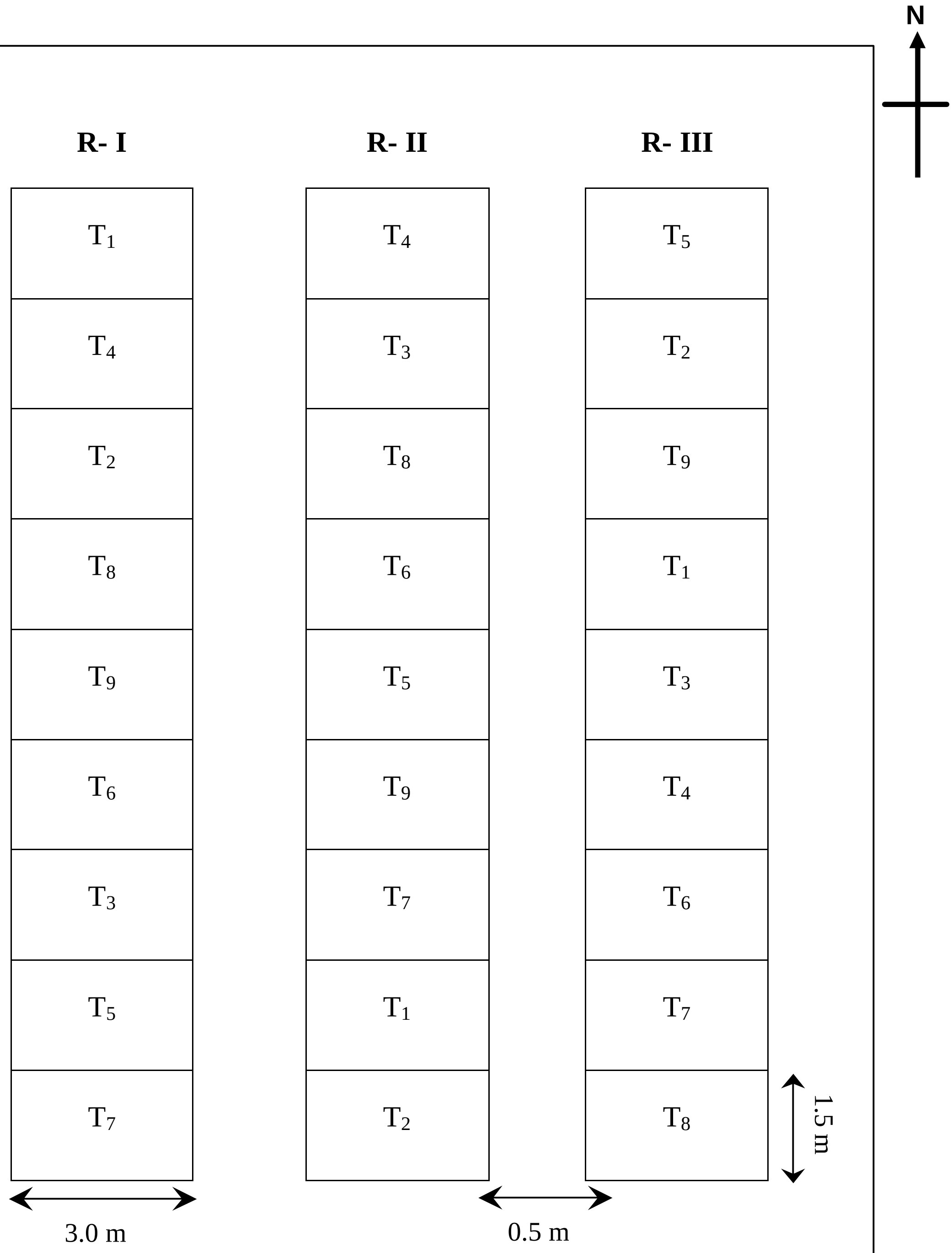


Fig 1: Plan of layout of Experiment - I

3.2.2.1 Land preparation

The land was brought to a fine tilth by repeated ploughing and harrowing. Individual plots were prepared as per the specifications. A spacing of 0.5 m between replication was provided for laying out of irrigation channels and bunds.

3.2.2.2 Manures and fertilizers application

Farm yard manure was applied at the rate of 25 tonnes per hectare at the time of land preparation. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively at the rate of 125:62.5:62.5 kg NPK per hectare as per the recommendation of university of agricultural sciences, Dharwad (Anon., 2009). At the time of sowing, half the dose of nitrogen and full dose of phosphorus and potassium were applied as basal dose and mixed thoroughly in the soil. The remaining half dose of nitrogen was top dressed 30 days after sowing.

3.2.2.3 Sowing

Healthy and bold garlic cloves of cultivar AAS-2 (Vannur Local) separated from the bulbs were dibbled at 7.5 cm apart in furrows opened at 15 cm apart.

3.2.2.4 Irrigation / water management and weeding

Immediately after dibbling light irrigation was given and further irrigations were given at an interval of 10 to 15 days throughout the crop growth period depending on weather conditions. Hand weeding was carried out once in 30 days to keep the plots free of weeds.

3.2.2.5 Plant protection

Seed cloves were treated with dithane M-45 (Mancozeb) @ 2 g/kg for ten minutes before planting. In order to control the *Alternaria* blight, the crop was sprayed with chlorothianil 70 wp and mancozeb 75 wp @ 2.5 g/l @ 30, 60 and 90 days after sowing.

3.2.2.6 Harvesting and curing

The crop was harvested at full maturity which was indicated by the change in the colour of the leaves and neck fall. The plants were uprooted from the net plot area of each plot separately. The soil particles adhering to the bulbs were removed and the plants were bundled and were kept for curing on sand under shade for fifteen days.

Plate 1: General view of Experimental plot

3.2.3 Observations recorded

Observations on the crop were recorded on five randomly selected plants from the net plot area. Following are the observations recorded at monthly intervals till harvest of the crop.

3.2.3.1 Growth parameters

3.2.3.2 Plant height (cm)

The plant height was measured from base of plant to the highest growing tip of leaf and average of five plants was taken as plant height.

3.2.3.3 Number of leaves per plant

The number of fully-grown green functional leaves was counted in each of the five plants and average was taken as number of leaves per plant at all crop growth stages.

3.2.3.4 Leaf length and breadth (cm)

Length of middle leaf on five selected plants was measured using centimeter scale. The average was expressed as length of the leaf and the leaf breadth was measured in the centre of the selected leaf.

3.2.3.5 Collar diameter (mm)

At the base of the plant, the collar diameter was recorded by using digital vernier calipers. The mean value of five selected plants was considered as collar diameter.

3.2.3.6 Fresh weight of garlic (g)

In each plot, five plants were uprooted and aerial portion was separated from the bulb. Fresh weight of the plant was recorded and average of this was taken.

3.2.3.7 Dry weight of garlic (g)

Aerial portion of the same five plants was oven dried at 60°C for 48 hours and dry weight of the foliage was recorded. The average dry weight per plant was calculated.

3.2.4 Yield and yield attributing parameters

3.2.4.1 Weight of bulb (g)

The weight of the five individual bulbs was recorded and the average was expressed as average weight of bulbs.

3.2.4.2 Bulb diameter (mm)

Digital vernier caliper was used for recording the bulb diameter of five bulbs and average bulb diameter was computed.

3.2.4.3 Number of cloves per bulb

The number of cloves per bulb was counted and were recorded and the mean of five bulbs were taken and expressed as number of cloves per bulb.

3.2.4.4 Weight of the cloves per bulb (g)

The weight of the cloves was recorded by dividing weight of bulbs and average of five bulbs was expressed as average weight of the cloves per bulb.

3.2.4.5 Bulb yield (t ha^{-1})

The bulbs from net plot area were harvested and cured completely and were weighed separately. The net plot yield was used to compute the yield per hectare.

3.2.5 Quality parameters

3.2.5.1 Sulphur content of bulbs

The Sulphur content in the plant sample was determined by wet digestion using diacid extract of the sample. One gram of ground plant sample was pre-digested in 25 ml $HN0_3$. Wet digestion of the sample was done with 10:4 mixture of $HN0_3$: $HCl0_4$ was carried out using hot plate in a digestion chamber. The solution turns turbid due to the conversion of sulphur to sulphate. Ten ml of the diacid extract of the plant sample was treated with 25 ml salt buffer (50 g $HgCl_2.6H_20$, 4.1g $KN0_3$ and 28 ml ethanol/liter), one ml 6 N HCI, one ml 0.5 per cent gum acacia and 0.5 g $BaCl_2$ crystals. The content was properly mixed by swirling the conical flask containing the solution. $BaCI_2$ crystals were precipitated as white $BaS0_4$. This provides turbidity to the solution which is proportional to the amount of sulphate present in the plant sample. The turbidity (absorbance) was read in spectrophotometer at 420 nm wavelength. Sulphur concentration in ppm was calculated from standard curve prepared from different concentrations of standard sulphur solution and was expressed in percentage (Bhargava and Raghupathi, 1993).

$$S\ (\%) = \frac{R}{4} \times \frac{100}{\text{Sample (g)}} \times \frac{100}{1000000}$$

Where,

R = Sulphur concentration in ppm.

3.2.6 Soil sampling and soil analysis

3.2.6.1 Soil sample collection and preparation

Representative soil samples from 0-15 cm depth were collected from the experimental site before the commencement of experiment and were analyzed for different physico-chemical properties (Appendix III). Similarly representative samples from each treatment plot at 0-15 cm depth were collected after the harvest of the crop and was brought to the laboratory, dried in shade and ground using wooden pestle and mortar, passed through 2 mm sieve and stored in an air tight container for further analysis.

3.2.7 Soil analysis

3.2.7.1 Soil texture

Texture of the soil was determined by international Pippet Method (Piper, 1966).

3.2.7.2 pH and Electrical Conductivity (dsm^{-1})

Soil pH was measured in 1:2.5 soil water suspension using pH meter (Systronic model). After the pH measurement the suspension was kept (undisturbed) overnight. The electrical conductivity of the suspension was measured by inserting the conductivity cell of the EC Bridge (Systronic model) in the supernatant solution (Page *et al.*, 182).

3.2.7.3 Organic carbon

Two mm sieved soil sample was ground using pestle and mortar to pass through 0.2 mm sieve. A known weight of the sample was treated with standard $K_2Cr_20_7$ and H_2S0_4. The untreated $K_2Cr_20_7$ was estimated by back titration with standard ferrous ammonium Sulphate using Orthophosphoric acid indicator (Diphenyl amine). A blank without soil was carried out and using these values the per cent organic carbon was computed (Jackson, 1973).

3.2.8 Determination of available nutrients in soil

3.2.8.1 Available nitrogen (kg ha^{-1})

The available nitrogen content in the soil was determined by modified Kjeldahl's method by Jackson (1973). A known weight of soil was treated with excess of alkaline 0.32% $KMn0_4$ (made alkaline with 25% NaOH solution) and it was distilled in Distill -M (Pelican make). The ammonia liberated was trapped in boric acid and was determined by titration against standard HCl. The available N content in kg ha $^{-1}$ was computed using titre value.

3.2.8.2 Available phosphorus (kg ha^{-1})

Available P content of the soil was extracted by using O.5 M $NaHC0_3$. The P content in the extract was determined by chloromolybdic blue colour method using spectrophotometer (Make-U model). The intensity of blue colour was determined at 660 nm. The available P content was computed and expressed in kg ha $^{-1}$ (Jackson, 1973).

3.2.8.3 Available potassium (kg ha^{-1})

The available K content was extracted using neutral N NH_40AC as described by Schollenbrger and Simon (1945). The concentration of K in the extractant was determined by flame photometer (Mclean *et al.*, 1982) and was expressed in kg per hectare.

3.2.8.4 Available Sulphur (kg ha^{-1})

Sulphate - S ($S0_4$-S) in soil was extracted using 0.15% $CaCl_2$.The $S0_4$-S in the extract was estimated by turbidimetic method using $BaCl_2$ as destabilizing agent (Chesin and Yien, 1951). The turbidity was measured using spectrophotometer at 420 nm and was expressed in kg per hectare.

3.2.9 Plant analysis

The plant samples were separately analyzed for uptake of nitrogen and sulphur content of bulb at harvest.

3.2.9.1 Preparation of sample

The fresh weight of the plant sample was recorded and samples were dried in oven at 60 ± 2^0 C for 48 hours and dry weight was recorded. The dried samples were powdered by using mixer grinder with stainless steel blade. The powdered samples were stored in airtight containers for further chemical analysis.

3.2.9.2 Digestion of the plant samples

One gram of powdered sample was predigested with concentrated $HN0_3$ overnight. Further, samples were digested using 5 ml of diacid mixture (10 ml $HN0_3$: 4 ml $HCl0_4$), until colorless and clear residue was developed. After cooling, the residue was dissolved in distilled water and then the volume was made upto 50 ml. This sample was used for nitrogen estimation. Modified Kjeldahl's method was adopted for the estimation of nitrogen in the digested sample.

3.2.9.3 Nitrogen

To determine the total N in plant sample, the powdered sample was digested with concentrated H_2S0_4 and digestion mixture (K_2S0_4 + $CuS0_4$ 5 H_20+ Selenium powder at 100:20: 1 ratios). After complete digestion, the content was transferred to distillation unit (Jel plus) and the liberated ammonia was trapped in boric acid. It was titrated against standard acid (HCl) to estimate the nitrogen content (Jackson, 1973).

3.2.9.4 Nitrogen uptake

The uptake of nitrogen was calculated by using the formula given below.

$$\text{Nitrogen uptake (kg/ha)} = \frac{\text{Nitrogen concentration (\%) x Weight of dry matter (kg/ha)}}{100}$$

3.2.9.5 Economics

The price of the inputs that were prevailing at the time of their use was considered for working out the economics of the various treatment combinations. Net returns per hectare were calculated by deducting the cost of cultivation from gross income per hectare and benefit cost ratio (BC) was worked out.

3.3 Experiment-2: Effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.)

Design		: Randomized Block Design (RBD)
Treatments		: Nine
Replications		: Three
Plot size	Gross	: 3.0 m x 1.5 m = 4.5 m^2
	Net	: 2.85 m x 1.43 m = 4.08 m^2
Spacing		: 15 cm x 7.5 cm
Cultivar		: AAS-2 (Vannur local)
Seed rate		: 500 kg ha^{-1}
RDF		: 125:62.5:62.5 NPK kg ha^{-1} + FYM 25 t ha^{-1}
Season		: *Rabi*, 2010-11

Treatment details

T_1- Maleic hydrazide (MH) 2500 ppm

T_2- MH 2500 ppm + Carbendazim 1000 ppm

T_3- MH 2500 ppm + Dithane M-45 1000 ppm.

T_4- Cycocel (CCC) 1000 ppm

T_5- CCC 1000 ppm + Carbendazim 1000 ppm

T_6- CCC 1000 ppm + Dithane M- 45 1000 ppm

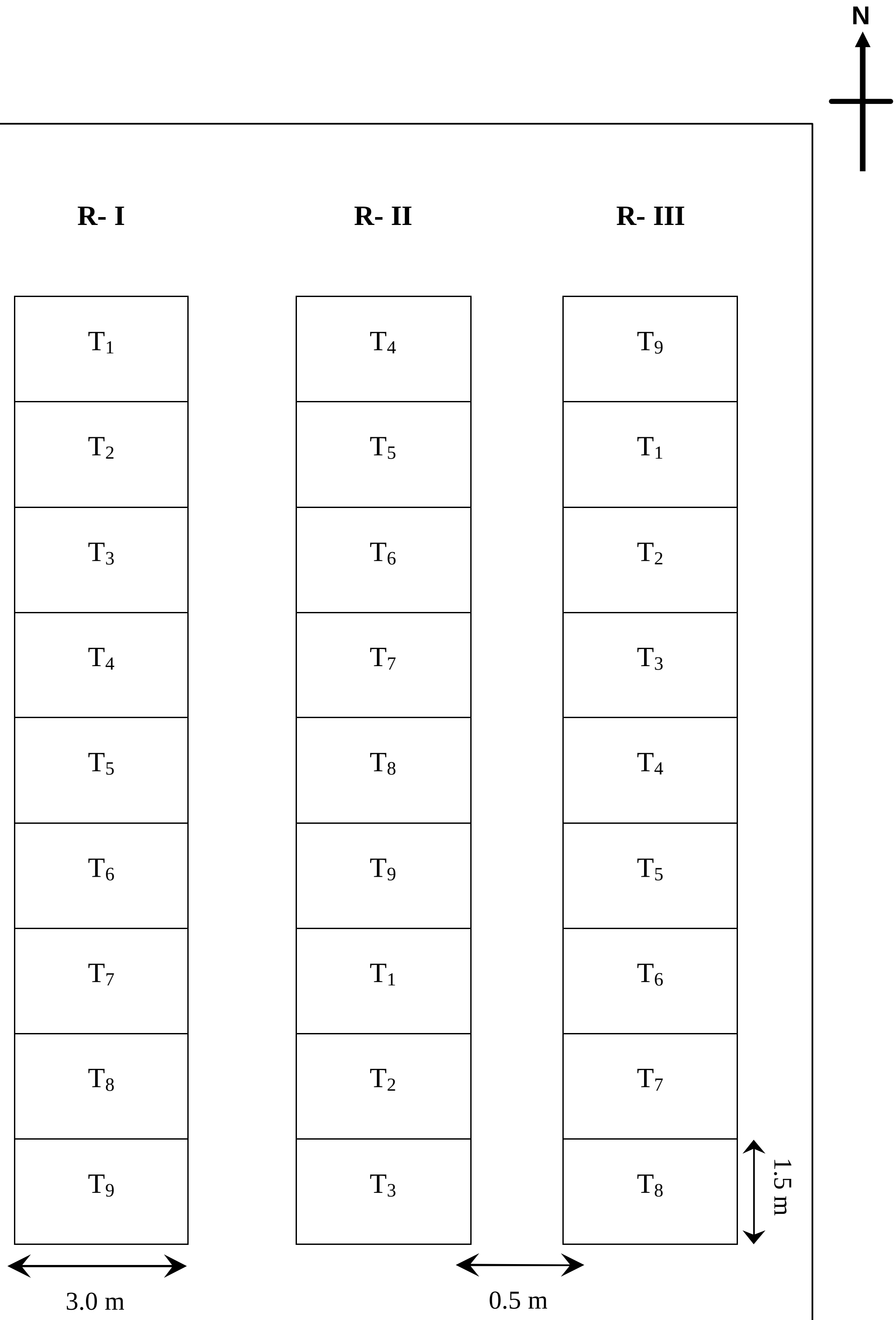


Fig 2: Plan of layout of Experiment - II

T_7- Borax 1000 ppm

T_8- Borax 1000 ppm + Carbendazim 1000 ppm

T_9- Control (unsprayed)

Note-sprays were given as per treatment three weeks before the harvest of the crop.

3.3.1 Storage studies

The bulbs obtained from experiment II during, 2010-11 were used for their storage studies for six months. The cured healthy garlic bulbs used as per treatment and 1.5 kg of bulbs in each treatment replicated thrice were knotted together by knotting the leaves and were kept in ambient conditions for storage studies in the spices and plantation crops laboratory of K.R.C. College of Horticulture, Arabhavi.

3.3.2 Observations recorded

Observations on growth parameters like plant height, number of leaves per plant, leaf length and breadth and collar diameter were recorded one week before and after imposing treatments in the field and yield parameters like weight of bulb, bulb diameter, number of cloves per bulb, weight of cloves per bulb and bulb yield were recorded as detailed under experiment I. In storage studies physiological loss in weight (PLW) of the bulbs was recorded at 30, 60, 90, 120, 150 and 180 days after storage (DAS). The recovery of healthy cloves was observed at the end of experiment.

The details of the methodology adopted for recording these observations during storage studies are described below.

3.3.2.1 Physiological loss in weight (%)

The physiological loss in weight was recorded at 30, 60, 90, 120, 150 and 180 days after storage using an electronic balance. The cumulative loss in weight of bulbs was calculated and was expressed as physiological loss in weight using the formula given below.

$$PLW (\%) = \frac{P_0 - P_1 \text{ or } P_2 \text{ or } P_3 \text{ or } P_4 \text{ or } P_5 \text{ or } P_6}{P_0} \times 100$$

Where P_0 = Initial weight P_1 = weight after 30 days

P_2 = weight after 60 days P_3 = weight after 90 days

P_4 = weight after 120 days P_5 = weight after 150 days

P_6 = weight after 180 days

3.3.2.2 Percentage of marketable cloves

At the end of storage period of 180 days, the bulbs were split open as per the treatment to extract the cloves. The healthy and emancipated cloves were separated and the weight of healthy cloves was recorded. The recovery of marketable cloves was calculated by using the following formula.

$$\text{Recovery of Marketable cloves (\%)} = \frac{\text{Weight of the healthy cloves obtained}}{\text{Initial weight of bulbs stored}} \text{ x } 100$$

3.3.2.3 Vigour of garlic cloves after storage period

Garlic bulbs were split open to extract cloves as per the treatments. The healthy cloves recovered from each treatment were sown in replicated plots in the field and were tested for initial vigour parameters like plant height, number of leaves, plant diameter, leaf length and breadth.

3.4 Statistical analysis

The data collected on various parameters in experiment I and II was subject to Fisher’s method of analysis of variance was applied for the analysis and interpretation of data as given by Panse and Sukhatme (1989). The level of significance used in ‘F’ and ‘t’ tests was p=0.05. Critical difference was calculated for the data wherever 'F' tests was significant.

4. EXPERIMENTAL RESULTS

The results of the experiments conducted on effect of organic and inorganic sources of nitrogen on growth, yield and quality and pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.) var. Vannur local are presented in this chapter.

4.1 Experiment I: Effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic

4.1.1 Plant height (cm)

The data pertaining to plant height recorded at different crop growth stages (30, 60, 90 days after sowing (DAS) and at harvest) is presented in Table 1.

Significant differences in plant height were observed at all the stages of crop growth except at 30 DAS. However, at 30 DAS, the maximum plant height (22.81 cm) was recorded in T_8 (100% RDN through vermicompost) and the minimum plant height (21.03 cm) was recorded in T_9 (control). At 60 DAS, the maximum plant height (43.94 cm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_1 (42.30 cm) and the minimum plant height (38.45 cm) was recorded in T_9 (control). At 90 DAS, the maximum plant height (54.06 cm) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_8 (53.03 cm), T_5 (52.03 cm) and T_1 (51.28 cm) and the minimum plant height (46.41 cm) was recorded in T_9 (control). At harvest, the maximum plant height (56.78 cm) was recorded in T_4 (100% RDN through FYM) and it was *on par* with T_1 (55.80 cm), T_2 (53.49 cm), T_5 (54.34 cm), T_6 (52.72 cm) and T_8 (55.64 cm) and the minimum plant height (48.97 cm) was recorded in T_9 (control).

4.1.2 Number leaves per plant

The data pertaining to the number of leaves per plant recorded at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 2.

Table 1: Plant height of garlic cv. Vannur Local at different crop growth stages and at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Plant height (cm)			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1	25% RDN through FYM + 75% RDN through urea	22.39	42.30	51.28	55.80
T_2	50% RDN through FYM + 50% RDN through urea	21.89	40.59	51.05	53.49
T_3	75% RDN through FYM + 25% RDN through urea	22.48	39.91	47.68	51.13
T_4	100% RDN through FYM	22.60	43.94	54.06	56.78
T_5	25% RDN through VC + 75% RDN through urea	22.19	40.87	52.30	54.34
T_6	50% RDN through VC + 50% RDN through urea	21.67	40.65	49.81	52.72
T_7	75% RDN through VC + 25% RDN through urea	22.13	38.80	46.46	51.65
T_8	100% RDN through VC	22.81	41.51	53.03	55.64
T_9	100% RDF (Control)	21.03	38.45	46.41	48.97
	Mean	**22.13**	**40.78**	**50.23**	**53.39**
	S.Em±	0.69	0.73	0.97	1.46
	C.D. (p= 0.05)	NS	2.20	2.91	4.37
	CV (%)	5.37	3.11	3.34	4.73

Note: NS- Non-significant Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost DAS - Days after sowing RDN - Recommended dose of nitrogen

Table 2: Number of leaves per plant of garlic cv. Vannur Local at different crop growth stages and at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Number of leaves per plant			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	25% RDN through FYM +75% RDN through urea	4.20	5.60	6.27	5.28
T_2	50% RDN through FYM + 50% RDN through urea	4.33	5.80	6.20	5.42
T_3	75% RDN through FYM + 25% RDN through urea	4.33	5.83	6.40	5.55
T_4	100% RDN through FYM	4.40	6.11	6.60	5.75
T_5	25% RDN through VC + 75% RDN through urea	4.00	5.47	6.20	5.42
T_6	50% RDN through VC + 50% RDN through urea	4.27	5.77	6.33	5.49
T_7	75% RDN through VC+ 25% RDN through urea	4.33	5.80	6.33	5.55
T_8	100% RDN through VC	4.40	6.00	6.53	5.62
T_9	100% RDF (Control)	3.76	4.01	5.19	4.80
	Mean	**4.23**	**5.61**	**6.23**	**5.43**
	S.Em±	0.10	0.44	0.15	0.19
	C.D. (p= 0.05)	0.30	1.19	0.46	NS
	CV (%)	4.11	12.23	4.28	6.00

Note: NS- Non-significant Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost DAS - Days after sowing RDN - Recommended dose of nitrogen

Significant differences in number of leaves per plant were observed at all the stages of crop growth except at harvest. At 30 DAS, the maximum number of leaves per plant (4.40) were observed in T_4 (100% RDN through FYM) and T_8 (100% RDN through vermicompost) and T_4 and T_8 were *on par* with T_2, T_3 and T_7 (4.33), T_6 (4.27) and T_1 (4.20). The least number of leaves per plant (3.76) was observed in T_9 (control). At 60 DAS, the maximum number of leaves per plant (6.11) was observed in T_4 (100% RDN through FYM) and was *on par* with T_8 (6.00), T_3 (5.83), T_2 (5.80), T_7 (5.80), T_6 (5.77), T_1 (5.60) and T_5 (5.47). Significantly least number of leaves per plant (4.01) was observed in T_9 (control). At 90 DAS, the maximum number of leaves per plant (6.60) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (6.53), T_3 (6.40), T_2 (6.20), T_7 (6.33), T_6 (6.33), T_1 (6.27) and T_5 (6.20). The least number of leaves per plant (5.19) was recorded in T_9 (control). At harvest, the maximum number of leaves per plant (5.75) was recorded in T_4 (100% RDN through FYM) and least number of leaves per plant (4.80) was recorded in T_9 (control).

4.1.3 Leaf length (cm)

The data on leaf length recorded at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 3.

Significant differences in leaf length were observed due to different treatments only at 60 and 90 DAS. There were no significant differences among different treatments at 30 DAS and at harvest. At 30 DAS, the maximum leaf length (15.66 cm) was observed in T_4 (100% RDN through FYM) and minimum leaf length (13.31 cm) was observed in T_9 (control). At 60 DAS, the maximum leaf length (20.67 cm) was recorded in T_8 (100% RDN through vermicompost) and was *on par* with T_4 (20.12 cm) and T_3 (18.34 cm). The minimum leaf length (15.34 cm) was recorded in T_9 (control). At 90 DAS, the maximum leaf length (22.75 cm) was observed in T_4 (100% RDN through FYM) and was *on par* with T_8 (22.51 cm), T_3 (21.83 cm), T_6 (21.26 cm), T_7 (20.91 cm) and T_2 (20.60 cm). The minimum leaf length (17.99 cm) was observed in T_9 (control). At harvest, the maximum leaf length (20.18 cm) was observed in T_4 (100% RDN through FYM) and minimum leaf length (15.84 cm) was recorded in T_9 (control).

Table 3: Leaf length of garlic cv. Vannur Local at different crop growth stages and at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Leaf length (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	25% RDN through FYM + 75% RDN through urea	14.00	17.00	19.69	17.28
T_2	50% RDN through FYM + 50% RDN through urea	13.76	17.29	20.60	18.67
T_3	75% RDN through FYM + 25% RDN through urea	13.43	18.34	21.83	19.26
T_4	100% RDN through FYM	15.66	20.12	22.75	20.18
T_5	25% RDN through VC + 75% RDN through urea	14.89	16.74	19.85	18.03
T_6	50% RDN through VC + 50% RDN through urea	14.65	17.51	21.26	18.64
T_7	75% RDN through VC + 25% RDN through urea	14.62	16.57	20.91	19.20
T_8	100% RDN through VC	15.45	20.67	22.51	19.61
T_9	100% RDF (Control)	13.31	15.34	17.99	15.84
	Mean	**14.42**	**17.73**	**20.82**	**18.52**
	S.Em±	0.91	0.88	0.91	1.15
	C.D. (p= 0.05)	NS	2.64	2.74	NS
	CV (%)	10.90	8.62	7.60	10.76

Note: NS- Non-significant Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost DAS - Days after sowing RDN - Recommended dose of nitrogen

4.1.4 Leaf breadth (cm)

The data recorded on leaf breadth at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 4.

There were significant differences among the different treatments with reference to leaf breadth at all the crop growth stages except at 30 DAS. At 30 DAS, the highest leaf breadth (0.50 cm) was recorded in T_8 (100% RDN through VC) and the least leaf breadth (0.45 cm) was recorded in T_1, T_2, T_5 and T_9 (control). At 60 DAS, the highest leaf breadth (0.81 cm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_3 and T_1 (0.79 cm), T_6 (0.75 cm), T_7 & T_8 (0.73 cm), T_5 (0.71 cm) and T_2 (0.69 cm). The least leaf breadth (0.53 cm) was recorded in T_9 (control). At 90 DAS, the highest leaf breadth (1.13 cm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (1.07 cm), T_1 & T_5 (1.05 cm), T_7 (1.03 cm) and T_6 (1.01 cm) and least leaf breadth (0.80 cm) was recorded in T_9 (control). At harvest, the highest leaf breadth (0.82 cm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 and T_3 (0.81 cm), T_5 (0.80 cm), T_7 (0.78 cm), T_1 (0.77 cm), T_2 (0.74 cm) and T_6 (0.73 cm) and the least leaf breadth (0.64 cm) was recorded in T_9 (control).

4.1.5 Collar diameter (mm)

The data recorded on collar diameter at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 5.

There were significant differences among different treatments with reference to collar diameter at all the stages of crop growth except at 30 DAS. At 30 DAS, the maximum collar diameter (3.49 mm) was recorded in T_4 (100% RDN through FYM) and the minimum collar diameter (2.94 mm) was recorded in T_9 (control). At 60 DAS, the maximum collar diameter (6.72 mm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (6.66 mm), T_3 (6.42 mm), T_7 (6.22 mm) and T_2 (6.15 mm) and minimum collar diameter (5.24 mm) was recorded in T_9 (control). At 90 DAS, the maximum collar diameter (7.31 mm) was recorded in T_4 (100% RDN through FYM) and was on par with T_8 (7.25 mm), T_3 (7.04 mm),T_7 (6.93 mm) T_6 (6.74 mm), T_1 (6.69 mm), T_5 (6.52 mm) and T_2 (6.79 mm) and minimum collar diameter (5.56 mm) was recorded in

Table 4: Leaf breadth of garlic cv. Vannur Local at different crop growth stages and at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Leaf breadth (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	25% RDN through FYM + 75% RDN through urea	0.45	0.79	1.05	0.77
T_2	50% RDN through FYM + 50% RDN through urea	0.45	0.69	1.00	0.74
T_3	75% RDN through FYM + 25% RDN through urea	0.47	0.79	0.97	0.81
T_4	100% RDN through FYM	0.49	0.81	1.13	0.82
T_5	25% RDN through VC + 75% RDN through urea	0.45	0.71	1.05	0.80
T_6	50% RDN through VC + 50% RDN through urea	0.46	0.75	1.01	0.73
T_7	75% RDN through VC + 25% RDN through urea	0.48	0.73	1.03	0.78
T_8	100% RDN through VC	0.50	0.73	1.07	0.81
T_9	100% RDF (Control)	0.45	0.53	0.80	0.64
	Mean	**0.47**	**0.73**	**1.01**	**0.77**
	S.Em±	0.03	0.05	0.04	0.03
	C.D. (p= 0.05)	NS	0.16	0.12	0.09
	CV (%)	10.19	12.41	6.70	6.86

Note: NS- Non-significant Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost DAS - Days after sowing RDN - Recommended dose of nitrogen

Table 5: Collar diameter of garlic cv. Vannur Local at different crop growth stages and at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Collar diameter (mm)			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1	25% RDN through FYM + 75% RDN through urea	3.02	6.05	6.69	5.14
T_2	50% RDN through FYM + 50% RDN through urea	3.09	6.15	6.79	5.18
T_3	75% RDN through FYM + 25% RDN through urea	3.33	6.42	7.04	6.16
T_4	100% RDN through FYM	3.49	6.72	7.31	6.76
T_5	25% RDN through VC + 75% RDN through urea	3.00	6.02	6.52	5.14
T_6	50% RDN through VC + 50% RDN through urea	3.08	6.11	6.74	5.22
T_7	75% RDN through VC + 25% RDN through urea	3.11	6.22	6.93	5.67
T_8	100% RDN through VC	3.42	6.66	7.25	6.53
T_9	100% RDF (Control)	2. 94	5.24	5.56	4.98
	Mean	**3.16**	**6.18**	**6.76**	**5.64**
	S.Em±	0.15	0.20	0.31	0.41
	C.D. (p= 0.05)	NS	0.60	0.92	1.24
	CV (%)	8.07	5.65	7.86	12.64

Note: NS- Non-significant   Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure   VC- Vermicompost   DAS - Days after sowing   RDN - Recommended dose of nitrogen

T_9 (control). At harvest, the maximum collar diameter (6.76 mm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (6.53 mm), T_3 (6.16 mm) and T_7 (5.67 mm) and minimum collar diameter (4.98 mm) was recorded in T_9 (control).

4.1.6 Fresh weight of garlic (g)

The result on fresh weight of garlic was recorded at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen are presented in Table 6.

Significant differences were observed with reference to fresh weight of garlic at all the crop growth stages except at 60 DAS. At 30 DAS, the highest fresh weight (24.93 g) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_2 (21.83 g), T_3 (22.30 g) and T_8 (23.33 g) and lowest fresh weight (17.50 g) was recorded in T_5. At 60 DAS highest fresh weight (46.67 g) was recorded in T_4 (100% RDN through FYM) and lowest fresh weight (33.33 g) was recorded in T_2. At 90 DAS, the highest fresh weight (45.33 g) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_1 (39.00 g), T_2 (37.33 g), T_3 (38.00 g) and T_4 (44.00 g) and lowest fresh weight (32.67 g) was recorded in T_9 (control). At harvest the highest fresh weight (22.00 g) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_4 (21.33 g) and lowest fresh weight (17.67 g) was recorded in T_1.

4.1.7 Dry weight of garlic (g)

The results of dry weight of garlic recorded at different stages of crop growth as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 6.

There were significant differences observed with reference to dry weight of garlic at all the crop growth stages. At 30 DAS, the highest dry weight (7.00 g) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_3 (5.67 g), T_8 (6.67 g), T_7 & T_9 (6.00 g) and lowest dry weight (4.17 g) was recorded in T_1. At 60 DAS, the highest dry weight (8.50 g) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_7 (7.33 g), T_3 (8.33 g), T_4 (7.83 g), T_5 (7.00 g), T_6 (8.17 g) and T_9 (6.33 g) and lowest dry weight (5.33 g) was recorded in T_1. At 90 DAS, the highest dry weight

Table 6: Fresh weight and dry weight of garlic cv. Vannur Local at different crop growth stages as influenced by soil application of organic and inorganic sources of nitrogen

	Treatment	30 DAS		60 DAS		90 DAS		At harvest	
		Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight . (g)	Fresh weight (g)	Dry weight (g)
T_1	25% RDN through FYM + 75% RDN through urea	19.67	4.17	35.83	5.33	39.00	8.67	17.67	3.83
T_2	50% RDN through FYM + 50% RDN through urea	21.83	5.17	33.33	6.03	37.33	8.83	18.33	4.33
T_3	75% RDN through FYM + 25% RDN through urea	22.30	5.67	39.33	8.33	38.00	8.00	19.67	4.83
T_4	100% RDN through FYM	24.93	7.00	46.67	7.83	44.00	10.33	21.33	5.83
T_5	25% RDN through VC + 75% RDN through urea	17.50	5.00	36.00	7.00	33.33	8.33	18.33	4.33
T_6	50% RDN through VC + 50% RDN through urea	19.50	5.33	38.00	8.17	33.67	8.00	18.50	4.00
T_7	75% RDN through VC + 25% RDN through urea	20.83	6.00	35.00	7.33	35.00	8.33	19.67	4.67
T_8	100% RDN through VC	23.33	6.67	41.00	8.50	45.33	10.00	22.00	6.00
T_9	100% RDF (Control)	20.87	6.00	35.33	6.33	32.67	7.33	19.50	4.83
	Mean	**21.20**	**5.67**	**37.83**	**7.06**	**37.59**	**8.65**	**19.44**	**4.74**
	S.Em±	1.30	0.47	3.78	0.81	2.84	0.57	0.71	0.36
	C.D. (p= 0.05)	3.90	1.42	NS	2.41	8.51	1.71	2.13	1.08
	CV (%)	10.62	14.48	17.30	19.76	13.08	11.41	6.34	13.19

Note: NS- Non-significant   Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure   VC- Vermicompost   DAS - Days after sowing   RDN - Recommended dose of nitrogen

(10.33 g) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_1 (8.67 g), T_2 (8.83 g) and T_8 (10.00 g) and least dry weight (7.33 g) was recorded in T_9 (control). At harvest the highest dry weight (6.00 g) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_4 (5.83 g) and lowest dry weight (3.83 g) was recorded in T_1.

4.1.8 Weight of bulb (g)

The data recorded on bulb weight as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were significant differences among the different treatments with reference to bulb weight. The highest bulb weight (35.00 g) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (33.67 g), T_3 (33.62 g), T_7 (33.00 g), T_2 (32.00 g), T_1 (31.00 g) and T_6 (30.64 g) the least bulb weight (28.32 g) was recorded in T_9 (control).

4.1.9 Bulb diameter (mm)

The data recorded on bulb diameter as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were significant differences among the different treatments with reference to bulb diameter. The highest bulb diameter (25.11 mm) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (24.57 mm), T_3 (24.57 mm), T_7 (24.41 mm) and T_2 (23.81 mm) and the least bulb diameter (22.50 mm) was recorded in T_9 (control).

4.1.10 Number of cloves per bulb

The data recorded on number of cloves per bulb as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were no significant differences among the different treatments with reference to number of cloves per bulb. The maximum number of cloves per bulb (19.33) was observed in T_7 (75% RDN through vermicompost + 25% RDN through urea) and minimum number of cloves per bulb (17.47) was recorded in T_5 (25% RDN through vermicompost + 75% RDN through urea).

Table 7: Yield and yield parameters of garlic cv. Vannur Local at harvest as influenced by soil application of organic and inorganic sources of nitrogen

	Treatment	Weight of five bulbs (g)	Bulb diameter (mm)	Number of cloves per bulb	Weight of cloves per bulb (g)	Bulb yield (kg/plot)	Bulb Yield (t/ha)
T_1	25% RDN through FYM + 75% RDN through urea	31.00	23.46	18.27	5.28	2.02	4.48
T_2	50% RDN through FYM + 50% RDN through urea	32.00	23.81	17.60	5.32	1.98	4.39
T_3	75% RDN through FYM + 25% RDN through urea	33.62	24.57	17.87	5.48	1.88	4.17
T_4	100% RDN through FYM	35.00	25.11	18.20	5.74	2.36	5.24
T_5	25% RDN through VC + 75% RDN through urea	30.00	23.32	17.47	5.07	1.99	4.43
T_6	50% RDN through VC + 50% RDN through urea	30.64	23.47	19.20	5.30	2.01	4.48
T_7	75% RDN through VC + 25% RDN through urea	33.00	24.41	19.33	5.40	1.92	4.27
T_8	100% RDN through VC	33.67	24.57	17.93	5.64	2.41	5.36
T_9	100% RDF (Control)	28.32	22.50	18.53	4.93	2.27	5.04
	Mean	**31.92**	**23.92**	**18.27**	**5.35**	**2.09**	**4.65**
	S.Em±	1.48	0.49	0.89	0.15	0.10	0.23
	C.D. (p= 0.05)	4.44	1.46	NS	0.46	0.31	0.68
	CV (%)	8.04	3.52	8.47	4.93	8.44	8.44

Note: NS- Non-significant   Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure   VC- Vermicompost   RDN - Recommended dose of nitrogen

Plate 2: Bulbs of garlic cv. Vannur Local in Experiment-I

Plate 3: Cloves of garlic cv. Vannur Local in Experiment-I

4.1.11 Weight of cloves per bulb (g)

The data pertaining to clove weight per bulb as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were significant differences among the different treatments with reference to clove weight per bulb. The highest clove weight per bulb (5.74 g) was recorded in T_4 (100% RDN through FYM) and was *on par* with T_8 (5.64 g), T_3 (5.48 g), T_7 (5.40 g), T_2 (5.32 g), T_1 (5.28 g) and T_6 (5.30 g) the least clove weight per bulb (4.93 g) was recorded in T_9 (control).

4.1.12 Bulb yield kg/ plot (4.5 m^2)

The data pertaining to bulb yield per plot as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were significant differences among the different treatments with reference to bulb yield per plot. The highest bulb yield per plot (2.41 kg) was observed in T_8 (100% RDN through vermicompost) and was *on par* with T_4 (2.36 kg) and T_9 (2.27 kg) and least bulb yield per plot (1.88 kg) was observed in T_3.

4.1.13 Bulb yield (t ha^{-1})

The data recorded on bulb yield per hectare as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 7.

There were significant differences among the different treatments with reference to bulb yield per hectare. The highest bulb yield per hectare (5.36 t ha^{-1}) was obtained in T_8 (100% RDN through vermicompost) and was *on par* with T_4 (5.24 t ha^{-1}) and T_9 (5.04 t ha^{-1}) and least bulb yield per hectare (4.17 t ha^{-1}) was recorded in T_3.

4.1.14 Sulphur content (%)

Sulphur content of garlic bulbs at harvest as influenced by organic and inorganic sources of nitrogen is presented in Table 8.

There were significant differences among the different treatments with reference to sulphur concentration of bulbs. Higher sulphur concentration of bulb (0.040%) was

Plate 4: Comparative bulb yield per plot of garlic cv. Vannur Local in Experiment-I

Table 8: Nitrogen uptake in garlic cv. Vannur Local and Sulphur content of bulb at harvest as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Sulphur content (%)	Total nitrogen uptake (kg ha^{-1})
T_1	25% RDN through FYM + 75% RDN through urea	0.028	18.57
T_2	50% RDN through FYM + 50% RDN through urea	0.031	19.37
T_3	75% RDN through FYM + 25% RDN through urea	0.034	23.59
T_4	100% RDN through FYM	0.038	29.37
T_5	25% RDN through VC + 75% RDN through urea	0.030	17.64
T_6	50% RDN through VC + 50% RDN through urea	0.030	20.34
T_7	75% RDN through VC + 25% RDN through urea	0.034	21.59
T_8	100% RDN through VC	0.040	29.51
T_9	100% RDF (Control)	0.032	25.68
	Mean	**0.033**	**22.68**
	S.Em±	0.001	0.24
	C.D. (p= 0.05)	0.003	0.72
	CV (%)	5.476	1.83

Note: Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost RDN - Recommended dose of nitrogen

recorded in T_8 (100% RDN through vermicompost) and was *on par* with T_4 (0.038%). Least sulphur concentration of bulb (0.028%) was recorded in T_1.

4.1.15 Nitrogen uptake (kg ha^{-1})

The data pertaining to total nitrogen uptake by garlic crop, as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 8.

There were significant differences among different treatments with respect to total nitrogen uptake. The highest total nitrogen uptake (29.51 kg ha^{-1}) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_4 (29.37 kg ha^{-1}) and least total nitrogen uptake (17.64 kg ha^{-1}) was recorded in T_5.

4.1.2 Physico-chemical properties of soil

The data pertaining to physico-chemical properties of soil after the harvest of garlic crop as influenced by soil application of organic and inorganic sources of nitrogen is presented in Table 9.

4.1.2.1 Potential hydrogen (p^H)

There were no significant differences among the different treatments with reference to pH. The highest P^H (8.49) was observed in T_9 (control) and least P^H (8.31) was observed in T_1.

4.1.2.2 Electrical conductivity (EC)

There were no significant differences among the different treatments with reference to EC. The highest EC (0.56 dsm^{-1}) was observed in T_4 (100% RDN through FYM) and least EC (0.43 dsm^{-1}) was observed in T_1 and T_6.

4.1.2.3 Organic carbon (OC)

Soil organic carbon content differed significantly among different treatments. The highest organic carbon (0.60 %) was recorded in T_4 (100% RDN through FYM) which was on par with T_8 (0.56 %) and the least organic carbon (0.43 %) was recorded in T_5 and T_9 (control).

Table 9: Physico-chemical properties and available nutrient status of soil after harvest of garlic crop as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Physico-chemical properties			Available nutrient status of soil (kg/ha)			
		pH	EC (dsm^{-1})	OC (%)	N	P	K	S
T_1	25% RDN through FYM + 75% RDN through urea	8.31	0.43	0.48	296	35.27	272	17.96
T_2	50% RDN through FYM + 50% RDN through urea	8.47	0.50	0.51	309	36.97	298	18.60
T_3	75% RDN through FYM + 25% RDN through urea	8.41	0.51	0.51	312	37.65	301	19.46
T_4	100% RDN through FYM	8.45	0.56	0.60	318	39.37	306	23.19
T_5	25% RDN through VC + 75% RDN through urea	8.33	0.52	0.43	302	34.11	266	17.76
T_6	50% RDN through VC + 50% RDN through urea	8.41	0.43	0.45	308	35.03	221	17.95
T_7	75% RDN through VC + 25% RDN through urea	8.38	0.53	0.46	312	38.03	308	20.23
T_8	100% RDN through VC	8.38	0.49	0.56	316	38.09	309	22.01
T_9	100% RDF (Control)	8.49	0.48	0.43	302	37.03	306	17.55
	Mean	**8.40**	**0.49**	**0.49**	**308**	**36.84**	**288**	**19.41**
	S.Em±	0.07	0.03	0.01	4.10	0.96	2.12	0.37
	C.D. (p= 0.05)	NS	NS	0.04	12.29	2.88	6.34	1.11
	CV (%)	1.34	11.06	4.21	2.30	4.52	1.27	3.30

Note: NS- Non-significant Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost RDN - Recommended dose of nitrogen

4.1.3 Available nutrients

Significant differences were observed among different treatments with respect to available N, P, K and S status of soil after the harvest of garlic crop as influenced by soil application of organic and inorganic sources of nitrogen in Table 9.

4.1.3.1 Available nitrogen (kg ha^{-1})

The available nitrogen content in soil differed significantly among different treatments. The highest available nitrogen content (318 kg ha^{-1}) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_2 (309 kg ha^{-1}), T_3 (312 kg ha-^{1}), T_6 (308 kg ha^{-1}), T_7 (312 kg ha^{-1}) and T_8 (316 kg ha^{-1}) and the least available nitrogen (296 kg ha^{-1}) was recorded in $T_{1.}$

4.1.3.2 Available phosphorus (kg ha^{-1})

The available phosphorus status of soil differed significantly due to different treatments. Significantly highest available phosphorus (39.37 kg ha^{-1}) was recorded in T_4 (100% RDN through FYM) which was *on par* with T_2 (36.97 kg ha^{-1}), T_3 (37.65 kg ha^{-1}), T_7 (38.03 kg ha^{-1}), T_8 (38.09 kg ha^{-1}) and T_9 (37.03 kg ha^{-1}) and the least available phosphorus (34.11 kg ha^{-1}) was recorded in $T_{5.}$

4.1.3.3 Available potassium (kg ha^{-1})

The available potassium status of soil differed significantly due to different treatment combinations. The highest available potassium (309 kg ha^{-1}) was recorded in T_8 (100% RDN through vermicompost) which was *on par* with T_4 (306 kg ha^{-1}), T_7 (308 kg ha^{-1}) and T_9 (306 kg ha^{-1}) and the least available potassium (221 kg ha^{-1}) was recorded in $T_{6.}$

4.1.3.4 Available sulphur (kg ha^{-1})

The available sulphur status of soil differed significantly due to different treatment combinations. Significantly highest available sulphur (23.19 kg ha^{-1}) was recorded in T_4 (100% RDN through FYM). Least available sulphur (17.55 kg ha^{-1}) was recorded in T_9 (control).

Table 10: Economics of garlic (cv. Vannur Local) cultivation as influenced by soil application of organic and inorganic sources of nitrogen

Treatment		Cost of cultivation (₹/ha)	Total yield (t ha^{-1})	Gross returns (₹/ha)	Net return (₹/ha)	B : C ratio
		a	b	c = b× Market price	d = c-a	e = d/a
T_1	25% RDN through FYM + 75% RDN through urea	70,685	4.48	2,24,000	1,53,315	2.17
T_2	50% RDN through FYM + 50% RDN through urea	74,763	4.39	2,19,500	1,44,738	1.94
T_3	75% RDN through FYM + 25% RDN through urea	78,850	4.17	2,08,500	1,29,650	1.65
T_4	100% RDN through FYM	82,919	5.24	2,62,000	1,79,081	2.16
T_5	25% RDN through VC + 75% RDN through urea	71,375	4.43	2,21,500	1,50,120	2.11
T_6	50% RDN through VC + 50% RDN through urea	76,173	4.48	2,24,000	1,47,828	1.94
T_7	75% RDN through VC + 25% RDN through urea	80,950	4.27	2,13,500	1,32,550	1.64
T_8	100% RDN through VC	85,729	5.36	2,68,000	1,82,271	2.13
T_9	100% RDF (Control)	66,596	5.04	2,52,000	1,85,404	2.79

Note: Recommended dose of P, K and FYM 25 t ha^{-1} were applied commonly to all the treatments
FYM- Farmyard manure VC- Vermicompost RDF-Recommended dose of fertilizers RDN - Recommended dose of nitrogen
Market price of garlic at April 2012 = ₹ 50/kg Cost of FYM = ₹ 1000/ton Cost of VC= ₹ 2000/ton

4.1.4 Economics of cultivation

The data on economics of cultivation of garlic as influenced by different treatments is presented in Table 10.

The highest benefit cost ratio of 1:2.79 was recorded in T_9 (100 % RDF) which was followed by T_1 (1:2.17), T_4 (1:2.16) and T_8 (1:2.13) and least benefit cost ratio was recorded in T_7 (1:1.64).

4.2 Experiment II: Effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic

4.2.1 Plant height (cm)

The data pertaining to plant height as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 11.

There were no significant differences among the different treatment designated plots with reference to plant height before spraying growth regulators and chemicals**.** A mean plant height of 57.18 cm was recorded before sprays of growth regulators and chemicals. Significant suppression in plant height was observed due to pre-harvest sprays of growth regulators and chemicals. Least plant height (57.33 cm) was recorded in T_1 (MH 2500 ppm) which was *on par* with T_2 (58.86 cm), T_4 (58.27 cm), T_5 (57.04 cm), T_6 (58.08 cm) and T_7 (59.86 cm), T_8 (60.75 cm) and maximum plant height (63.96 cm) was recorded in T_9 (control).

4.2.2 Number of leaves per plant

The data on number of leaves per plant as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 11.

The mean number of leaves recorded per plant (6.84) was a week before sprays of growth regulators and chemicals. Significant reduction in number of leaves produced per plant was observed due to pre-harvest sprays of growth regulators and chemicals. Least number of leaves per plant (6.55) was recorded in T_5 (CCC 1000 ppm + Carbendazim 1000 ppm) which was *on par* with T_1 (6.83), T_2 (6.73) and the highest number of leaves per plant (7.40) was recorded in T_9 (control).

Table 11: Effect of pre-harvest sprays of growth regulators and chemicals on plant height and number of leaves per plant of garlic cv. Vannur Local during *rabi* season of 2010 – 2011

Treatment		Plant height (cm)		Number of leaves per plant	
		Before spray	**After spray**	**Before spray**	**After spray**
T_1	Maleic hydrazide (MH) 2500 ppm	56.92	57.33	7.00	6.83
T_2	MH 2500 ppm + Carbendazim 1000 ppm	57.69	58.86	6.73	6.73
T_3	MH 2500 ppm + Dithane M-45 1000 ppm	59.66	61.57	6.80	7.20
T_4	Cycocel (CCC) 1000 ppm	57.60	58.27	7.07	7.30
T_5	CCC 1000 ppm + Carbendazim 1000 ppm	56.39	57.04	6.73	6.55
T_6	CCC 1000 ppm + Dithane M- 45 1000 ppm	56.28	58.08	6.87	7.27
T_7	Borax 1000 ppm	55.90	59.86	6.67	7.20
T_8	Borax 1000 ppm + Carbendazim 1000 ppm	56.39	60.75	7.07	7.10
T_9	Control (Unsprayed)	57.80	63.96	6.60	7.40
	Mean	**57.18**	**59.53**	**6.84**	**7.06**
	S. Em ±	0.92	1.40	0.16	0.17
	C. D. (p= 0.05)	NS	4.19	NS	0.52
	CV (%)	2.80	4.07	3.96	4.27

Note- NS = Non -significant   Sprays were given as per treatments three weeks before harvest.
MH - Maleic hydrazide   CCC - Cycocel

4.2.3 Leaf length (cm)

The data on leaf length as influenced by the pre-harvest sprays of growth regulators and chemicals is presented in Table 12.

The mean leaf length of 22.98 cm was recorded before the pre-harvest sprays of growth regulators and chemicals. Significant reduction in leaf length was observed due to pre-harvest sprays of growth regulators and chemicals. The least leaf length (22.06 cm) was recorded T_5 (CCC 1000 ppm + Carbendazim 1000 ppm) and this treatment was *on par* with T_1 (23.99 cm), T_4 (22.78 cm), T_6 (23.53 cm,) and T_8 (22.74 cm), and the highest leaf length (26.63 cm) was recorded in T_9 (control).

4.2.4 Leaf breadth (cm)

The data recorded on leaf breadth as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 12.

The mean leaf breadth was recorded before the pre-harvest sprays of growth regulators and chemicals was 0.91 cm. Significant differences were observed among the different treatments due to pre-harvest sprays of growth regulators and chemicals. The highest leaf breadth (1.03 cm) was recorded T_4 (CCC 1000 ppm) which was *on par* with T_1 (0.97 cm), T_2 (0.99 cm) and T_3 (0.96 cm) and the least leaf breadth (0.91 cm) was recorded in T_9 (control).

4.2.5 Collar diameter (mm)

The data recorded on collar diameter as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 12.

The mean collar diameter of 8.16 mm was recorded a week before the pre-harvest sprays of growth regulators and chemicals. Significant differences were observed among the different treatments with reference to collar diameter due to pre-harvest sprays of growth regulators and chemicals at harvest. The highest collar diameter (9.11 mm) was recorded in T_4 (CCC 1000 ppm) and was *on par* with T_2 (8.45 mm), T_6 (8.55 mm), T_7 (8.63 mm) and T_8 (8.27 mm) and least collar diameter (7.58 mm) was recorded in T_9 (control).

Table 12: Effect of pre-harvest sprays of growth regulators and chemicals on leaf length, leaf breadth and collar diameter of garlic cv. Vannur Local during *rabi* season of 2010 – 2011

Treatment		Leaf length (cm)		Leaf breadth (cm)		Collar diameter (mm)	
		Before spray	After spray	Before spray	After spray	Before spray	After spray
T_1	Maleic hydrazide (MH) 2500 ppm	23.56	23.99	0.90	0.97	8.21	8.10
T_2	MH 2500 ppm + Carbendazim 1000 ppm	24.28	24.71	0.91	0.99	8.36	8.45
T_3	MH 2500 ppm + Dithane M-45 1000 ppm	24.48	25.24	0.88	0.96	7.56	7.65
T_4	Cycocel (CCC) 1000 ppm	22.68	22.78	0.95	1.03	9.02	9.11
T_5	CCC 1000 ppm + Carbendazim 1000 ppm	21.96	22.06	0.88	0.92	8.21	8.03
T_6	CCC 1000 ppm + Dithane M- 45 1000 ppm	22.09	23.52	0.84	0.92	8.46	8.55
T_7	Borax 1000 ppm	22.90	24.33	0.93	1.01	7.94	8.63
T_8	Borax 1000 ppm + Carbendazim 1000 ppm	22.31	22.74	1.01	1.01	8.18	8.27
T_9	Control (Unsprayed)	22.53	26.63	0.89	0.91	7.51	7.58
	Mean	**22.98**	**24.00**	**0.91**	**0.97**	**8.16**	**8.25**
	S. Em ±	0.64	0.72	0.03	0.03	0.29	0.29
	C. D. (p= 0.05)	NS	2.17	NS	0.08	NS	0.86
	CV (%)	4.83	5.22	6.05	4.48	6.10	6.05

Note- NS = Non -significant   Sprays were given as per treatments three weeks before harvest.
MH - Maleic hydrazide   CCC - Cycocel

4.2.6 Bulb weight (g)

The data pertaining to bulb weight as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

There were no significant differences among different treatments with reference to bulb weight due to pre-harvest sprays of growth regulators and chemicals. However, the highest bulb weight (38.67 g) was recorded T_5 (CCC 1000 ppm + Carbendazim 1000 ppm) and the least bulb weight (29.33 g) was recorded in T_8.

4.2.7 Bulb diameter (mm)

The data pertaining to bulb diameter as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

The bulb diameter was not affected significantly due to pre-harvest sprays of growth regulators and chemicals. However, the highest bulb diameter (24.54 mm) was recorded T_6 (CCC 1000 ppm + Dithane M-45 1000 ppm) and the least bulb diameter (23.16 mm) was recorded in T_9 (control).

4.2.8 Clove weight (g)

The data recorded on clove weight per bulb as influenced by pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

There were no significant differences among the different treatments with reference to clove weight per bulb. However, the highest clove weight per bulb (6.23 g) was recorded in T_1 (Maleic hydrazide 2500 ppm) and the least clove weight per bulb (5.02 g) was recorded in T_8 (Borax 1000 ppm + Carbendazim 1000 ppm).

4.2.9 Number of cloves per bulb

The data recorded on number of cloves per bulb as influenced by the pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

There were no significant differences among different treatments with reference to number of cloves per bulb due to pre-harvest sprays of growth regulators and chemicals.

Table 13: Effect of pre-harvest sprays of growth regulators and chemicals on yield and yield attributes of garlic cv. Vannur Local during *rabi* season of 2010 - 2011

Treatment		Weight of five bulbs (g)	Bulb diameter (mm)	Weight of cloves per bulb (g)	Number of cloves per bulb	Bulb yield (kg/plot)	Bulb yield (t/ha)
T_1	Maleic hydrazide (MH) 2500 ppm	36.67	23.22	6.23	19.93	3.06	6.81
T_2	MH 2500 ppm + Carbendazim 1000 ppm	30.67	23.28	5.34	19.53	2.57	5.70
T_3	MH 2500 ppm + Dithane M-45 1000 ppm	29.33	23.42	5.32	17.80	2.91	6.47
T_4	Cycocel (CCC) 1000 ppm	34.00	23.08	6.15	19.53	3.29	7.31
T_5	CCC 1000 ppm + Carbendazim 1000 ppm	38.67	23.78	5.61	19.53	2.68	5.96
T_6	CCC 1000 ppm + Dithane M- 45 1000 ppm	36.00	24.54	5.40	20.27	3.17	7.04
T_7	Borax 1000 ppm	32.67	23.81	5.32	17.67	3.04	6.76
T_8	Borax 1000 ppm + Carbendazim 1000 ppm	29.33	23.57	5.02	20.00	2.59	5.75
T_9	Control (Unsprayed)	32.00	23.16	5.36	18.43	3.13	6.95
	Mean	**33.26**	**23.54**	**5.53**	**19.19**	**2.94**	**6.53**
	S. Em ±	3.51	0.79	0.25	1.02	0.40	0.89
	C. D. (p= 0.05)	NS	NS	NS	NS	NS	NS
	CV (%)	18.28	5.84	7.89	9.18	23.66	23.66

Note- NS = Non-significant Sprays were given as per treatments three weeks before harvest.
MH - Maleic hydrazide CCC - Cycocel

Plate 5: Bulbs of garlic cv. Vannur Local in Experiment-II

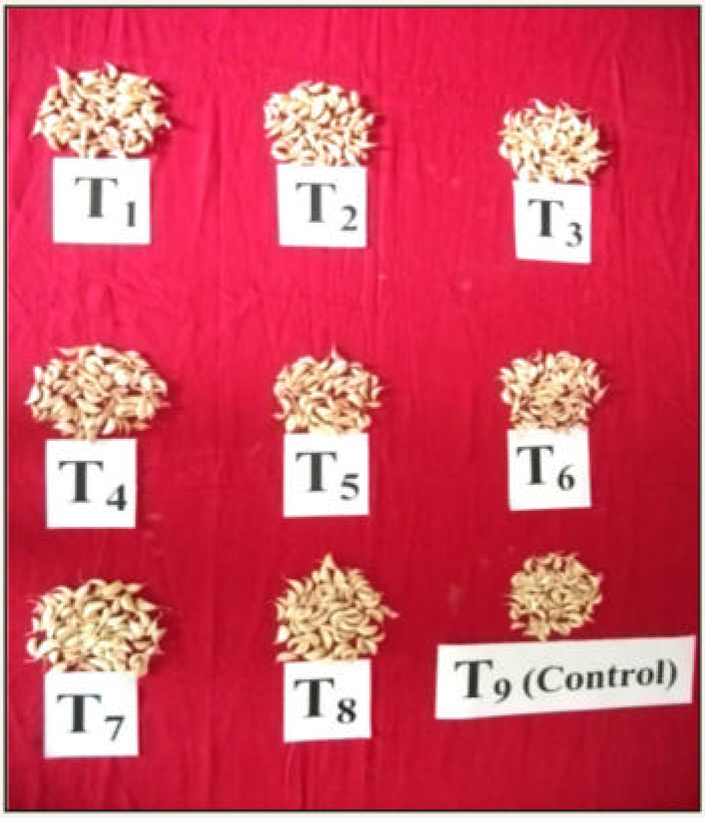


Plate 6: Cloves of garlic cv. Vannur Local in Experiment-II

T_1- Maleic hydrazide (MH) 2500 ppm

T_2- MH 2500 ppm + Carbendazim 1000 ppm

T_3- MH 2500 ppm + Dithane M-45 1000 ppm

T_4- Cycocel (CCC) 1000 ppm

T_5- CCC 1000 ppm + Carbendazim 1000 ppm

T_6- CCC 1000 ppm + Dithane M-45 1000 ppm

T_7- Borax 1000 ppm

T_8- Borax 1000 ppm + Carbendazim1000 ppm

T_9- Control (Unsprayed)

Maximum number of cloves per bulb (20.27) was recorded T_6 (CCC 1000 ppm + Dithane M-45 1000 ppm) and the minimum number of cloves per bulb (17.67) was recorded in T_7.

4.2.10 Bulb yield (kg/ plot)

The data pertaining to bulb yield per plot as influenced by the pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

The bulb yield per plot was not affected significantly by pre-harvest sprays of growth regulators and chemicals. The highest bulb yield per plot (3.29 kg) was obtained in T_4 (Cycocel 1000 ppm) and the least bulb yield per plot (2.57 kg) was recorded in T_2 (MH 2500 ppm + Carbendazim 1000 ppm)

4.2.11 Bulb yield (t ha^{-1})

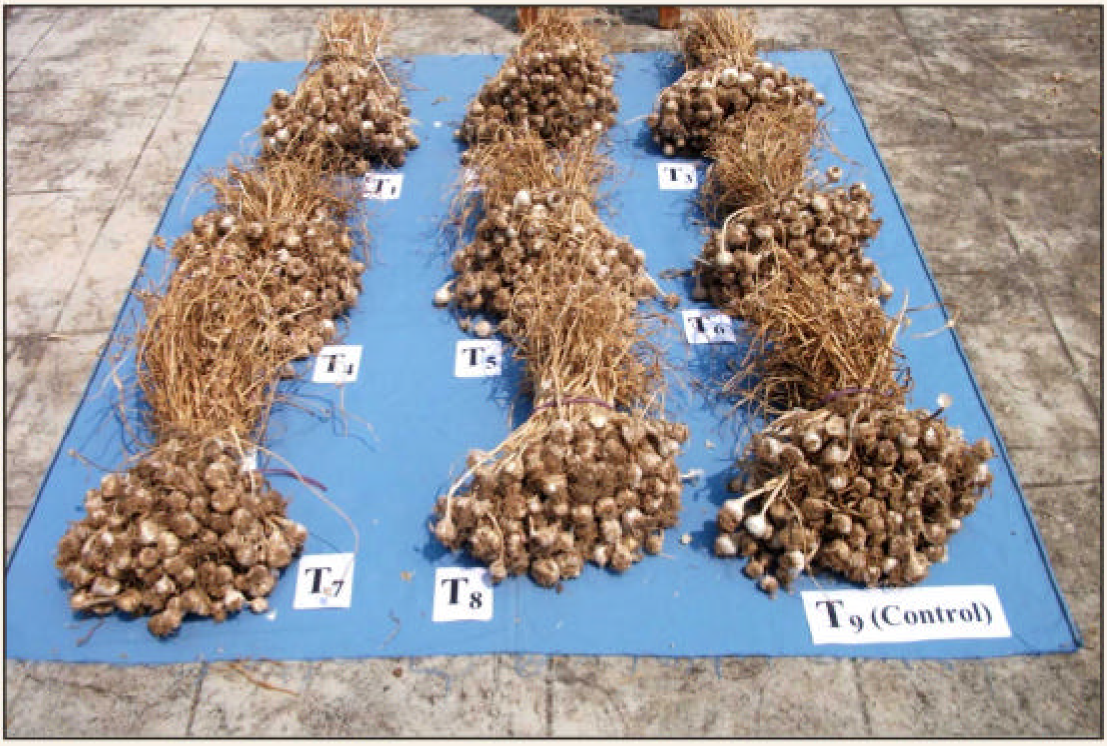
The data on bulb yield per hectare as influenced by the pre-harvest sprays of growth regulators and chemicals is presented in Table 13.

There was no significant difference among different treatments with reference to bulb yield per hectare. However, the highest bulb yield per hectare (7.31 t ha^{-1}) was recorded in T_4 (Cycocel 1000 ppm) and the least bulb yield per hectare (5.70 t ha^{-1}) was obtained from T_2.

4.2.12 Physiological loss in weight (PLW %)

The data pertaining to physiological loss in weight as influenced by pre-harvest sprays of growth regulators and chemicals at different storage durations is presented in Table 14.

Significant differences were observed among different treatments with reference to physiological loss in weight at all the stages of storage except at 30 days after storage (DAS). At 30 DAS, the least physiological loss in weight (3.22%) was observed in T_7 (Borax 1000 ppm) while, the highest physiological loss in weight (4.66%) was observed in T_6. At 60 DAS, the least cumulative physiological loss in weight (6.40%) was observed in T_1 (MH 2500 ppm) and it was *on par* with T_2 (7.13%), T_4 (8.17%), T_5 (7.53%), T_6 (7.02%), T_7 (8.07%) and T_8 (8.33%) and highest physiological loss in weight (10.73%) was



T_1- Maleic hydrazide (MH) 2500 ppm
T_2- MH 2500 ppm + Carbendazim 1000 ppm
T_3- MH 2500 ppm + Dithane M-45 1000 ppm
T_4- Cycocel (CCC) 1000 ppm
T_5- CCC 1000 ppm + Carbendazim 1000 ppm
T_6- CCC 1000 ppm + Dithane M-45 1000 ppm
T_7- Borax 1000 ppm
T_8- Borax 1000 ppm + Carbendazim1000 ppm
T_9- Control (Unsprayed)

Plate 7: Comparative bulb yield per plot of garlic cv. Vannur Local in Experiment-II

Table 14: Effect of pre-harvest sprays of growth regulators and chemicals on cumulative physiological loss in weight (PLW %) and recovery of healthy cloves of garlic cv. Vannur Local in storage life

Treatment		Cumulative physiological loss in weight (%)						Recovery of healthy cloves (%) at the end of storage life
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	180 DAS	
T_1	Maleic hydrazide (MH) 2500 ppm	3.77	6.40	13.23	16.97	23.17	31.97	35.35
T_2	MH 2500 ppm + Carbendazim 1000 ppm	4.31	7.13	12.77	17.93	23.83	30.67	39.64
T_3	MH 2500 ppm + Dithane M-45 1000 ppm	4.44	8.97	12.70	19.10	27.53	34.93	33.27
T_4	Cycocel (CCC) 1000 ppm	3.63	8.17	12.63	17.93	24.87	33.33	39.48
T_5	CCC 1000 ppm + Carbendazim 1000 ppm	3.60	7.53	11.35	17.33	25.53	34.07	35.82
T_6	CCC 1000 ppm + Dithane M- 45 1000 ppm	4.66	7.20	11.93	17.33	24.17	33.10	41.04
T_7	Borax 1000 ppm	3.22	8.07	13.47	18.30	25.60	34.80	32.46
T_8	Borax 1000 ppm + Carbendazim 1000 ppm	4.51	8.33	14.00	19.43	27.27	34.43	34.67
T_9	Control (Unsprayed)	4.13	10.73	17.47	23.84	29.83	39.57	24.41
	Mean	**4.03**	**8.06**	**13.28**	**18.69**	**25.76**	**34.10**	**35.24**
	S. Em ±	0.62	0.76	1.06	1.17	1.15	1.49	2.91
	C. D. (p= 0.05)	NS	2.29	3.18	3.50	3.44	4.47	8.71
	CV (%)	26.80	16.40	13.81	10.82	7.71	7.57	14.30

Note- NS = Non-significant   Sprays were given as per treatments three weeks before harvest.   DAS- Days after storage
MH - Maleic hydrazide   CCC - Cycocel

observed in T_9 (control). At 90 DAS, significantly least cumulative physiological loss in weight (11.35%) was recorded in T_5 (CCC 1000 ppm + Carbendazim 1000 ppm) and it was *on par* with all other treatments except T_9 (control), whereas the highest physiological loss in weight (17.47%) was recorded in T_9 (control). At 120 DAS, significantly least cumulative physiological loss in weight (16.97%) was recorded in T_1 (MH 2500 ppm) and it was *on par* with all other treatments except T_9 (control) while, the highest physiological loss in weight (23.84%) was recorded in T_9 (control). At 150 DAS, significantly least cumulative physiological loss in weight (23.17%) was recorded in T_1 (MH 2500 ppm) and it was *on par* with T_2 (23.83%), T_4 (24.87%), T_5 (25.53%), T_6 (24.17%) and T_7 (25.60%) whereas the highest physiological loss in weight (29.83%) was recorded in T_9 (control). At 180 DAS, significantly least cumulative physiological loss in weight (30.67%) was recorded in T_2 (MH 2500 ppm + Carbendazim 1000 ppm) and it was *on par* with all other treatments except T_9 (control). Significantly highest physiological loss in weight (39.57%) was recorded in T_9 (control).

4.2.13 Recovery of healthy cloves (%)

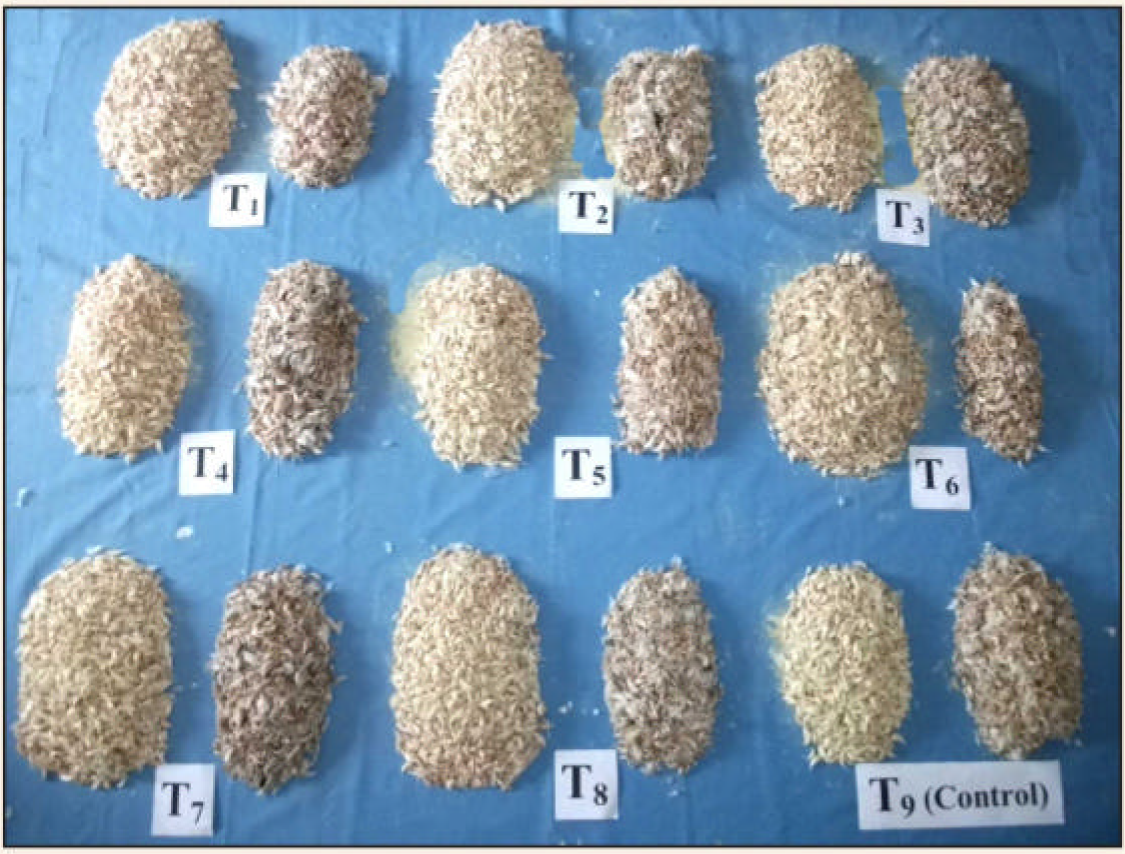
The data pertaining to recovery of healthy cloves at the end of storage period of 180 days as influenced by the pre-harvest sprays of growth regulators and chemicals is presented in Table 14.

The highest recovery of healthy cloves (41.04%) was recorded in T_6 (CCC 1000 ppm + Dithane M-45 1000 ppm) and it was *on par* with all other treatments except T_9 (control). The recovery of healthy cloves (24.41%) was least in T_9 (control) and was *on par* with T_7 (32.46 %)

4.2.14 Vigour of garlic seedlings after storage

The data pertaining to vigour of garlic seedlings after storage period of 180 days as influenced by the pre-harvest sprays of growth regulators and chemicals during previous season is presented in Table 15.

Significant differences were observed due to previous season treatments with reference to vigour (Plant height). However, the data pertaining to number of leaves per plant, leaf length and breadth and plant diameter were non significant. Significantly highest



T_1- Maleic hydrazide (MH) 2500 ppm
T_2- MH 2500 ppm + Carbendazim 1000 ppm
T_3- MH 2500 ppm + Dithane M-45 1000 ppm
T_4- Cycocel (CCC) 1000 ppm
T_5- CCC 1000 ppm + Carbendazim 1000 ppm
T_6- CCC 1000 ppm + Dithane M-45 1000 ppm
T_7- Borax 1000 ppm
T_8- Borax 1000 ppm + Carbendazim1000 ppm
T_9- Control (Unsprayed)

Plate 8: Recovery of healthy cloves of garlic cv. Vannur Local in Experiment-II

Table 15: Initial vigour of garlic cv. Vannur Local after storage period of 180 days during *rabi* season of 2011 - 2012

Treatment		30 Days after sowing (DAS)				
		Plant height (cm)	**No. of leaves per plant**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Collar diameter (mm)**
T_1	Maleic hydrazide (MH) 2500 ppm	22.39	4.53	11.58	0.45	3.29
T_2	MH 2500 ppm + Carbendazim 1000 ppm	22.73	4.27	12.05	0.47	3.36
T_3	MH 2500 ppm + Dithane M-45 1000 ppm	19.28	4.35	10.30	0.42	3.52
T_4	Cycocel (CCC) 1000 ppm	21.19	4.27	10.63	0.38	3.20
T_5	CCC 1000 ppm + Carbendazim 1000 ppm	21.93	4.60	11.73	0.39	3.31
T_6	CCC 1000ppm + Dithane M- 45 1000 ppm	22.63	4.47	11.88	0.39	3.53
T_7	Borax 1000 ppm	22.03	4.60	10.96	0.42	3.12
T_8	Borax 1000 ppm + Carbendazim 1000 ppm	22.14	4.13	10.68	0.39	3.19
T_9	Control (Unsprayed)	18.16	4.20	10.72	0.38	3.46
	Mean	**21.39**	**4.05**	**11.17**	**0.41**	**3.33**
	S. Em ±	0.95	0.16	0.84	0.04	0.19
	C. D. (p= 0.05)	2.85	NS	NS	NS	NS
	CV (%)	7.69	6.22	13.02	15.61	9.80

Note- NS = Non-significant Sprays were given as per treatments three weeks before harvest during previous season. DAS- Days after sowing
MH - Maleic hydrazide CCC - Cycocel

plant height (22.73 cm) was recorded in cloves obtained from storage treatment T_2 (MH 2500 ppm + Carbendazim 1000 ppm) and it was *on par* with T_1 (22.39 cm), T_4 (21.19 cm), T_5 (21.93 cm), T_6 (22.63 cm) T_7 (22.03 cm) and T_8 (22.14 cm) and the least plant height (18.16 cm) was recorded in cloves obtained from T_9 (control). The highest number of leaves per plant (4.60) was observed in cloves obtained from T_5 and T_7 and the least number of leaves per plant (4.13) were observed in T_8. The highest leaf length (12.05 cm) was observed in cloves obtained from T_2 and the least leaf length (10.30 cm) was observed in T_3. Highest leaf breadth (0.47 cm) was observed in cloves obtained from T_2 while the least leaf breadth (0.38 cm) was observed in T_4 & T_9 (control). The treatment T_6 recorded the highest collar diameter of 3.53 mm whereas T_7 recorded the least collar diameter (3.12 mm).

5. DISCUSSION

Organic production enhances the soil health and helps in producing quality food besides reducing the underground water pollution because of leaching of nitrogenous fertilizers. Hence, the investigation on impact of organic sources of nitrogen in combination with inorganic sources has become important to study the growth, yield and quality of crop plants. Among the spices, garlic is an important spice grown commercially in India. Information on the use of organic farming alongwith inorganic fertilizers is meager and it is not advisable to dispense with the use of chemical fertilizers abruptly. So, the whole strategy should be to use chemical fertilizers and organic manures for high and sustainable crop production. The results of the field experiments conducted on the effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic and nutrient uptake are discussed here under.

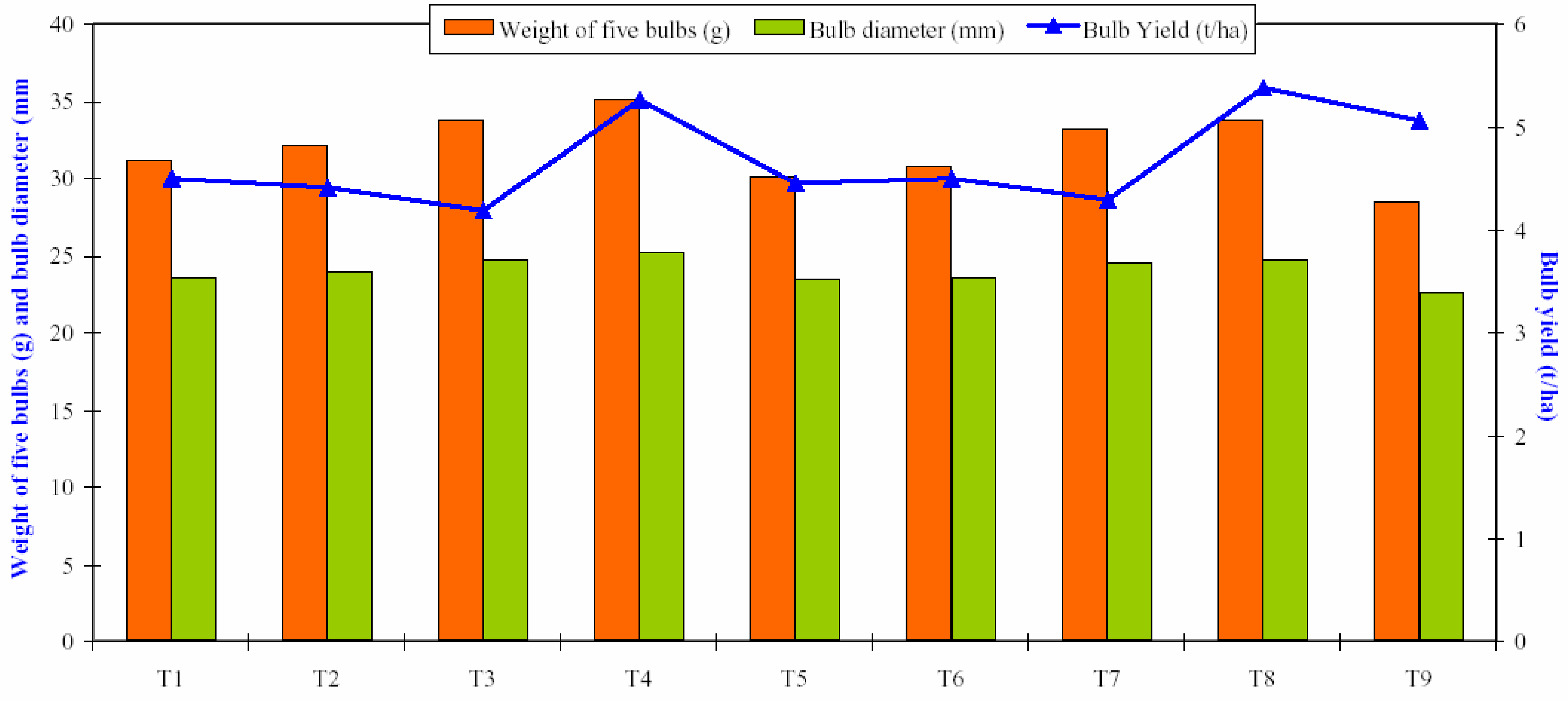
5.1 Experiment I: Effect of organic and inorganic sources of nitrogen on growth, yield and quality

5.1.1 Effect of organic and inorganic sources of nitrogen on growth and growth attributes

Growth and growth attributes like plant height, number of leaves per plant, leaf length, leaf breadth and collar diameter were influenced by inorganic and organic sources of nitrogen in the form of farm yard manure and vermicompost. The results obtained in the present investigations confirm with the earlier findings of Selvaraj *et al.* (1993), Seno *et al.* (1995), Lal *et al.* (2002), Chattopadhyay *et al.* (2006), Gowda *et al.* (2007), Ranjan *et al.* (2010), Verma *et al.* (2011), Pratap *et al.* (2011), Rohidas *et al.* (2011) and Puttaraju *et al.* (2011), who reported better growth of garlic and onion crops with application of organic and inorganic sources of nutrients.

5.1.2 Effect of organic and inorganic sources of nitrogen on yield and quality

The bulb yield of garlic was significantly influenced due to application of nitrogen through organic and inorganic sources of nitrogen (Fig. 3). The highest bulb yield (5.36 t ha^{-1}) was recorded in T_8 (100 % RDN through vermicompost) which was *on par* with T_4 (5.24 t ha^{-1}) and T_9 (5.04 t ha^{-1}). These results are supported by the earlier findings of Verma *et al.* (2011), Pratap *et al.* (2011), Gowda *et al.* (2007), Mamatha *et al.* (2006),



T_1- 25% RDN through FYM + 75% RDN through urea
T_2-50% RDN through FYM + 50% RDN through urea
T_3-75% RDN through FYM + 25% RDN through urea
T_4-100% RDN through FYM
T_5-25% RDN through VC + 75% RDN through urea
T_6- 50% RDN through VC + 50% RDN through urea
T_7- 75% RDN through VC + 25% RDN through urea
T_8-100% RDN through VC
T_9- 100% RDF (Control)

Fig. 3: Yield parameters of garlic cv. Vannur Local as influenced by soil application of organic and inorganic sources of nitrogen (Experiment-I)

Dhankhar *et al.* (2011) and Patel *et al.* (2011). The yield attributing character like weight of bulb, bulb diameter, weight of cloves increased progressively with the increased level of FYM and VC. These results are supported by the earlier findings of Jambhekar (1996), Rosen and Tong (2001), Lal *et al.* (2002) and Patil *et al.* (2007). Sufficient supply of organic manures has increased growth and yield attributing characters. Organic manures also increased the adsorption power of the soil for nutrient exchange.

The favourable effects of organic manures on quality parameters in crop plants have been reported by several scientists (Mamatha *et al.*, 2006, Naruka and Rathore, 2005, Qureshi and Lawande, 2006). In the present investigations higher sulphur concentration was recorded in T_8 (0.040%) and T_4 (0.038%). This might be due to supply of sulphur from organic sources which might have helped in synthesis of sulphur containing amino acids from organic manures.

5.1.3 Effect of organic and inorganic sources of nitrogen on dry matter accumulation

Dry matter accumulation was highest in both 100 per cent FYM and 100 per cent VC as nitrogen sources at all the crop growth stages. Increased dry matter content might be due to better chlorophyll synthesis as organic sources contain appreciable quantities of magnesium. These results are in conformity with the earlier findings of Mallanagouda *et al.* (1995).

5.1.4 Effect of organic and inorganic sources of nitrogen on nutrient uptake

In the present investigation highest amount of nitrogen uptake was recorded in T_4 (100% RDN through FYM) and T_8 (100% RDN through vermicompost). This may be due to the higher proportion of nitrogen available in the soil due to higher application of organic sources of nitrogen. These results are in conformity with the earlier findings of Mamatha *et al.* (2006), Gasti *et al.* (2011c) and Shashidhar *et al.* (2005).

5.1.5 Physico-chemical properties and available nutrient status of soil after harvest of the crop

5.1.5.1 Physico-chemical properties

Physico-chemical properties of the soil were enhanced due to application of organic and inorganic sources of nitrogen. Physico-chemical properties of soil like organic carbon, electrical conductivity and P^H increased with the substitution of farm yard manure and vermicompost at the rate of 25, 50, 75 and 100 per cent RDN. These results are in agreement with the earlier findings of Mamatha *et al.* (2006) and Singh *et al.* (2001). This may be attributed to the direct addition of organic matter in the form of farm yard manure and vermicompost to the soil.

5.1.6 Available nutrients in soil

The data on soil analysis after the harvest of the garlic crop indicated that NPK and S content varied significantly due to different treatments. NPK and S contents increased due to supplementation with organic manures in different proportions (Fig. 4).

5.1.6.1 Available nitrogen

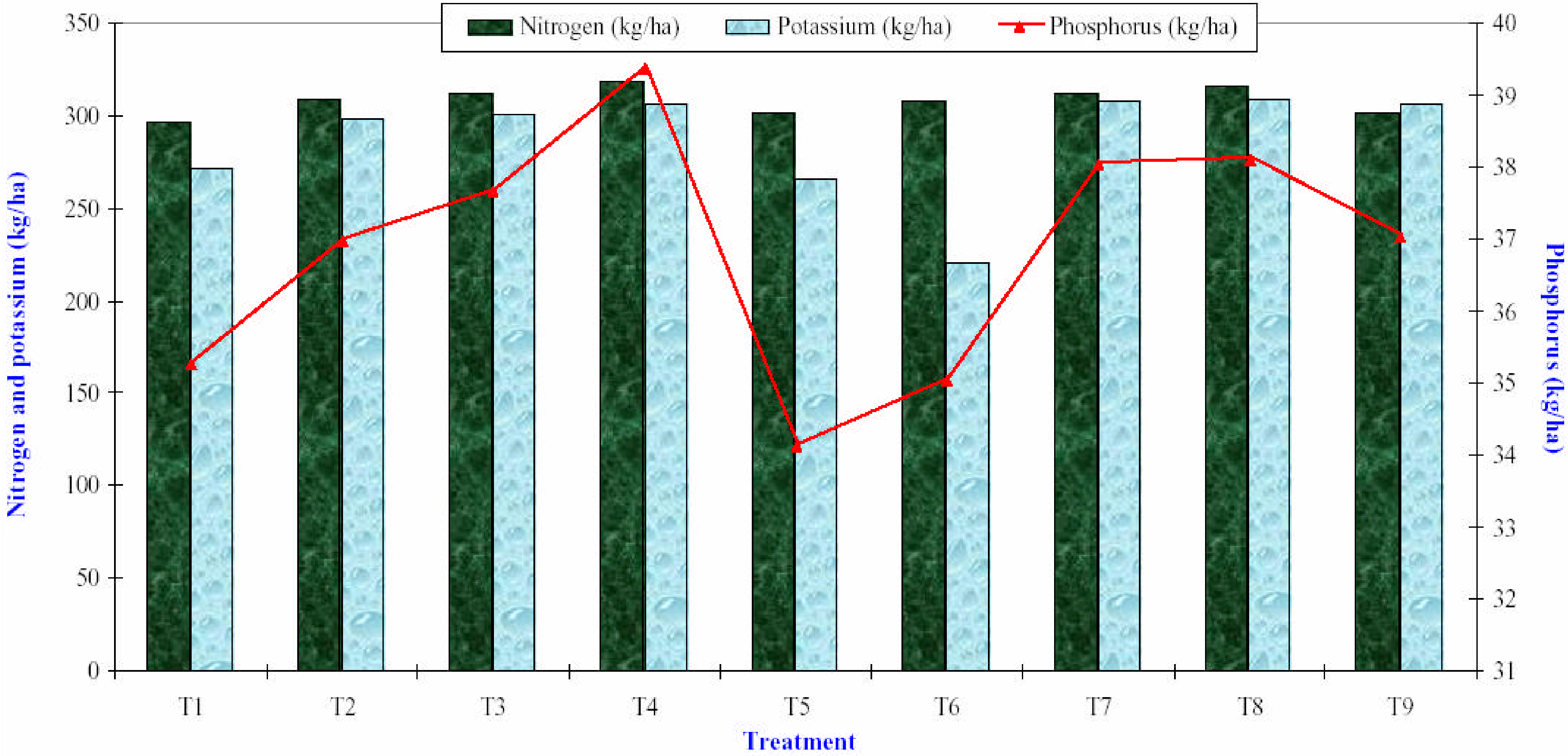
There was a buildup of available nitrogen due to different treatments. This might be due to the improvement of soil physical conditions which might have favored the microbial activity and mineralization process by the application of organics. Many workers have observed improvement in available soil nitrogen due to the application of organic manures which might be due to greater capacity of organic colloid's to adsorb NO_3 and NH_4 in the form of nitrogen. These results are in conformity with the earlier findings of Mamatha *et al.* (2006), Singh and Singh (1995) and Patil (1995).

5.1.6.2 Available phosphorus

Organic and inorganic sources of nitrogen had significant effect on the available phosphorus status of the soil. Similar results have been reported earlier by Mamatha *et al.* (2006), Patil (1995), Gasti *et al.* (2011) and Shashidhar *et al.* (2005). The highest recovery of available phosphorus in organic manure treatments might be due to solubilization of soil phosphorus by organic acid produced during decomposition/mineralization of organic manures and release of phosphorus contained in the organic manures. It might also be due to the formation of soluble complexes between humic/fulvic acids and phosphate.

5.1.6.3 Available potassium

Potassium content increased with increase in the application of organic and inorganic sources of nitrogen. The increase might be due to the direct contribution of potassium to the pool of available potassium in the soil due to addition of organic and inorganic sources of nitrogen. Similar results have been reported by Mamatha *et al.* (2006), Patil (1995), Gasti *et al.* (2011) and Shashidhar *et al.* (2005).



T_1- 25% RDN through FYM + 75% RDN through urea; T_2-50% RDN through FYM + 50% RDN through urea; T_3-75% RDN through FYM + 25% RDN through urea; T_4-100% RDN through FYM; T_5-25% RDN through VC + 75% RDN through urea; T_6- 50% RDN through VC + 50% RDN through urea; T_7- 75% RDN through VC + 25% RDN through urea; T_8-100% RDN through VC; T_9- 100% RDF (Control)

Fig. 4: Available nutrient status of soil (kg/ha) after harvest of garlic crop as influenced by soil application of organic and inorganic sources of nitrogen (Experiment-I)

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5.1.6.4 Available sulphur

The available sulphur content in the soil increased with the application of organic and inorganic sources of nitrogen compared to control. The increase in the sulphur content might be due to direct contribution of sulphur from organic and inorganic sources of nitrogen applied to the soil. These results support the earlier findings of Mamatha *et al.* (2006).

5.1.7 Economics of cultivation

The economics worked out for different organic and inorganic sources of nitrogen for cultivation of garlic revealed that highest gross returns (2.68 lakhs) were obtained in T_8 (100 per cent RDN through VC) which was followed by T_4 -100 per cent RDN through farm yard manure (2.62 lakhs). Gross returns obtained in 100 per cent organic nitrogen supplements are higher when compared to T_9 (2.52 lakhs). But due to the higher cost of farm yard manure and vermicompost, the net returns decreased compared to control T_9 (100% RDF). The highest benefit cost ratio (1: 2.79) was recorded in T_9 (100 % RDF) compared to T_1 (1:2.17) and T_4 (1: 2.16). But application of organic sources of nitrogen in the form of farm yard manure is found to improve the soil properties compared to control. In the long run this might be beneficial for sustainable crop production, as soil health also should be taken into consideration. In addition, the crop plants are generally known to respond to organics over a longer period of time. These factors favour the partial substitution of inorganic with organic manures. Hence, T_9 (100 % RDF) which has recorded highest benefit cost ratio (1:2.79) may be profitable in short term and T_1 (1:2.17), T_4 (1: 2.16) and T_8 (1: 2.13) which have also recorded next highest B:C ratio can be profitable in the long run. These results support the earlier findings of Verma *et al.* (2011), Pratap *et al.* (2011) and Puttaraju *et al.* (2011).

5.2 Experiment II: Effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic

Garlic is a seasonal crop and is grown in *rabi* season for commercial production in Belgaum district of Karnataka. The garlic bulbs obtained from *rabi* season crop needs to be stored until next *rabi* season. Significant losses in quality and quantity of garlic occur during storage due to desiccation, decay and sprouting of which results in price rise in the market. Pre-harvest sprays of growth regulators and chemicals are known to enhance the storage life of bulb crops. The results obtained from present the investigation on pre-harvest sprays of growth regulators and chemicals are discussed hereunder.

5.2.1 Effect of pre-harvest sprays of growth regulators and chemicals on growth and yield

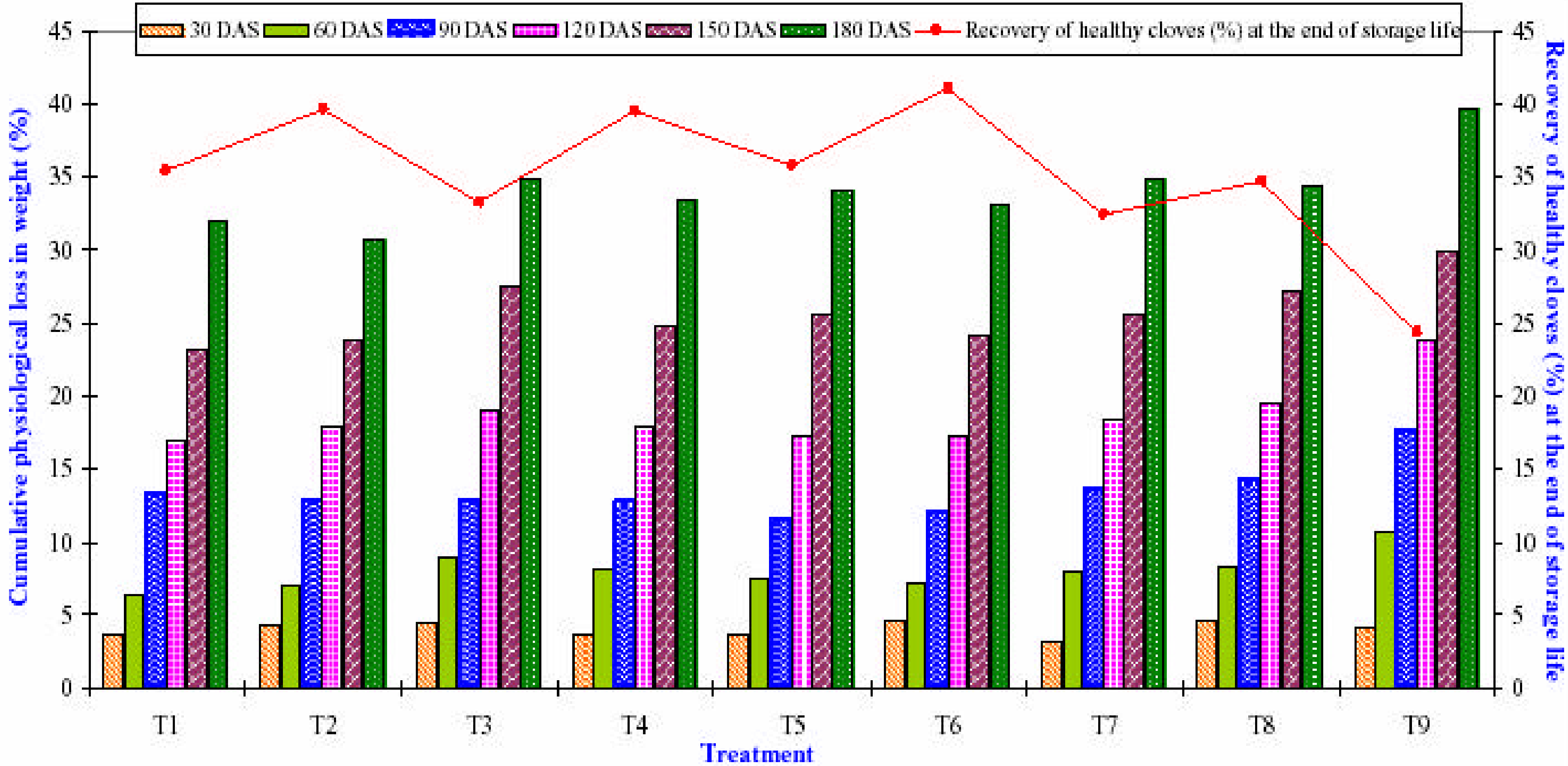
Pre-harvest sprays of growth regulators and chemicals influenced the growth parameters like plant height, number of leaves per plant, leaf length and breadth of leaves and collar diameter. There was suppression of plant height, reduction in the number of leaves, increase in leaf breadth and collar diameter due to pre-harvest sprays of growth regulators and chemicals. This may be due to the effect of growth retardants which suppress the growth.

However, yield and yield parameters were not affected by the pre-harvest sprays of growth regulators and chemicals. Treatments T_4 (Cycocel 1000 ppm) and T_6 (Cycocel 1000 ppm + Dithane M-45 1000 ppm) recorded higher bulb yield due to pre-harvest sprays of growth regulators and chemicals. These results confirm the earlier findings of Memane *et al.* (2008), Singh *et al.* (2008), Gasti *et al.* (2011), Sankar *et al.* (2011) and Anbukkarasi *et al.* (2011).

5.2.2 Effect of pre-harvest sprays of growth regulators and chemicals on physiological loss in weight and recovery of healthy cloves

Pre-harvest sprays of growth regulators and chemicals significantly reduced the cumulative physiological loss in weight in storage compared to control (Fig. 5).

Pre-harvest sprays of growth regulators and chemicals enhanced the recovery of healthy cloves compared to control. These results support the earlier findings of Sinclair (1985), Sidhu and Chadha (1986), Abdul (1988), Gopalkrishnarao (1998), Vijayakumar *et al.* (1989), Akhilesh *et al.* (2010) and Kukanoor *et al.* (2007). All the pre-harvest sprays of growth regulators and chemicals were found to be significantly superior in reducing the physiological loss in weight and enhancing the recovery of healthy cloves. This may be due to reduction in the moisture loss because of pre-harvest sprays of growth regulators and chemicals. Pre-harvest spray of maleic hydrazide is known to reduce the cell division after harvest and retain cell structural integrity in the apical region (Masters *et al.* 1985).



T_1- Maleic hydrazide (MH) 2500 ppm
T_2- MH 2500 ppm + Carbendazim 1000 ppm
T_3- MH 2500 ppm + Dithane M-45 1000 ppm
T_4- Cycocel (CCC) 1000 ppm
T_5- CCC 1000 ppm + Carbendazim 1000 ppm
T_6- CCC 1000 ppm + Dithane M-45 1000 ppm
T_7- Borax 1000 ppm
T_8- Borax 1000 ppm + Carbendazim100 ppm
T_9- Control (unsprayed)

Fig 5: Effect of pre-harvest sprays of growth regulators and chemicals on cumulative physiological loss in weight (%) and recovery of healthy cloves at the end of storage life of garlic cv. Vannur Local

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5.2.3 Vigour of garlic seedlings after storage

The vigour of garlic seedlings with reference to plant height was significantly influenced by previous season. Pre-harvest sprays of growth regulators and chemicals compared to unsprayed control. This may be due to reduced physiological loss in weight in storage in treatments involving pre-harvest sprays of growth regulators and chemicals.

Practical utility

Following inference of practical utility can be drawn based on discussion

1. Integrating the nutrient supply through organics and inorganic has resulted in increase in bulb yield and improvement in quality of garlic. Supplementation of 25, 50, 75 and 100 per cent RDN through organics needs to be experimented in the long run

2. Application of 75 per cent or 100 per cent nitrogen through farm yard manure and vermicompost and 100 per cent RDF recorded the maximum net returns and has been found to be economically viable treatments.

3. Pre-harvest sprays of growth regulators like maleic hydrazide 2500 ppm + carbendazim 1000 ppm were found to significantly reduce the physiological loss in weight of the garlic bulbs in storage over a period of six months. This resulted in higher recovery of healthy cloves in MH 2500 ppm + carbendazim 1000 ppm which was *on par* with cycocel 1000 ppm + dithane M- 45 1000 ppm. These growth regulators can be employed to reduce the storage losses and to recover higher proportion of healthy cloves.

Future line of work

1. Long term trials of organic manures needs to be conducted to know the effect of organic manures on garlic as well as on the physico-chemical and biological properties of soils.

2. Applications of higher doses of organic manures with reduced level of inorganic fertilizers to the crop may be undertaken.

3. Studies on nutrient releasing pattern from organic sources to plant needs to be studied.

6. SUMMARY AND CONCLUSIONS

Field experiments were conducted to study the effect of organic and inorganic sources of nitrogen on growth, yield and quality and pre-harvest sprays of growth regulators and chemicals on storage life of garlic cv. Vannur local at the experimental field of Spices and Plantation crops Department, Kittur Rani Channamma College of Horticulture, Arabhavi under irrigated condition during *rabi* season in 2010-2011 and 2011-2012. The salient findings of the study are summarized hereunder.

6.1 Experiment I: Effect of organic and inorganic sources of nitrogen on growth, yield and quality of garlic

Application of organic manures in the form of either farm yard manure or vermicompost in different proportions to supplement nitrogen significantly influenced the vegetative parameters like plant height, number of leaves per plant, leaf length and breadth of leaves and collar diameter at different stages of crop growth.

Bulb yield of garlic was significantly influenced by substitution of inorganic nitrogen by organic sources. Treatment T_4 (100 % RDN - FYM), T_8 (100 % RDN - VC) and T_9 (100 % RDF) recorded higher bulb yield and they differed significantly with all other treatments. Yield attributes like weight of bulb and bulb diameter differed significantly due to different treatments. However, the number of cloves per bulb and weight of cloves were not affected by different treatments.

There was a significant difference in dry matter accumulation due to different treatments at all the crop growth stages. Higher dry matter accumulation was recorded in T_4 (100 % RDN- FYM) and T_8 (100 % RDN- VC) compared to other treatments.

Sulphur concentration (%) in garlic bulbs was significantly influenced by organic and inorganic sources of nitrogen and it was highest (0.040 %) was recorded in T_8 (100 % RDN- VC) and was *on par* with T_4 (100 % RDN- FYM).

The total uptake of nitrogen was influenced significantly by organic and inorganic sources of nitrogen. The nitrogen uptake showed an increasing trend with increase in the proportion of organic manures. Application of 100 per cent farm yard manure and 100 per cent vermicompost recorded highest total nitrogen uptake (29.37 kg ha $^{-1}$ and 29.51 kg ha^{-1}, respectively).

There was improvement in the physico-chemical properties of soil after the harvest of garlic due to application of 100 per cent RDN through farm yard manure and vermicompost. Application of organic manures resulted in an increase in the organic carbon content of the soil and also the electrical conductivity.

Available NPK and S status was enhanced by the application of 100 per cent RDN through farm yard manure and vermicompost.

Higher benefit cost ratio (1:2.79) was recorded in 100 per cent RDF which was followed by T_1 (1:2.17), T_4 (1:2.16) and T_8 (1:2.13).

From this study it can be concluded that, integrating organic and inorganic sources of nitrogen is found to be beneficial in enhancing the yield, quality and nutrient uptake in garlic.

6.2 Experiment II: Effect of pre-harvest sprays of growth regulators and chemicals on storage life

Pre-harvest sprays of growth regulators and chemicals influenced the growth parameters like plant height, number of leaves, leaf length and breadth of the leaves and collar diameter. Both maleic hydrazide 2500 ppm and cycocel 1000 ppm were effective in reducing the plant height, number of leaves, leaf length & breadth of the leaves and collar diameter.

Pre-harvest sprays of growth regulators and chemicals did not affect the yield of garlic significantly. The highest yield was recorded in T_4 (Cycocel 1000 ppm). Pre-harvest sprays of growth regulators and chemicals significantly reduced the cumulative physiological loss in weight compared to control over a period of six months which resulted in highest recovery of healthy cloves in treated plots compared to control.

Growth of garlic seedlings after storage with reference to plant height was influenced by pre-harvest sprays of growth regulators and chemicals of the previous season.

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* - *Originals not seen*

Appendix I: Meteorological data recorded during the experimental period (2010-12) at Agricultural Research Station, Arabhavi

Month	Temperature (°C)		Mean relative humidity (%)	Rainfall (mm)	Evaporation (mm)
	Minimum	Maximum			
November 2010	17.67	32.43	81.25	85.20	2.96
December 2010	13.19	29.99	78.26	0.00	2.90
January 2011	16.76	31.25	71.05	0.0	3.1
February 2011	10.2	31.20	67.04	2.3	3.8
March 2011	16.0	34.84	78.26	0.0	5.1
April 2011	18.2	36.19	65.78	92.0	5.1
May 2011	19.9	36.43	63.03	85.6	5.7
June 2011	20.9	28.88	77.80	81.1	9.7
July 2011	19.9	29.22	81.74	60.2	2.8
August 2011	19.1	28.80	81.35	89.3	2.7
September 2011	18.3	29.75	77.48	26.0	3.3
October 2011	14.7	31.14	73.74	213.7	2.5
November 2011	19.96	29.17	67.95	0.0	3.6
December 2011	16.15	29.46	66.85	0.0	2.8
January 2012	9.3	29.64	67.94	0.0	2.9
February 2012	10.2	32.45	55.39	0.0	4.0
March 2012	16.0	36.33	95.85	0.0	5.17

Appendix II: Nutrient content of Farmyard manure and vermicompost

Sl. No.	Elements	Farmyard manure (%)	Vermicompost (%)
1	Nitrogen	0.70	1.21
2	Phosphorus	0.38	0.86
3	Potassium	0.67	1.01
4	Sulphur	0.23	0.35
5	Calcium	0.18	0.53
6	Magnesium	0.15	0.21

Appendix III: Physical and chemical properties of soil of the experimental site

Sl. No	Parameters	Values
1	**Particle size distribution (%)**	
a	Sand	47.50
b	Silt	17.50
c	Clay	35.00
d	Soil type	Black
2	**Chemical Properties**	
a	pH (1:2.5)	8.10
b	Electrical conductivity ($dSm-^{1}$)	0.37
c	Organic carbon (%)	0.45
d	Available Nitrogen (Kg ha^{-1})	286
e	Available phosphorus (Kg ha^{-1})	27.57
f	Available Potassium (Kg ha^{-1})	196
g	Available Sulphur (Kg ha^{-1})	17.51

Appendix IV: Cost of cultivation (₹/ha) for garlic cv. Vannur Local as per the prevailing prices during April, 2012

Sl. No.	Particulars of	Unit	Rate per unit (₹)	Total units required ha^{-1}	Total cost (₹ /ha)
1.	**Land preparation**				
	a) Tractor b) Bullock pair	Hour Day	500/ha 250/day	2 Hours 1 day	1,000=00 250=00
2.	**Cost of inputs**				
	a) Garlic cloves	Kg	50/kg	500 kg	25,000=00
	b) Fertilizers (NPK ha^{-1})	Kg		125:62.5:62.5	4,346=00
	c) Plant protection chemicals				
	i) Dithane M-45 (Seed treatments)	2 g/kg	320/kg	1 kg	320=00
	ii) Dithane M-45 (spray)	Kg	320/kg	4 kg	1,280=00
3.	**Cost of labour**				
	a) Land preparation	Md	80	4	320=00
	b) Sowing				
	i) Women labour	Md	70	5	350=00
	ii) Men labour	Md	80	2	160=00
	c) Weeding (4 times)	Md	70	15×4 times	4,200=00
	d) Top dressing	Md	70	3	210=00
	e) Irrigation (8 times)	Md	80	4×8 times	2,560=00
	f) plant protection (3 times)	Md	80	2×3 times	480=00
	g) Harvesting	Md	70	10	700=00
	h) Curing and cleaning	Md	70	6	420=00
4.	Manure application (FYM)	tons	1000/ton	25 t ha^{-1}	25,000=00
Total					66,596=00

Md = Man day Women labour =₹ 70/day Men labour =₹ 80/day

Appendix V: Cost of fertilizers and manures for garlic cultivation as per the prevailing market prices during April, 2012

Sl. No	Particulars	Dosage	Cost (₹) /ha
I.	**Inorganic fertilizers**		
	1. Nitrogen (urea ₹ 5.62/kg)		
	a) 100 % N	125 kg N ha^{-1}	1,527
	b) 75 % N	93.75 kg N ha^{-1}	1,145.25
	c) 50% N	62.5 kg N ha^{-1}	763.50
	d) 25 % N	31.25 kg N ha^{-1}	381.75
	2. Phosphorous (SSP ₹ 4.2/kg)		
	a) 100 % P	62.5 kg N ha^{-1}	1,640
	3. Potassium (MOP ₹ 11.32/kg)		
	a) 100 % P	62.5 kg N ha^{-1}	1,179
	Organic manures		
	1. Farmyard manure (₹ 1000/ton)		
	a) 100 % FYM	17.85 t ha^{-1}	17,850
	b) 75 % FYM	13.40 t ha^{-1}	13,400
	c) 50% FYM	8.93 t ha^{-1}	8,930
	d) 25 % FYM	4.47 t ha^{-1}	4,470
II.	2. Vermicompost (₹ 2000/ton)		
	a) 100 % VC	10.33 t ha^{-1}	20,660
	b) 75 % VC	7.75 t ha^{-1}	15,500
	c) 50% VC	5.17 t ha^{-1}	10,340
	d) 25 % VC	2.58 t ha^{-1}	5,160

EFFECT OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON GROWTH, YIELD AND QUALITY AND PRE-HARVEST SPRAYS OF GROWTH REGULATORS AND CHEMICALS ON STORAGE LIFE OF GARLIC (*Allium sativum* L.)

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ABSTRACT

Field experiments were conducted during *rabi*, 2010-2011 at Kittur Rani Channamma College of Horticulture, Arabhavi farm to study the effect of organic and inorganic sources of nitrogen on growth, yield and quality and pre-harvest sprays of growth regulators and chemicals on storage life of garlic. The field trials were laid out in a Randomized Block Design with nine treatments and three replications.

Significant differences were observed among different treatments with reference to plant height, number of leaves per plant, leaf length and breadth and collar diameter due to organic and inorganic sources of nitrogen. Significant differences were also observed with reference to yield parameter like weight of bulbs, bulb diameter, weight of cloves and bulb yield due to nitrogen sources. Significantly highest bulb yield (5.36 t/ha) was recorded in T_8 (100 % RDN through vermicompost) and least bulb yield (4.17 t/ha) was recorded in T_3 (75% RDN through FYM + 25% RDN through urea). Highest B: C ratio (2.71) was recorded in T_9 (100% RDF) and least (1.64) was recorded in T_7 (75% RDN through VC + 25% RDN through urea).

Pre-harvest Sprays of growth regulators and chemicals significantly influenced the plant height, number of leaves per plant, leaf length and breadth and plant diameter. However, the bulb yield was not affected by pre-harvest sprays of growth regulators and chemicals. Pre-harvest Sprays of growth regulators and chemicals significantly reduced the physiological loss in weight upto 180 days of storage. Significantly least cumulative physiological loss in weight (30.67%) was recorded in T_2 (Maleic hydrazide 2500 ppm + Carbendazim 1000 ppm) and highest cumulative physiological loss in weight (39.57%) was recorded in T_9-control (unsprayed) as 180 days of storage. All the growth regulators and chemicals significantly enhance the recovery of healthy cloves compared to control.