" Studies on Integrated Nutrient Management in Onion (*Allium cepa* L.) CV Agrifound Light Red"

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(Vegetable Science)

By

DEVENDRA KUMAR TEMBHARE

DEPARTMENT OF HORTICULTURE
Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur
College of Agriculture
REWA (M.P.)

2011

CERTIFICATE - I

This is to certify that the thesis entitled ***"Studies on integrated nutrient management in onion (Allium cepa L.) Cv Agrifound Light Red''*** *submitted in partial fulfillment of the requirement for the degree of* ***"MASTER OF SCIENCE" in HORTICULTURE (VEGETABLE SCIENCE)*** *of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by* ***Mr. Devendra Kumar Tembhare*** *under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instruction.*

No part of the thesis has been submitted for any other degree or diploma (Certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations has been acknowledged by him.

Place : Rewa

Date : 14/07/2011

(Dr. U.S. Bose)

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Member	**(Dr.T.K.Singh)**	.....
Member	**(Dr.I.M.Khan)**	.....
Member	**(Dr. A. K. Jain)**	.....

CERTIFICATE – II

This is to certify that the thesis entitled ***"Studies on integrated nutrient management in onion (Allium cepa L.) Cv Agrifound Light Red"*** *submitted by* ***Mr. Devendra Kumar Tembhare*** *to the J.N. Krishi Vishwa Vidyalaya, Jabalpur in partial fulfillment of the requirements for the degree of* ***"Master of Science in Horticulture(Vegetable Science)*** *in the Department of* ***Horticulture, College of Agriculture, Rewa (M.P.)*** *has been approved after evaluation by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.*

Place : Rewa

Date : 30.08.2011

(Dr. U.S. Bose)

Chairman
Advisory Committee

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Director of Instructions	**(Dr. O.P. Veda)**	.....

Head of Section Horticulture
College of Agriculture
Rewa (M.P.)

22.9.11

Director Instructions
J.N. Krishi Vishwa Vidyalaya
JABALPUR

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LIST OF ABBREVIATIONS

Words	Abbreviations
±	Plus or Minus
Centimeter	cm
Co-workers	*et al.*
Critical difference	C.D.
Cultivar	cv.
Degree of centigrade	°C
Degree of Freedom	d.f.
Days after storage	DAS
East-West	E-W
Error mean sum of squares	M.S.S.E.
Figure	Fig.
Fisher's value	"F" value
Gibberellic acid	GA
Gram(s)	g
Hectare	ha
Kilogram(s)	kg
Hour	hr
Maximum	Max.
Mean sum of square	M.S.S.
Metre	m
Chlorophyll content Index	CCI
Minimum	Min.
Non-significant	N.S.
North-South	N-S
Number	No.
Per	/
Per cent	%
Leaf area index	LAI
Days after transplanting	DAT
Quintal	q
Randomized block design	RBD
Replication sum of square	RSS
Serial No.	S.No.
Significant at 5% level	*
Significant at 1% level	**
Source of variation	S.V.
Sum of square	S.S.
Standard error of means	S.Em±
Standard error of difference	S.Ed
Tabulated	Tab.
Analysis of variance	ANOVA
Namely	Viz.
Volume	Vol.

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INTRODUCTION

Chapter – I

INTRODUCTION

Onion (*Allium cepa* L, 2n=16) belongs to family Amarayllidaceae. Onion is a hardy bulbous plant. It is a short duration crop. The edible portion is a modified stem which is known as bulb and develops under ground. It is mainly used for cuisine and culinary purpose, it also relished with meals as salad. Onion is the most important commercial vegetable crop grown all over the world. The crop is very useful for human beings because of its several nutritional and medicinal values. It occupies an important position among vegetable crops in kitchen garden as well as commercial production. It plays a vital role in Indian economy; Onion occupies an important position in the country and ranks first in area (4.21 lakh hectare) and second in production (5.97 million tones) with about 11% share after china in the world. Onion is the oriented crop earning valuable foreign exchange for the country. Onion the demand for onion is worldwide. Onion is the second only to tomato their importance as a vegetable in the tropics.

In Madhya Pradesh the crop occupies 23.55 thousand hectare area with the production of 331.70 thousand tones and productivity 141.15 q/ha. during 2005-06 (Anon. 2005-06).

The pungency of onion is due to the presence of sulphur compound in very small quantity (0.005%) in the volatile oil of the plant juice. The main compound is allylpropyle disulphide ($C_6 H_{12} S_2$). The red colour of onion is due to the presence of pigment anthocyanin and yellow colour is due to the presence of quercetin. Onion also contains a peculiar form of sugar to which sweet flavor of roasted onion is felt. It affords an excellent form of food iron and on

this account many often be eaten freely with advantage by persons suffering from anemia.

As regard with the productivity it is much below than the national average because of certain production constraints affecting the growth behaviors and yield traits. The combined application of organic manures and inorganic fertilizers has paramount importance in ameliorating the yield. Inorganic fertilizers now a day are costly. Secondly the sole application of inorganic fertilizers deteriorates the quality of soil affects the economics of production and human health as well as, where organic manures and bio-fertilizers are cheap, easily available and eco – friendly. It improves the physio-chemical properties of the soil which is very useful for the sustainable crop production as well as soil fertility and productivity. Although many attempts have been made to study the role of inorganic fertilizers on onion crop however, systematic fertilization of different organic manures for onion cultivation is needed particularly as the research work and technology on this aspect is very scanty in Madhya Pradesh. Looking to the above facts in view, the present research work was taken up with the following objectives:

1. To study the effect of organic, inorganic and biological sources of nutrients.
2. To determine the efficacy of INM on quality of onion.
3. To find out the response of nutrients separately and combined.
4. To find out the appropriate ratio of inorganic and organic sources of nutrients on growth and yield of onion.

REVIEW OF LITERATURE

Chapter –II

REVIEW LITERATURE

A good deal of research has been done in India to evaluate the response of onion to applied organic manures as well as chemical fertilizers. However, the information is not up to the mark in relation to the interaction of improved varieties of onion with certain organic manures like FYM. Poultry manure, Goat manure PSB and vermicompost manures etc as compared to NPK fertilizers. This has encouraged generating information's for onion growers of this region. The up- to date literature available on thesis aspects has been reviewed in this chapter.

Terran *et al.* (1994) studied the thirteen treatment combinations involving N, P and K, filter press cake, mycorrhizal inoculation (*Glomus* fasciculatum and *G. manihotis*) and the bio-fertilizers onibiostirl (Azotobcter sp) all growth indices were assessed 60 days after sowing and the data were tabulated. The best results with regard to plant and bulb size were obtained with filter cake application at 180 t/h plus Glomus fasciculatum a.i. 1 kg/m^2 both applied at sowing. All treatments involving organic matter (filter cake) gave superior results to those lacking it.

Serrano *et al.* (1995) conducted a trial to evaluate the response of onion (cv. Crystal Wax) to LEDA (Liquid effluent from an anaerobic digester) bio-fertilizer (obtained from cow dung). Soil treatments were 500, 750 or 1000 ml LEDAl m of row alone or 250, 500 or 750 ml LEDA/m or row combined with chemical fertilizer (N and P at 60 and 40 kg/ha respectively). A chemical fertilizers only treatment with 120 kg N and 80 kg P/ha was also included. The final treatment consisted of 1000 ml LEDA/m of row applied as 4 foliar

applications. Results showed that a mixture of LEDA and chemical fertilizer gave the best result in terms of leaf number and meridional and equatorial bulb diameters. The highest value for fresh bulb yield (22.26 t/ha) was obtained with 750 ml LEDA/m combined with 60 kg N and 40 kg P/ha. The chemical fertilizer only treatment yielded 16.81 t/ha and the total LEDA treatment yielded 17.36 t/ha.

Nasima *et al.* (1997) conducted field experiment at Dhaka in Bangladesh to compare the aquatic weed water hyacinth as manure with drain algae. Cattle manure and inorganic fertilizer (urea + triple super phosphate + murite of potash) on carrots, onions, spinach, Amaranthus and Momordica charantia. Fruit yields of M Charantia were comparable with water hyacinth and drain algae and much higher than with cattle manure 9 t/ha or inorganic fertilizer (N.P.K.) Crushing water hyacinth before drying had no effect on onion yields. Spinach yields were higher from manuring with composted water hyacinth than from using dried material. Composted water hyacinth produced higher leaf yields of Amaranthus than dried material but crushing the plant material before composting reduce leaf yields compared with using uncrushed material.

Rumpel *et al.* (1997) found that soil density decreased while porosity and water retention increased significantly with FYM. Also, the organic C content and humus content was over 2 times higher with FYM. The combination treatment did not increase total N content after crop harvest compared to FYM alone. Soil pH was higher with FYM. Tomato yield was significantly higher with NPK compared to FYM whereas carrot yield was higher with FYM compared to the other 2 treatments. Onion yields were significantly higher with the combined fertilizer treatment compared to FYM alone which itself was significantly higher than NPK alone. Onions also showed the greatest need for crop rotation. Tomatoes grown for 9 years as a monoculture gave yields similar to those grown in rotation.

Varu *et al.* (1997) conducted a field experiment at Baroda, Gujarat in 1994-95. Onion cultivar Talaja White seedlings, transplanted on 25-26 October 1994, were given the following fertilizer treatments: NPK (100 kg N , 50 kg P_2O_5, 50 kg K_2O/ha); farmyard manure (FYM at 50 t/ha); a concentrated organic manure (Dharatidharara at 4 t/ha); FYM (25 t/ha + Dharatidhara (2 t/ha) ; FYM (25 t/ha) + NPK (full rate); FYM (95 t/ha) + NPK (half rate) + Dharatidhara (2 t/ha); and no fertilizer . Data are tabulated on number of leaves/plant, plant height, bulb yield, bulb diameter, bulb weight and bulb volume. The highest bulb yield (32.70 t/ha) was obtained for the FYM + NPK + Dharatidhara treatment. This treatment also gave the highest bulb diameter, weight and volume.

Chee (1998) evaluated the effect of vermi-compost incorporation (8 t/ha) and arbuscular mycorhizae inoculation on onion yields and nutrient content in general , 120 days after sowing , plant yield and nutrient content increased with applied vermi-compost or mycorrhizal inoculation. This nutrient increase was attributed to nutrients supplied by the vermin-compost or the establishment of mycorrhizl symbiosis. The combined application of vermi-compost and mycorrhizal inoculation slightly decreased arbuscular colonization without affecting yields, but contrarily increased P and K content demonstrating that simultaneous application of 2 or more bio-fertilizers is not always profitable.

Rumpel (1998) studied the effects of fertilizer application on the yield of onion cv. Blonska in a long term, static fertilizer experiment. The following treatments were compared with an unfertilized control, farmyard manure (FYM) applied annually at 20, 40 or 60 t/ha. NPK applied at single, double or triple rates (single rate = 75 kg N, 50 kg P2O5 and 100 kg K_2O/ha), combinations of FYM at these rates and the double rate of NPK, the double rate of NPK + 10 kg Mg/ha, and PK, NK and NP (as in the double rates of NPK). FYM

+ NPK gave the highest marketable yields of bulbs (41.7, 44.2 and 46.3 t/ha, respectively). FYM alone gave better results than NPK fertilizer only at low soil moisture, whereas with an adequate water supply, yields were similar for the 2 forms of fertilizer. Applying Mg had no beneficial effect. Fertilizes supplying only 2 of the 3 mains nutrients (PK, NK, or NP) produced low yields.

Cho-Cho *et al.* (1999) reported that the combined effect of effective Microorganisms (EM) and organic manures showed improvement not only in production of some crops including onion but also in chemical and physical properties of cultivated soil.

Daly and Stewart (1999) evaluated the influence of effective micro- organisms (EM), commercially available microbial inoculants containing yeasts, fungi, bacteria and actinomycetes in field trials of commercially produced, irrigated vegetable crops on organic farms in Canterbury, New Zealand. Em plus molasses were both applied at 10 liters/ha in 10000 liters/ha water, three times to the onions, twice on the peas and seven times to the sweet corn. EM plus molasses increased the onion yield by 29% and the proportion of highest grade onions by 76%. EM plus molasses also increase pea yields by 31% and sweet corn cob weights by 23%.

Mowla *et al.* (1999) conducted two field experiments in Gazipur, Bangladesh to study the effects of residual soil moisture and rainfall on the performance of onion (cv. Taherpuri) and to quantity the water used for onion cultivation. The average NPK fertilizer and organic manure rates used in the T3/S9k canal area were 42, 59, 42 and 13799 kg/ha. Farmers in the T2/S11K canal area did not apply any organic manure, but applied 67.39 and 31 kg/ha of N, P and K fertilizers, respectively. In the T6/S9k canal area, chemical fertilizers were not applied in 4 locations and manure in 2 locations. In 1990, average yields of onion recorded for T3/S9K, T6/S9K and T2 / S11K

were 1003, 7807 and 7800 kg/ha, respectively. Combatively higher yields were obtained with less water when chemical fertilizers were applied with manure.

Singh and Kohli (1999) had grown eight tomato hybrids at a spacing of 90 x 30 cm and given 4 rates of NPK fertilizer. Data are tabulated on plant height, number of branches per plant, days to 50 % flowering and marketable fruit yields for each cultivar and fertilizer rate. Averaged across NPK treatments marketable fruit yield was highest in CV Menka (469.7 q/ha) and lowest in cv. Rachna (108.2 q/ha). The highest marketable yield overall (560.7 q/ha) was produced by cv. Menka given 200 kg N + 150 kg P + 110 kg K /ha.

Geerha *et al.* (2000) conducted a field experiment in Andhra Pradesh, to study the effects of FYM at 0.0, 12.5 and 25.0 t/ha and K fertilizer (0, 50, 100 and 200 kg/ha as muriate of potash). On the yield and nutrition of onion cv. Nasik Red grown on Alfisol with medium K content FYM and K fertilizers significantly increased the shoot and bulb yields of onion. FYM at 25 t/ha and 200 kg K/ha, individually or in combination, gave the highest dry matter production, K content, K uptake and bulb yields.

Mihelic *et al.* (2001) conducted field trials on onion with five treatments (0=non fertilized control; COMP = composted chicken manure, shredded wood and bark FYM = well matured farmyard manure; NPK1 = mineral fertilizer application with split application of N; NPK2= mineral fertilizer application. Where FYM had been applied SMN was consistently higher than that of the control. The apparent N recovery from FYM was 19% in contrast, COMP showed slight N immobilization for 12 months after the first application. Later, following net (re) mineralization with COMP, there was an apparent N recovery of 5%. Crop yields closely followed N uptake

(R2=95%). After two years, NPK1, NPK2 and FYM treatments resulted in higher yields compared to COMP.

Samawat *et al.* (2001) conducted a trial on the effect of three levels of chemical fertilizer and five levels of vermicompost on root and shoot growth, fruit weight and the number of tomato were investigated. Chemical fertilizer and vermicompost had a significant effect on root and fruit weight and number of tomatoes. In 100% vermicompost treatment, fruit weight and fruit number, and shoot and root weight were three, four, five and nine times more than the control treatment respectively.

Singh *et al.* (2001-02) studied the effects of basal application of farmyard manure (25 or 40 t/ha) combined with foliar application of NPK mixture (100:50:50 kg/ha) and micronutrient (zinc, copper and boron) on the growth, yield quality and storage of onion. Basal and foliar treatments had no significant effects on the plant stand and neck thickness of onions. The highest bulb diameter, bulb size index , total soluble solids, dry matter, weight of 20 bulbs , and gross and marketable yield were highest with basal application of NPK and foliar application of 1% Multik 30, 45 and 60 days after planting . The pyruvic acid content was highest with basal application of NPK and foliar application of 1% Polyfed 30, 45 and 60 days after planting. Differences in the effects of the of the interaction between the foliar and basal treatments on plant stand neck thickness, total soluble solids and pyruvic acid content were not significant however, basal application of NPK + foliar application of 1% Multik resulted in the highest bulb diameter bulb size index , weight of 20 bulbs, and gross and marketable yield.

Alkaff *et al.* (2002) evaluated the effect of bio fertilizer (Halex 2, containing a mixture of Azospirillum. Azotobacter and Kiebsiella), mineral fertilizer (100 kg urea /fed, 50 kg triple super phosphate/fed),

farmyard manure (FYM), with or without power 4, on the bulb yield of onion cv. Baftaim. They reported that application of fertilizers increased the bulb diameter bulb height and total yield of onion. The highest increments in bulb diameter (14.2%) and height (12.3%) were recorded with the mineral fertilizer, while the lowest increments (10.3 and 8.4%, respectively) were recorded with biofertilizer. The highest rate of increase in total yield/fed (21.76%) was recorded with FYM followed by the mineral fertilizer and biofertilizer. Foliar application of Power 4 (6 g) decreased all characters evaluated.

Dhruv *et al.* (2002) conducted a filed experiment to investigate the fertilizer management practices on potato, onion and rice. The treatments were N, P and K at p,, 50, 100 and 150% of the recommended rate in 9 treatment combinations. Farmyard manure (FYM) at 30 t/ha and Zn sulfate at 25 kg/ha were also applied to potato. Onion grown after potato supplied with 150 % N, P and K rates required only the recommended N, P and K rates (100, 22 and 67 kg/ha respectively), while rice required the rate of 120 kg N/ha and 33 K/ha. Potato and onion responded to N, P and K, while rice responded only to N and K. FYM combined with inorganic N at 160 kg/ha on the potato crop was as effective as the 150% recommended N, P and K rates. FYM + N also helped in minimizing yield reduction and maintained the crop productivity at a higher level than the use of fertilizer alone. The highest net return (64046) and highest benefit cost ratio (2.03) was recorded in potato –onion rice sequence when FYM + N was applied. FYM applied for 5 years improved the organic carbon status of the soil by 20% and countered the acidification effect of urea.

Gowda *et al.* (2002) conducted a study in the summer season of 1999 in Bangalore, Karnataka in India to investigate the effects of different fertilizer levels (N: P: K at 125: 75:60, 150: 100:75 and 175: 125:100 kg/ha) on okra cultivars Arka Anamika, Varsha and Vishal.

Dry matter accumulation and nutrient (N, P and K) accumulation increased with increasing fertilizer levels. The highest fertilizer level resulted in the highest nutrient uptake. Varsha showed the highest nutrient uptake and accumulation in leaves and fruits at the highest level of fertilizer.

Gunadi *et al.* (2002) reported that the vermi-compost were applied to soil in rows of tomatoes at the rates of 4.5 t/ha, and the numbers of soil arthropods in tropic groups were compared with those in soil receiving conventional composts and inorganic fertilizers. All treatments received the same total amounts of nutrients. The applications of vermin composts increased the number of tropic groups of soil arthropods.

Jayathilake *et al.* (2002) determined the integrated effect of organic manures, bio fertilizers and chemical fertilizers on onion growth and yield. Treatments consisted of FYM and vermi-compost and two types of bio fertilizers (Azotobacter and Azospirillum), either alone or in combination with chemical fertilizers. An additional increase of 14.23 % in plant height and 30.72 % in leaf number was observed in plants treated with Azotobacter + Vermi-compost + Chemical fertilizers compared to the control. An increase in leaf area with integrated use of organic manures, biofertilizers and chemical fertilizers over the control was observed. Significantly higher bulb weight and bulb diameters were recorded upon treatment with Azospirillum + 50 recommended N through vermi-compost + 50 % N and 100 % PK through chemical fertilizers (60: 31 g and 6.46 cm, respectively). Using Azotobacter instead of Azospirillum in the above combination also resulted in high bulb weight and diameter (59.51 g and 6.38 cm, respectively). Bulb yield was highest (22.4 %) with the application of Azospirillum + vermicompost + chemical fertilizers. A significant yield reduction was observed when vermi-compost was

substituted with FYM in the same integrated nutrient management system.

Khalil *et al.* (2002) studied the effects of farmyard (FYM : 40 , 50 and 60 m^3/feddan) and chicken (20 , 25 and 30 m^3/feddan) manures on onion cv. Shahdaweel N (100 kg feddan as urea) was also applied at 45 and 60 days after transplanting , whereas P (30 kg/feddan as calcium super phosphate) was applied as a basal dressing. K (24 kg fedan as potassium sulfate) was in comported before transplanting. The tallest plants were obtained with 25 and 30 m^3 chicken manure/feddan. Chicken manure, inorganic fertilizers were more effective than FYM in increasing leaf number per plant. The highest average bulb weight, marketable bulb yield, and K content were recorded for m^3 chicken manure/feddan. Chicken manures resulted in the highest total bulb yield, marketable bulb percentage, and P content N content was highest with inorganic fertilizer application

Kretschmer (2002) reported that the results from the third year of an Organic variety test plot indicated good results for Hyfort, Hystar, Hytech and Renate. The bulbs are available in organic quality. At the Qukarspel (Netherlands) -open day the breeding house Cause /Tezier presented the new bunching onion variety Cristobal, suitable for protected, plastic tunnel and field production.

Lal *et al.* (2002) determined the effects of farmyard manure (FYM: 0. 50 and 100 t/ha) and irrigation (4, 5, 6 and 7 cm) on the growth and yield of onion cv. Hisar 2 in a field experiment conducted in Haryana. Plant height, number of leaves per plant, bulb size and bulb yield increased with increasing rates of farmyard and irrigation. The interactions effects between FYM and irrigation were significant only for bulb size and yield.

Mareggiani *et al.* (2002) conducted experiment organically grown cabbage cv. Brunswick. Three organic soil amendments (incorporation of horse manure, green oat manure and corn stubble) were combined with two tactics to manage aphid populations (intercropping with green onion *Allium fistulosum* and garlic (*Allium sativum*) alcohol spray). A split plot design with four replications was used. Treatments with garlic alcohol and green onion intercropping led to a significant reduction in the number of aphid's p- 0.05). Treatment with horse manure resulted in the highest yield and reduced the aphid population, while green manure and corn stubble had the opposite effect (P- 0.05).

Mohd. Rafi *et al.* (2002) studied the effect of organic and inorganic fertilizers on yield and quality of tomato cv. Parbhani "Yashashri" conducted at Parbhani revealed that application of 50% recommended dose of FYM @ 12.5 t/ha along with reduced levels of recommended doses of fertilizers (50 % of the recommended dose of fertilizers of 100: 50:50 NPK kg/ha) resulted in the highest yield with high quality. The study also revealed that the ready made organic manures of commercial companies used in this study were inferior to traditional organic manures viz., FYM and vermicompost. These results were in conformation with findings of Sendurkumaran *et al.* (1998) and Nanthakumar and Veeraraghavathatham (1999) who observed similar increase in yield in tomato and brInjal respectively. When plots were fertilized with both organic and inorganic sources than inorganic source alone. Sendurkumaran *et al.* (1998) found that the quality parameters such as TSS, ascorbic acid and lycopene were comparatively higher in tomato when grown organically. Similar, observations have been made by Chinnaswami and Mariakulamadai (1996) and Sendurkumaran *et al.* (1998) in tomato.

Muthuramalingam *et al.* (2002a) showed that the closer spacing of 45 x 5 cm recorded the maximum uptake of N, P and K. Treatment

with closer spacing of 45 x 5 cm and higher dose of manurial treatment 60:60:30 kg NPK/ha along with FYM at 25 t/ha . Aazospirillum at 2 kg/ha and phosphobacterium at 2 kg/ha recorded the highest uptake of N, P and K nutrients and resulted in maximum bulb yield.

Muthuramalingam *et al.* (2002 b) found that the treatment with spacing of 45 x 5 cm and higher dose of manorial treatment 60:60:30 kg/ha along with FYM, Azospirillum and phosphobacterium recorded the highest uptake of N, P and K and maximum bulb yield.

Prabhakaran and Pitchai (2002) conducted field and pot experiments at Agriculture College and Research Institute, Killikulam situated in Tirunelveli district of Tamil Nadu state during November 1999- March 2000 to study possibility of substitution of N with organic N sources viz. FYM, press mud, fish meal, pig manure and poultry manure to get superior quality fruits of tomato var, PKM-1, Urea was taken for comparison. Based on the N content of the organic N Source on dry weight basis, the quantities required for the substitution of recommended dose of N at 50 and 100 percent level were worked out and applied. Application of organic N sources at both levels increase pH, TSS, titratable acidity, reducing and non-reducing sugar, crude protein and ascorbic acid content of tomato over no manure (control).

Renuka and Ravi Sankar (2002) reported that vigorous growth of tomato crop with early flowering and high yields could be obtained with the application of FYM + biogas slurry registering an increased yield of two and half times over the control NPK inorganic fertilizer application . Thus, it can be inferred that tomato crop would respond to application of organic manures either in combination with FYM or alone. Further, the application of organic manures helped to maintain good health of soil. They further narrated that earliness of flowering

and fruiting is an important trait in tomato crop. The data of the experiment showed of organic manures like FYM + biogas slurry (21.5 days), followed by biogas slurry alone (23.43 days) and vermicompost + FYM (23.6 days) were found to superior. This earliness in three cases could be attributed to the faster enhancement of vegetative growth and storing sufficient reserved food material for differentiation of buds into flower buds (Kuppuswamy *et al.* 1992). The delayed flowering (30.8 days) was recorded by the inorganic fertilizer treatment NPK + FYM which could be due to extended vegetative phase of the plant by availability of inorganic nitrogen . In tomato large fruits are preferred, in the present study, they found that application of biogas slurry + FYM, vermicompost + FYM vermicompost alone and biogas slurry alone have recorded maximum fruit size including more number of fruits per plant while the NPK inorganic fertilizer application recorded the minimum size (10.66 cc.) These results are clearly explaining that application of biogas slurry or vermicompost along with FYM was superior to obtain large size fruits of tomato even during hot weather period of the experiment conducted. The yield of tomato also showed that the application of biogas slurry + FYM followed by neem cake + FYM and vermicompost + FYM were found to be far superior over other treatments.

Santhi *et al.* (2002) conducted soil test crop response correlation studies with onion under integrated plant nutrition system. Fertilizer adjustment equations under IPNS were formulated for onion. The nutrient requirement for producing one quintal of fresh onion bulbs was found to be 0.375, 0.329 and 0.466 kg of N, P_2O_5 and K_2O respectively. The percent contributions from soil and fertilizer nutrients were found to be 14.13 and 38.28 for N, 35.33 and 56.61 for P_2O_5 and 14.33 and 70.03 for K_2O respectively. Likewise, the percent contributions from farmyard manure (FYM) and FYM +

Azospirillum were 20.32 and 22.51 for N, 16.55 and 17.12 for P_2O_5 and 25.17 and 25.66 for K_2O, respectively. The percent contribution of N from Azospirillum was found to be 22.38. The quantity of fertilizers that could be adjusted to the levels and sources of organic manures was evaluated to be 36, 15 and 27 kg/ha of N, P_2O_5 and 52, 16 and 27 kg/ha of N, P_2O_5 and K2 O, respectively, for fertilizers with FYM + Azospirillum.

Sule *et al.* (2002) found that for onion, the average areas under bio fertilizer users and nonusers were 0.47 and 0.50 ha, respectively. An average productivity of bio-fertilizer users and nonusers was 20.05 and 18.13 t/ha, respectively. The use of Azospirillum increased the productivity by 10.59%. For sugarcane, the average areas under biofertilizer users and nonusers were similar (1.27 ha). An average productivity of biofertilizer users and nonusers was 89.57 and 82.86 t/ha, respectively, Azotobacter use increased the productivity by 8.09%.

Subba Rao and Ravi Sankar (2002) inferred that brinjal crop would respond well to application of organic manure either alone or in combination with FYM besides improving the soil status. While the plant height and numbers of branches per plant influenced by organic manures were on par with the chemical inorganic fertilizers, the influence of organic manures on leaf number. LAI and dry matter production were superior over inorganic fertilizer application.

Abbey and Kanton (2003) determined the effects of 3 or 6 to FYM/ha and inorganic fertilizer (NPK) as well as of cessation of irrigation on the growth, yield bulb quality of onion cv. Bawku Red in a field experiment conducted in Ghana. Plant height, bulb weight and diameter and bulb yield were highest with the application of FYM alone with NPK fertilizers. With holding irrigation had no significant effects on the time when the foliage begins to break over.

Prabu *et al.* (2003) recorded the highest yield of okra with 2/3 RDF +FYM+Azospirillum VAM. Correlation study revealed significantly positive relationship between yield attributes (plant height, leaf area , total chlorophyll content, fruit length, fruit diameter, fruit weigh t, N P and K contents in plant) and yield . Amongst the attributes, N content showed the highest correlation (r= 0.954) followed by plant height (r= 0.934) and P content (r=0.921). The least influence on yield was exhibited by chlorophyll content (r= 0.602).

Sharma *et al.* (2003) found that application of fertilizers at the rate of 100% (125 kg N, 33 kg P and 50 kg K/ha) and 150% (187 kg N, 49 kg P and 75 kg K/ha) of recommended dose registered an increase of 42 and 56 % over 50% NPK level in bulb yield of onion. Similarly, application of FYM at 10 and 20 tones/ha increased bulb yield of 9 and 19% over 100% NPK alone, respectively. Bulb yield recorded in the case of 100% NPK alone with 20 tones FYM/ha (19.87 tones/ha) was at par with 150% NPK alone (18.82 tones/ha) thereby signifying the saving of chemical fertilizers of 52 kg N 16 kg P and 25 kg K/ha. Use of NPK fertilizer alone with FYM also resulted in significant improvement in available N, P, K status of the soil.

Mondal *et al.* (2004) found in case of onion that application of neem seed power along with 75% of NPK through inorganic fertilizer gave significantly of neem seed power, alone with 75% of NPK through inorganic fertilizer gave significantly highest number of laves per plant (13.58), bulb yield (15.25 tones/ha), bulb diameter and vitamin C content (8.10 mg /100 g). Significantly higher response was also found in the treatment receiving FYM and pelleted form of organic matter, along with 75 % of NPK through inorganic fertilizer.

Jha *et al.* (2005) the present study was undertaken to screen the VAM fungi for onion crop during the rabi season of 1999-2000 with promising cultivars pusa midair. The VAM species were use for inculcating none with full dose of N but without P and K phosphorus application was deliberately missed to explore the possibility of estimating P requirement met out by Same species on the other hand the experiment soil was having too high K content (386 .9 kg available K per ha) to apply to the field. Best performing species was identified based on the yield parameters.

Yadav *et al.* (2005) conducted an experiment in randomized block design at Agriculture Research Station, Durgapur, and Jaipur for three years to find out the suitable dose of nitrogen with and without bio-fertilizer (Azospirillum) in onion var Ral on the basis of pooled data for three years. It is concluded that 75% dose of nitrogen along with Azospirillium application gave significantly highest onion yield (3.28.4 q/ha) and net return of 31/287/ha with B:C ratio 1:10.

Jha *et al.* (2006) concluded that the onion cultivars Pusa Madhavi, singly in combination with reduced inorganic fertilizers dose co-inoculation of VAM with non-symbiotic N_2 fixing PGRP strains proved to be the best treatment to promote growth and yield of onion . Dual inoculation could me*et al*most 50 percent of the nitrogen and phosphorus demand of the crop. Bio-fertilizer application was also found to have influence on reducing the storage losses of cured onion.

Kannan *et al.* (2006) found that application of different organic N sources had conspicuously increased the yield of tomato over the control. Among the different organic N sources, application of 75% N as vermicompost with Azisprillum recorded 45% higher yield of tomato fruits followed by 75% coir pith compost with Azospirillum over the control and application of 100 and 50%

organic with Azospirillum also produced higher yield over the control.

Vimala *et al.* (2006) concluded from the studies on the effect of various rates of an organic fertilizer on the growth yield and nutrient content of cabbage at seldom. Study also revealed the significant influence effects on N & K contents with organic fertilizer. Organic fertilizer improved soil chemical properties also as compared to inorganic fertilizer that 40 t/ha of processed poultry manure as the sole source of nutrients can be recommended for organic cultivation of cabbage grown on clay soil under shelter.

Pandey *et al.* (2007) conducted a yield experiment to study the effect of FYM, inorganic fertilizers and biofertilizer on cabbage production. Full (100%) recommended dose of NPK significantly increased the head yield by 28.4% and 66.2% over 50% NPK and control, respectively. It was at par with 75% NPK + 10 FYM t/ha + Azotobacter treatment. Application of 75% NPK + 10 + FYM t/ha + Azotobacter resulted in the maximum uptake of nutrients by cabbage head. Significant improvement owing to appropriate combination of NPK, FYM and Azotobacter inoculation improved the N status but could not improve P.K. and S status. There was consistent improvement in the status of available NPK and S in soil with the addition of higher nutrient inputs through FYM and inorganic fertilizers.

Bahadur *et al.* (2007) investigated the effect of organic amendments and biofertilizer on growth, yield and quality of Chinese cabbage. They found that organic manure as sole or in combination with biofertilizer gave more head yield dry matter and carbohydrate content than conventional fertilizers.

Kumar and Sharma (2007) carried out during 2002 and 2003 to study the effect of biofertilizers (Azotobacter, Azospirillum and

Pseudomonas) applied alone, in combination with themselves, with 75 percent (75, 56.25 and 41.25 kg/ha) and 100 percent (100, 75 and 55 kg/ha) NPK plus full dose of FYM, i.e. 25 t/ha on tomato production having 20 treatment combinations.The maximum fruit yield per plant are per hectare were obtained were obtained in Azotobacter inoculation to seedlings + 100 % NPK + FYM treatment , whereas during 2003, maximum fruit yield per plant and per hectare was obtained in Pseudomonas + 75% NPK +FYM treatment respectively. But the pooled data revealed that maximum yield per plant (1264.0 g) and per hectare (421.3 q) was obtained in the treatment having Azotobacter inoculation to seedlings + 100% NPK + FYM along with a maximum cost benefit ratio of 1:3.15. The improvement in yield might be due to the excretion of ammonia in the rhizosphere in the presence of root exudates, which helps in modification of nutrient uptake by the plants, thus maximizing fruit size and ultimately yield.

Ahmed (2009) reported that the effect of some bio-fertilizers such as rhizobacterin, nitrobein, biogein, phosphorein, microbein combined with different levels of NPK mineral fertilizers on growth, yield, and yield quality and storability of onion bulbs. The results indicated that, applying the rhizobacterin plus phosphorein, nitrobein plus phosphorein and biogein plus phosphorein combined with 75% of the recommended dose of mineral fertilizers significantly increased plant height, dry weight per plant, bulb weight and total bulb yield. Applying rhizobacterin plus phosphorein, nitrobein plus phosphorein and biogein plus phosphorein combined with 75% of the recommended dose of mineral fertilizers were recommended for onion production without reducing productivity. Other benefits of these treatments include reduction the cost of chemical fertilizers, avoiding the risk of nitrate accumulation in the edible portions and the pollution of the environment.

Keniseto Chuda *et al.* (2009) reported that the eight treatments (control, FYM at 20 t/ha, pig manure at 10 t/ha, vermicompost at 5 t/ha, 100% NPK, 50% NPK+50% FYM, 50% NPK+50% pig manure, 50% NPK+50% vermicompost) were included in the experiment. Results revealed that T6 (50% NPK+50% FYM) recorded significantly higher plant height (45.45 cm), number of leaves/plant (12.67), neck thickness (2.95 cm), bulb size (5.84 cm), doubling (1.78%) and bulb yield (141.47 q/ha). However, effect of integrated nutrient management on days of maturity for marketing and bolting were found to be non-significant.

Deb *et al.* (2009) reported that the nutrient and water requirement of onion employing local cultivar Sukhsagar, laid out in split plot design, replicated thrice, with four levels of irrigation (no irrigation, farmers practice i.e. 6-8 days interval, irrigation at 0.55 and 0.80 atmospheric tension) as main plot treatments and three levels of fertilizer (no fertilizer, N:K:S at 100:120:40 kg/ha and N:K:S at 150:180:60 kg/ha) as sub-plot treatments. There was significant influence of fertilizer application on plant height, number of leaves per plant, neck thickness, bolting, bulb weight, bulb diameter, bulb yield, weight loss, rotting and sprouting of onion bulb. A fertilizer dose of N150 kg, K180 kg and S60 kg/ha was superior to other doses of fertilizer. Higher doses of fertilizer increased weight loss, rotting and sprouting percentages. All the characters were found to be negatively correlated with CU in both the years. It depicts that with the increase in consumptive use, there will be definite decrease in plant height, number of leaves, bolting, neck thickness, diameter and weight of bulbs, yield and post harvest attributes too. With an increase in CUE, there has been certain concomitant increase in the yield attributing characters including the post harvest parameters.

El-Tantawy and El-Beik (2009) reported that the effect of nitrogen levels (N), sulphur (S) and copper (Cu) on growth, yield and weight loss (%) of onion (Allium cepa L.). The data revealed that application of high dose of nitrogen (120 kg N/fed.) increased plant height, number of leaves/plant, dry

weight of different onion plant organs (roots, leaves, bulbs and total dry weight), yield of 1st grade, total yield, marketable yield and exportable yield as well as the bulbs weight loss, but it decreased the bulbing ratio. Application of 200 kgS/fed. with spray of Cu at 30 ppm was the superior treatment for increasing onion vegetative growth, dry weight of different plant organs, 1st grade, total yield, marketable yield, exportable yield, and storability of onion bulbs. Moreover, application of 120 kg N/fed.+ 200 kg S/fed. in combination with spray of Cu at 30 ppm outdid the other treatments which significantly increased the vegetative growth, dry weight of different plant organs as well as total dry weight per plant, and yield components, but application of 120 kg N/fed. alone (control treatment) significantly increased the weight loss of bulbs.

Hari *et al.* (2009) reported that the effect of organic manures viz., neem cake (NC, 10 and 20 q/ha) and vermi compost (VC, 7 and 3.5 t/ha) in combination with nitrogenous fertilizer (50 and 75% RNF) on bulb growth yield and quality on onion, cv. Arka kalyan. Significantly the highest bulb weight and bulb yield were recorded in treatment with the application of VC @ 7 t/ha+75% RNF (75.53 g and 202.85 q/ha, respectively). With regards to quality, the highest TSS (%) was recorded in the same treatment followed by application of NC @ 20 t/ha+75% RNF. The cost:benefit ratio was highest in 100% RNF (7.7) compared to other treatments.

Ethel Ngullie *et al.* (2009) revealed that the effect of organic manures and biofertilizer on the growth, yield and quality of onion (Allium cepa L.) under humid tropical climate of Nagaland. Data showed significantly higher plant height with FYM at 30 tonnes/ha (30.3-45.2 cm) compared to FYM at 30 tonnes/ha+Azotobacter (26.3-41.7 cm) or pig manure at 20 tonnes/ha (25.0-41.7 cm). Following observations taken at 15-day intervals up to 75 days after planting. Individual bulb weight and bulb yield were significantly higher with FYM at 30 tonnes/ha (40.0 g/bulb and 140.0 tonnes/ha) compared to rest of the treatments (24.5-34.9 g/bulb and 85.7-122.1 tonnes/ha) and control (19.9 g/bulb and 69.8 tonnes/ha). The total soluble

solids (14.3%) with FYM at 30 tonnes/ha were higher by 2.1% over control (12.2%) compared to treatments either with other bulky manures (11.6-13.4%) or manures plus bioinoculants (12.3-12.1%).

Pawar *et al.* (2009) reported that the experiment was conducted at Central Farm, MPKV, Rahuri (M.S.) during rabi 2004-05 with N-2-4-1 variety of onion with a view to study the effect of Integrated Nutrient Management on growth and yield of onion seed crop. Growth parameters like plant height, number of seed stalks per plant and total dry matter were highest in 100% RDF (120:60:60 NPK kg/ha)+20 t FYM ha-1.

Rao *et al.* (2010) revealed that the treatments consisted of: 100% N through chemical fertilizer + 50 kg P/ha + 50 kg K/ha (T1); 100 % N through vermicompost produced by Eudrilus eugeniae + 50 kg/ha P + 50 kg K/ha (T2); 50% N through vermicompost produced by E. eugeniae + 50% N through chemical fertilizer + 50 kg P/ha + 50 kg K/ha (T3); and control (T4). T1 increased the total yield by up to 7.25 t/ha after 120 days of treatment (DOT) and plant height by up 30.00% after 30 DOT compared to the control. After 60 DOT, leaf length increased by up to 2.60%. After 90 and 120 DOT, leaf size increased by 23.6 and 15.20%, respectively. T2 enhanced plant height and increased the yield by up to 8.75 t/ha. Leaf length after 30 DOT increased by up to 50.00%. After 60 DOT, leaf length increased by up to 11.30%. After 90 and 120 DOT, leaf size increased by 36.45 and 53.64%, respectively. T3 increased the total yield after 120 DOF by up to 9.75 t/ha. Plant height after 30 DOT increased by up to 51.60%. After 60 DOF, leaf length increased by up to 52.6%. After 90 and 120 DOF, leaf size increased by up to 71.4 and 56.65%, respectively.

Jahan *et al.* (2010) evaluate the effect of nitrogen (N) and potassium (K) fertilizers levels on the growth, yield and nutrient concentration of onion. The research was carried out with four levels of nitrogen viz; 0, 60, 120 and 180 kg N ha-1 and three levels of potassium viz: 0, 60 and 120 kg K2O ha-1. Data were recorded on yield and yield components. Most of the

parameters varied significantly with different levels of nitrogen but not with potassium. Single application of N had significant influence on bulb yield. The highest bulb yield (8.53 ton ha^{-1}) was obtained when plants were grown with nitrogen at 120 kg/ha but higher levels of N did not show any significance increase in yield of onion. The lowest yield (6.70 ton ha_{-1}) was recorded in the control treatments. Application of potassium at 60 kg K_2O ha^{-1} produced the highest bulb yield (7.77 ton ha-1) which was statistically identical with that of 0 or 120 kg K_2O ha^{-1}. The effect of interaction between nitrogen and potassium was statistically significant. The combination of 120 kg N and 60 kg K_2O ha^{-1} gave the highest bulb yield (9.40 ton ha^{-1}). On overall considerations, 120 kg N and 60 kg K_2O ha^{-1} were considered as optimum dose for the yield of onion.

Lee Jong Tae (2010) study was carried out to maximize the fertilization efficiency of mixed organic fertilizer (OF) for organically managed onion (*Allium cepa* L.) production. Four organic topdressing treatments, which all followed the same basal fertilization with solid OF, consisted of solid OF without mulch (OF/OFnM), liquid organic fertilizer without mulch (OF/LOFnM), liquid organic fertilizer under mulch (OF/LOFuM) and liquid organic fertilizer over mulch (OF/LOFoM). Chemical fertilizer (CF) and no fertilizer (NF) were treated as controls. The solid organic fertilization base was 2.0 ton ha-1, and 4.57 ton ha-1 and was used for topdressing. The total amount of liquid organic fertilization was 133.2 ton ha-1, which was divided into 6 applications from February through March. Onion top weight in CF was significantly higher than that in OF groups at the peak growth stage, while there was not much difference in bulb weight between the CF and OF/LOFoM treatment. Finally, the onion marketable yield was 45.9 ton ha-1 in the OF/LOFoM treatment, which exceeded that in the CF treatment by up to 1.9 ton. Furthermore, OF/LOFoM was the most effective among all the treatments in transferring the nutrients from sink to source. Organic fertilizer increased population number of soil microorganisms like aerobes, actinomycetes in the field.

Sharma *et al.* (2010) revealed that the effect of biofertilizers (Azospirillum and Azotobacter) and nitrogen on growth and yield of onion. There were 12 treatment combinations of three levels of biofertilizers and four levels of nitrogen. Both bacterial inoculants responded to all levels of chemical nitrogen with an increase in growth and yield as compared to corresponding control. Azotobacter inoculation markedly increased growth and yield over control. However, the performance was better with respect to 75% level of nitrogen with Azotobacter.

Singh *et al.* (2011) reported that the maximum plant height at 90 DAT was 59.33 cm, leaves 13.81 /plant and neck diameter 2.34 cm due to 100% NPK application. This was equally followed by 75% FDF+BF and 75% RDF+VC. The organic manures their combination with inorganic fertilizer and inorganic source of nutrients, 100% NPK performed the best and resulted in maximum percent of 'A' grade onion bulb (87.68%) followed by 75% RDF +VC(77.07%) and then 75% RDF+BF or FYM (71.20 to 71.93%). Among these treatment (N_{100} P_{60} K_{50}) produced the maximum bulb yield 242.84 q/ha, being significantly higher to same rest of treatment followed by 75% RDF+PM (229.33 q/ha), 75% RDF+BF (226.57 q/ha) and then 75% RDF+VC (217.51 q/ha). Consequently the net return also followed the same trend RDF application gave the maximum net return up to Rs 72000 /ha followed by 75% RDF+BF (Rs 64701 /ha) and then 75% RDF alone(Rs 59107 /ha). The highest B:C ratio obtained by RDF (N_{100} P_{60} K_{50}) was 2.45. This was closely followed by 75% RDF+BF (2.33) and then 75% RDF alone (2.21).

MATERIAL AND METHODS

Chapter – III

MATERIALS AND METHODS

This chapter embodies concise dissertation of the method adopted and materials used during the course of investigation. The experiment "Studies on integrated nutrient management in onion (*Allium cepa* L.) Agrifound light Red" was at Department of Horticulture, College of Agriculture, and Rewa (M.P.) during the rabi season of 2010-11.

Experimental site

The experiment was carried out in net house condition at Fruit research station Kuthulia Farm, Department of Horticulture, College of Agriculture, Rewa (M.P.) during November – May 2010-11.

Climate and weather condition

Rewa is situated in the north eastern part of Madhya Pradesh. The climate of the region is semi-arid and subtropical having extreme winter and summer, Rewa is also situated at the latitude of 24 ^{0}31 N, longitude 81^{0}15 E and an altitude of 306.0 m, above the mean sea level. The weather as observed during experimental time was cool, winter followed by warm spring.

The meteorological data regarding temperature, rainfall and humidity were recorded during the experimental period at the meteorological observatory, located at the Kuthulia farm (Table 3.1) and presented graphically in Fig 3.1.

Table 3.1 Meteorological data during the experimental period

Months	Temperature (^{O}C)		Humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
Nov. 2010	30.77	18.52	87.35	55.25	-
Dec. 2010	26.22	10.72	84.40	61.65	43.00
Jan. 2011	23.26	4.15	84.53	60.99	-
Feb 2011	28.67	8.65	78.38	53.03	-
March2011	33.67	13.04	83.64	42.10	-
April 2011	40.90	17.75	78.04	60.86	-
May 2011	42.40	23.20	82.80	30.64	6.4

Source: Meteorological Observatory, Agriculture College Kuthulia Farm, Rewa (M.P.)

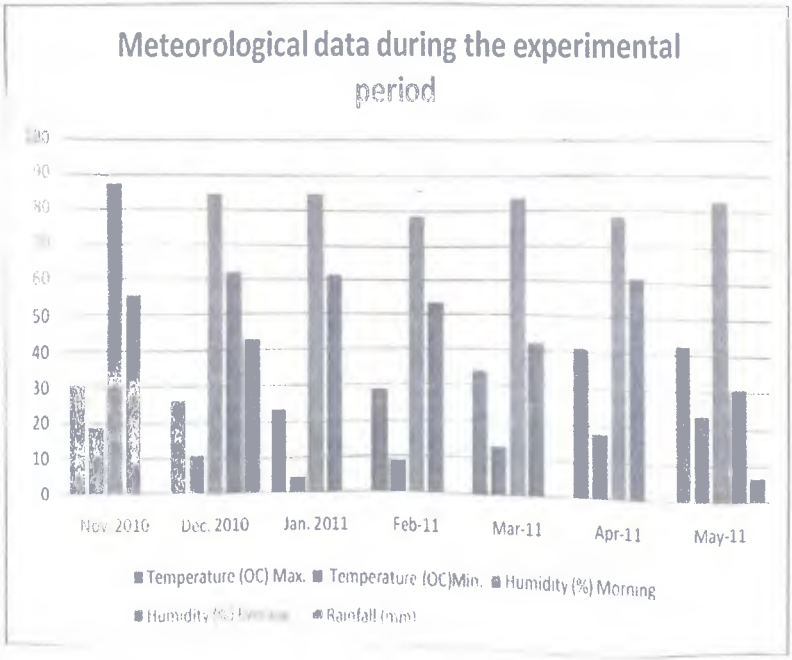


Fig. 3.1 Meteorological graph during the experimental period

Soil

The soil of the experimental field was clay loam. It was fairly rich in organic matter and have good water holding capacity. The source of irrigation was electric pump.

Fertility status of the soil Experiment Field

	Soil constituents	Analysis value
A.	Physical Properties	
	Sand (%)	25.31
	Silt (%)	39.04
	Clay (%)	35.75
B.	Chemical properties	
	pH	7.15
	Organic carbon (%)	0.53
	Electrical conductivity (ds/m)	0.30
	Available Nitrogen (kg/ha)	233.2
	Available Phosphorus (kg/ha)	12.84
	Available Potash (kg/ha)	299.6

Preparation of the field

The following tillage operations were done for the preparation of the pulverized field for transplanting of onion seedlings.

Table 3.2 Details of cultural operations performed in the experiment

S. No.	Operations	Date
1	Sowing seed in nursery	20.11.2010
2	First, Second and third ploughing	4.12.20010 12.12.2010 17.12.2010
3	Soil sample	22.12.2010
4	Layout, preparation of beds and channel	28.12.2010
5	PSB bio- fertilizer, FYM, Vermi compost, Poultry manure, NPK application as basal dose	29.12.2010
6	Transplanting of seedling	2.1.2011
7	Irrigation I & II	2.1.2011 14.1.2011
8	Seeding – I	30.1.2011
9	Gap filling	1.2.2011
10	Irrigation III	1.2.2011
11	Half nitrogen in urea form as top dressing	2.2.2011
12	Irrigation IV	7.2.2011
13	Irrigation V	21.2.2011
14	Irrigation VI	5.3.2011
15	Weeding II	12.3.2011
16	Irrigation VII	15.32011
17	Irrigation VIII, IX, X, XI, XII & XIII	28.3.2011 16.3.2011 8.4.2011 18.4.2011 28.4.2011 12.5.2011
18	Harvesting	28.5.2011

Experimental details

The experiment was laid out in randomized block design. The details are given below.

Treatments:

T_1 : Bio-fertilizer (BF) (PSB) 100 g/ha

T_2 : Vermi compost (5 t/ha)

T_3 : FYM (20 t/ha)

T_4 : Poultry manure (1.5 t/ha)+Goat manure (1.5 t/ha)

T_5 : 50 % RDF +VC

T_6 : 50% RDF + BF

T_7 : 50 % RDF + FYM

T_8 : 75% RDF

T_9 : 100% RDF(N100:P80:K60/ha)

T_{10} : Control (no manures and fertilizers)

Details of layout:

1	Number of treatments	:	10
2	Number of replications	:	4
3	Total number of plots	:	40
4	Size of plot	:	4.87 sqm (1.95 x 2.50m)
	Net plot size	:	4.34 sqm (1.85 x 2.35m)
5	Plant to plant distance	:	10 cm
6	Row to row distance	:	15 cm
7	Plot border	:	0.50 m
8	Replication border	:	1.0 m
9	Size of field	:	375 sqm(25x 15 m)

The experiment was laid out in Randomized Block Design with 4 replications. The treatments were allocated at random to different plots. The plan of layout is illustrated in Fig 3.2.

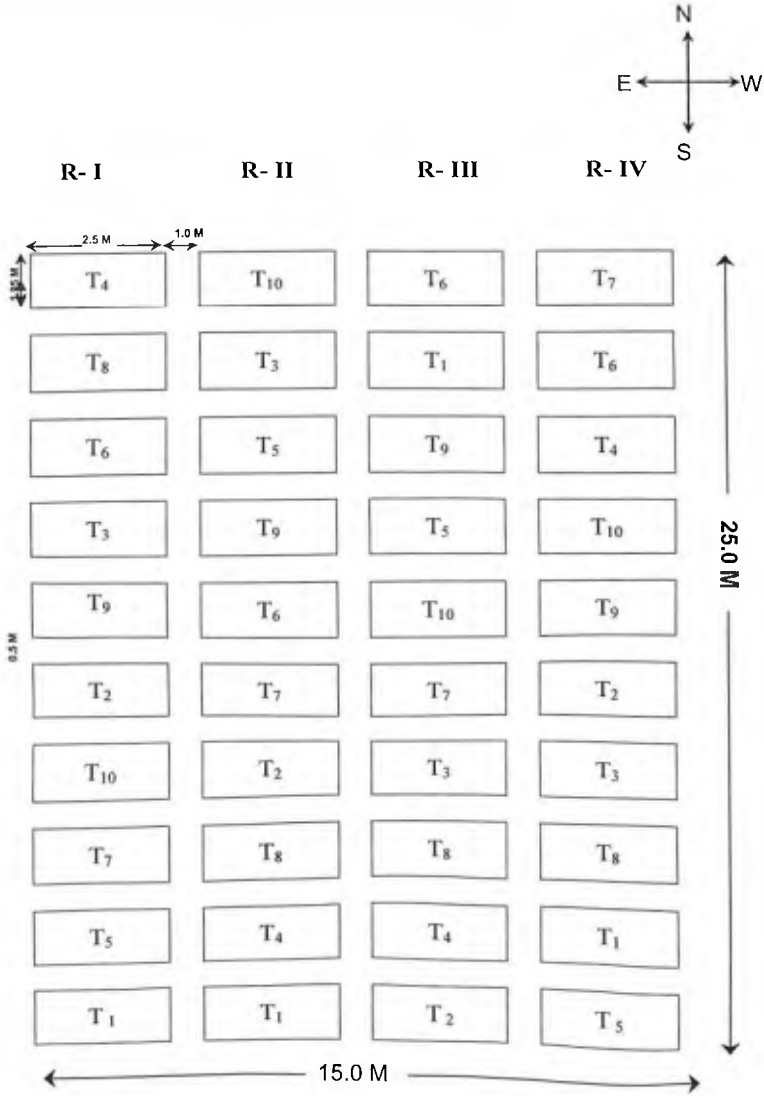


Fig. 3.2 Layout plan of experimental field in net house condition.

Application of fertilizers and manures:

Particulars	Per hectare	Source
Bio fertilizers	100 grams	(PSB)
Poultry manure + Goat manure	3 tones	-
Vermi compost	5 tones	-
FYM	20 tones	-
Nitrogen	217 kg	Urea
Phosphorus	500 kg	S.S.P
Potash	99.6 kg	M.O.P

Seed treatment

The seed of onion variety "Agrifound Light Red" were treated before sowing in nursery with Bavistin+Carbandazin (SAAF) @ 3gm. /kg.

Nursery raising

The seed of onion variety Agrifound Light Red was obtained from authorized dealer. The nursery of 3 m long and 1.2 m wide and 10 cm above the ground level were prepared and were manured then treated seed were sown on 20 November in line. All intercultural operations were done as and when required.

Transplanting

43 days old seedlings of uniform size were transplanted on 2 January 2011. The spacing 15 cm row to row and 10 cm plant to plant was maintained. The seedlings were transplanted in cool evening according to the layout.

Observations and its procedure

The following observations were recorded

(a) Pre –harvest observations

1. Height of the plant (cm) at 30, 60, 90 DAT
2. Number of leaves/plant at 30, 60, 90 DAT
3. Neck diameter of onion bulb (cm) at 30, 60, 90 DAT
4. Chlorophyll content index
5. Leaf area index (LAI)
6. Bolting %

(b) Post – harvest observations

1. Fresh weight of bulb (g)
2. Dry weight of bulb after 30 days of harvest (g)
3. Bulb diameter (cm)
4. No. of roots/bulb
5. No. of scalpes/bulb
6. Yield per hectare (q)
7. Grading of bulbs (%)

Five plants in each plot were selected randomly for recording observations successive and following characters were noted for study purpose during stage of growth. The observations were taken at regular interval of 30 days.

(a) Pre- harvest observation

1. Height of the plant (cm):

Monthly measurement of onion plants were recorded from ground level up to growing point with the help of mater scale from 30 days after transplanting.

2. Number of leaves/plant:

The numbers of emerged green leaves were counted at monthly interval.

3. Neck diameter (cm):

The neck diameter of the bulb was measured in cm at the successive stage of growth with the help of Verneer calipers.

4. Chlorophyll content index:

Chlorophyll content index was measured with in help of chlorophyll content meter model "CCM - 200 "of opt- Science Inc. USA.

The observation was taken from use second leaf from the top in different treatment at 60 days after transplanting. The instrument measure chlorophyll content index directly and indirectly.

5. Leaf area index:

The leaf area describes the size of the assimilatory apparatus of plant stand and serves as a primary value for the calculation of all other grow the characteristics. LAI defined as leaf area (A) or as assimilatory surface area over a certain ground area (P) and was calculated at per Watson's (procedure1952):

$$LAI = A/P$$

Where A= Total leaf area of the crop

P=Total ground area under the crop

6. Bolting %

The bolting % was recorded the standing crop in experiment before harvesting. Bolting data was recorded just after initiation at 90 days after transplanting.

(b) Post harvest observations

1. Fresh weight of bulb:

The bulbs of tagged plants were weighed (g) after removing the levels and roots. Spring balance was used for weighing.

2. Dry weight of bulb:

Dry weight of bulb/100 g fresh weight were taken and calculated.

3. Bulb diameter:

The diameter of bulb was recorded in (cm) with the help of Varnier calipers and the average of each treatment was worked out for the diameter of bulb.

4. No. of roots /bulb:

Roots of lifted plants were counted from each plot and the mean was recorded.

5. The number of Scalpes/bulb:

The numbers of Scalpes/bulb were counted after harvesting of onion crop.

6. Yield per hectare (q):

The total yield per plot at the time of digging was calculated and converted into q/ha.

7. Grading of onion bulb (%):

The onion bulb taken for recording the data were categorized according to their size and they were put in to there categories. The bulb having more than 5.5 cm diameters were categorized under 'A' grade between 5.5 to 4.5 cm under 'B' grade and less than 4.5 cm was under 'C' grade.

Statistical analysis and interpretation of data

The data collected during the investigation were analyzed statistically by the method of "Analysis of variance". The significance of various treatments was judged as suggested by Chandel (1997) Applying 'F' test. The skeleton of analysis of variance is presented in Table 3.3.

Table 3.3 The skeleton of analysis of variance

Sources of variation	d.f.	S.S.	M.S.S.	'F' cal.	F tab at 5%
Replication	3	-	-	-	2.96
Treatments	9	-	-	-	2.25
Error	27	-	-	-	-
Total	39	-	-	-	-

The 'F' test was performed for judging the significance of treatments mean squares. The significant differences between different treatments means were judge by using critical difference (C.D.).

The standard error was calculated as under.

$$\text{S.E.m} \pm \text{ for treatments} = \sqrt{\frac{V_E}{r}}$$

Where,

V_E = Error variance, r = Replication

C.D. (5%) for treatments = S. Em + $\sqrt{2 \times t_{tab}}$ 5 % error d.f.

Presentation of data

All the interpretations of the data in the chapter "Experimental findings "are based of 'F' test and critical difference. The results of various characters as influenced by different treatments have been illustrated by histogram and graphical curves.

RESULTS

Chapter - IV

RESULTS

The experimental observations were recorded on growth characters, yield component, quality character and yield from various treatments. The data were statistically computed for different characters. Thereafter, these are presented in this chapter with suitable diagrams. The "ANOVA" table for each observation has been highlighted in the Appendix section.

4.1. Pre harvest observations

4.1.1 Plant height

The data presented in Table 4.1 and Fig 4.1 (Appendices I,II and III) on different growth intervals indicated that the plant height of onion was increased steadily with the age of plant up to 90 days after transplanting . The height in different treatments which ranged from 13.41 to 25.40 cm at 30 DAT stage was went up to its maximum range from42.28 to 59.31 cm at 90 DAT stage.

Table 4.1 Mean height of plant (cm) at different growth stages as influenced by Different treatments

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90DAT
T_1 : Bio fertilizer (BF) (PSB) 100 g/ha	16.87	32.77	44.03
T_2 : Vermi compost-5t/ha	18.35	33.32	45.49
T_3 : FYM 20 t/ha	19.00	33.03	45.38
T_4 : Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	19.75	34.89	47.53
T_5 : 50% RDF + VC	21.53	37.07	48.98
T_6 : 50% RDF + BF	20.20	35.91	49.78
T_7 : 50% RDF + FYM	21.57	37.71	50.65
T_8 : 75% RDF	22.18	44.84	56.61
T_9 : 100% RDF (100:80:60 N: P:K)	25.40	50.84	59.31
T_{10} : Control (no manures and fertilizers	13.41	30.41	42.28
SEm±	**0.98**	**1.468**	**1.85**
C.D. (5%)	**3.57**	**5.31**	**6.70**

DAT = days after transplanting

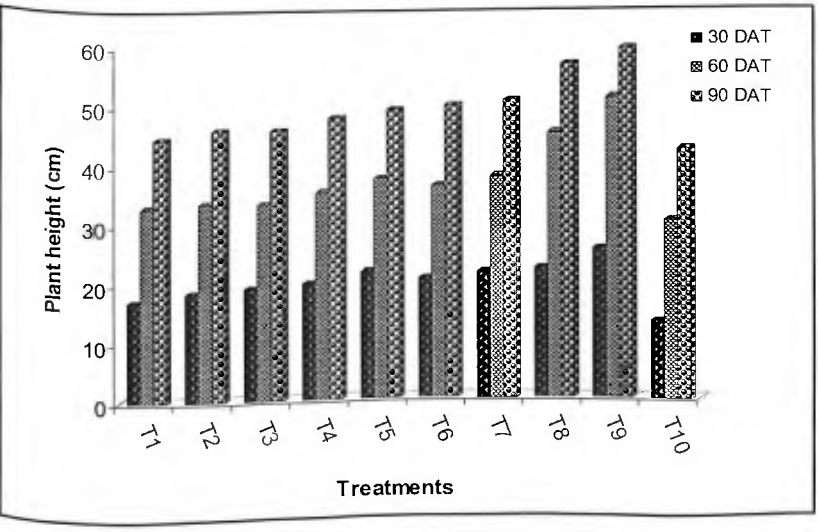


Fig. 4.1 Mean height of plant (cm) at different growth stages as influenced by different treatments

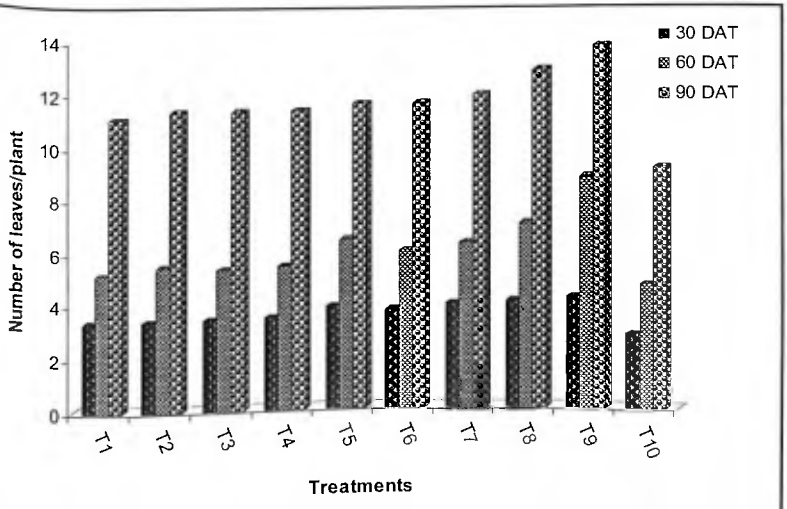
As regards with the treatments effect, all the organic manures and inorganic fertilizers influenced the plant height significantly at all the growth intervals. Among the treatments, 100% RDF ($N_{100}P_{80}K_{60}$) application raised the height significantly over control and few other treatments at all the stages of observation. The significantly maximum plant height at 90 DAT stage was 59.31 cm in case of NPK application over rest of the treatment. However, this was followed by 75 % RDF (56.61 cm) being significantly superior to FYM treatment at 90 DAT stage. The other treatments having organic manure (PSB and VC) were found comparatively less effective for increasing the plant height. Control treatment resulted in the lowest values at 90 DAT stages of observation.

4.1.2 Number of leaves

The data in Table 4.2 and Fig 4.2 (Appendices IV, V and VI) revealed that the number of leaves, increased with the successive growth of onion plant up to 90 DAT stage. The leaf number in different treatments ranged from 2.78 to 4.23 at 30 DAT stage and finally at 90 DAT stage, it went up to the range from =9.13 to 13.70.

Table 4.2 Mean number of leaves of onion at different growth stages as influenced by different treatments

Treatments	Number of leaves/plant		
	30 DAT	60 DAT	90DAT
T_1 : Bio fertilizer (BF) (PSB) 100 g/ha	3.30	5.13	10.99
T_2 : Vermi compost-5t/ha	3.38	5.43	11.24
T_3 : FYM 20 t/ha	3.44	5.35	11.23
T_4 : Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	3.50	5.45	11.31
T_5 : 50% RDF + VC	3.85	6.38	11.58
T_6 : 50% RDF + BF	3.68	5.95	11.55
T_7 : 50% RDF + FYM	3.90	6.25	11.91
T_8 : 75% RDF	4.05	7.03	12.83
T_9 : 100% RDF (100:80:60 N: P:K)	4.23	8.78	13.70
T_{10} : Control (no manures and fertilizers	2.78	4.70	9.13
SEm±	**0.20**	**0.40**	**0.5148**
C.D. (5%)	**0.729**	**1.477**	**1.86**



The number of leaves was found to deviate significant due to various treatments at every growth stage. Amongst the organic manures, inorganic fertilizers and their combinations N_{100} P_{80} K_{60} application brought about significantly higher number of leaves over control and few other treatments at all the observation stages. The maximum leaf number at 90 DAT stage was 13.70 per plant in case of NPK application. This was at par with 75% RDF (12.83 /plant). However, the third best was 50% RDF + FYM (11.91 and then 50% RDF + VC (11.58) and being significantly superior to most of the other treatments. The organic manures alone like bio -fertilizer, farmyard manure, vermi-compost and poultry manure were found equally less effective in the formation of leaves /plant. The lowest numbers of leaves plant were recorded in case of control treatment at each stage with respect to this parameter.

4.1.3 Neck diameter of onion bulbs

The neck diameter of onion bulbs was significantly influenced due to organic manures, inorganic fertilizers and their combinations at every stage of observation (Table 4.3, Fig 4.3 and Appendices VII, VIII and IX).

The neck diameter, in general, encouraged with the advancement of plant growth up to 90 DAT stage. At the initial 30 DAT stage, the neck diameter of different treatments ranged from 0.51 to 0.84 cm, whereas at the final 90 DAT stage, it ranged from 1.31 to 2.68.

All the treatments exerted significant influence upon this parameter at every stage of observation. Amongst the different treatments, 100 % RDF (N_{100} P_{80} K_{60}) application resulted in significantly higher neck diameter over rest of the treatments at every stage of growth. The maximum neck diameter at 90 DAT stage was 2.68 cm in case of NPK application.

able 4.3 Mean neck diameter (cm) of onion at different growth stages as influenced by different treatments

Treatments	Neck diameter of onion bulb (cm)		
	30 DAT	60 DAT	90DAT
T_1 : Bio fertilizer (BF) (PSB) 100 g/ha	0.60	1.22	1.66
T_2 : Vermi compost-5t/ha	0.61	1.28	1.75
T_3 : FYM 20 t/ha	0.64	1.29	1.79
T_4 : Poultry manure (1.5 t/ha)+ goat manure (1.5 t/ha)	0.65	1.64	1.80
T_5 : 50% RDF + VC	0.72	1.74	1.84
T_6 : 50% RDF + BF	0.66	1.70	1.88
T_7 : 50% RDF + FYM	0.72	1.78	1.90
T_8 : 75% RDF	0.77	2.02	2.03
T_9 : 100% RDF (100:80:60 N: P:K)	0.84	2.10	2.68
T_{10} : Control (no manures and fertilizers	0.51	1.15	1.31
SEm±	**0.0266**	**0.128**	**0.077**
C.D. (5%)	**0.09654**	**0.4651**	**0.28**

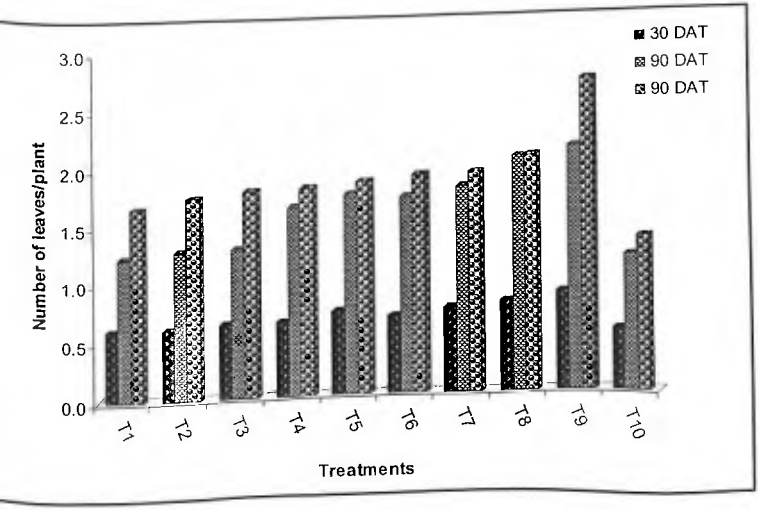


Fig. 4.3 Mean neck diameter (cm) of onion at different growth stages as influenced by different treatments

This was followed by 75% RDF (2.03 cm), 50% RDF + FYM (1.90 cm) and 50% RDF+ BF (1.88 cm) which also brought about significantly higher values over control at every stage. However, all treatments of organic manure alone resulted in significantly lower value over NPK at most of the observation stages. The fertilizer combination, 50% RDF + FYM attained the third position with regard to this parameter. The fertilizer 50% RDF + VC and 50% PM+ 50% GM were found to be equally effective in raising this parameter. The control treatment recorded the significantly lowest neck diameter at every stage of observation.

4.1.4 Chlorophyll content index (CCI)

The data pertaining to this physiological parameter in table 4.4 and Fig 4.4 (Appendix- X) reveal that it was significantly influenced due to organic manures, inorganic fertilizer and their combinations at stage of observation.

The CCI, enhanced with the enhancement of plant growth stage. At the 60 DAT stage, the CCI of different treatments ranged from 14.46 to 29.30.

All the treatments except bio fertilizer (T_1) and FYM (T_3) exerted significant impact upon CCI over control at stage of observation. Amongst the different treatments, 100% RDF (N_{100} P_{80} K_{60}) application registered significantly higher CCI over control as well as some other treatments at 60 DAT stage. However, at 60 DAT stage, 100% RDF proved significantly superior to all the remaining treatments. This was however followed by 75% RDF, 50%RDF +FYM and 50% RDF+VC. Amongst the organic manures, biofertilizer gave the lowest response. The control treatment recorded significantly lowest CCI at stage of observation.

Table 4.4 Mean chlorophyll content index of onion at 60 DAT growth stage as influenced by different treatments

Treatments	Chlorophyll content index
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	16.15
T_2 Vermi compost-5t/ha	18.65
T_3 FYM 20 t/ha	17.95
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	19.15
T_5 50% RDF + VC	20.60
T_6 50% RDF + BF	19.87
T_7 50% RDF + FYM	20.94
T_8 75% RDF	22.97
$T_9$100% RDF (100:80:60 N: P:K)	29.30
T_{10}Control (no manures and fertilizers	14.46
SEm±	**1.23**
C.D. (5%)	**4.48**

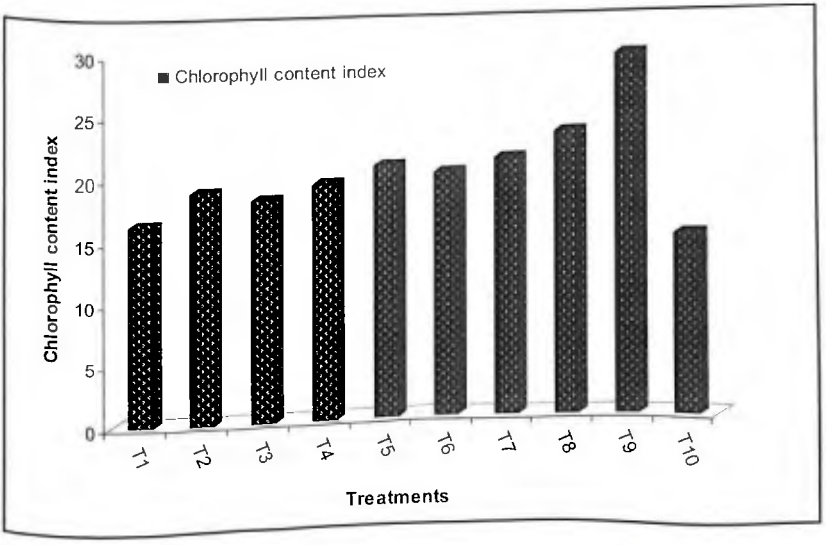


Fig.4.4 Mean chlorophyll content index of onion at 60 DAT growth stage as influenced by different treatments

4.1.5 Leaf area index (LAI) at 30, 60, 90 DAT

The data recorded on leaf area index are presented in Table 4.5 and illustrated diagrammatically in Fig 4.5 (Appendix XI, XII, and XIII). The RDF treatment results in significantly higher leaf area index over T_5 to T_7 and control (0.49). Amongst these treatments NPK application gave the maximum leaf area index up to 1.02 which was significantly higher to those of T_1 to T_7 and T_{10} (control) treatments.

That means 75% RDF alone and 50 %RDF combination with organic manures (T_5 to T_7) was at par to N_{100} P_{80} K_{60} in their effect. 50% RDF with each of the organic manures attained equally higher position (0.80 to 0.88 leaf area index).

The organic manure treatments alone and combination with 50% organic manures were also at par with each other in their effect. The 100% BF and control treatment s gave the lower effect.

Table 4.5 Mean of leaf area index in onion at different growth stages as nfluenced by different treatments

Treatments	Leaf area index (LAI)		
	30 DAT	60 DAT	90DAT
T_1 : Bio fertilizer (BF) (PSB) 100 g/ha	0.23	0.39	0.55
T_2 : Vermi compost-5t/ha	0.25	0.47	0.79
T_3 : FYM 20 t/ha	0.27	0.48	0.72
T_4 : Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	0.32	0.50	0.80
T_5 : 50% RDF + VC	0.30	0.55	0.88
T_6 : 50% RDF + BF	0.32	0.53	0.83
T_7 : 50% RDF + FYM	0.31	0.54	0.84
T_8 : 75% RDF	0.38	0.57	0.91
T_9 : 100% RDF (100:80:60 N: P:K)	0.50	0.61	1.02
T_{10} : Control (no manures and fertilizers	0.17	0.31	0.49
SEm±	**0.015**	**0.025**	**0.0305**
C.D. (5%)	**0.057**	**0.0914**	**0.110**

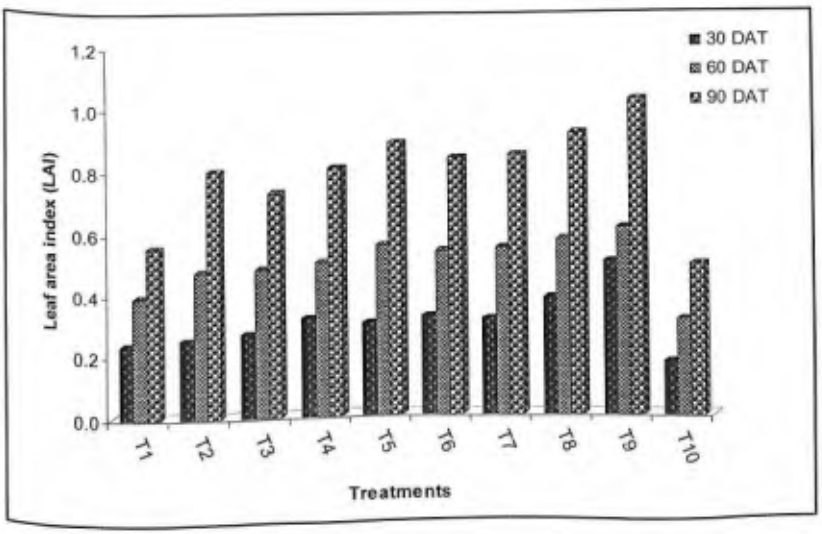


Fig. 4.5 Mean of leaf area index in onion at different growth stages as influenced by different treatments

4.1.6 Bolting percentage

The data in Table 4.6 and Fig 4.6 (Appendices XIV) revealed that the number of bolted plants, increased with the successive growth of onion plant up to before harvesting stage. The bolting Percentage in different treatments ranged from 0.41% to 1.80% at before harvesting stage. The bolting Percentage was found to deviate significant due to various treatments at growth stage. Amongst the organic manures, inorganic fertilizers and their combinations control treatment brought about significantly higher bolting Percentage over 100%RDF and few other treatments at the before harvesting stage. The maximum bolting Percentage at 90 DAT stage was 1.80% .In case of bolting Percentage, this was at par with PSB treatment (1.67%). However, the best was 100%RDF, 75%RDF, 50% RDF + FYM and then 50% RDF + BF (0.85%) and being significantly superior to most of the other treatments. The lowest numbers of bolted plants were recorded in case of 100%RDF treatment at harvesting stage with respect to this parameter.

Table 4.6 Mean of bolting percentage of onion before harvesting stage as influenced by different treatments

Treatments	Bolting Percentage
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	1.67
T_2 Vermi compost-5t/ha	1.48
T_3 FYM 20 t/ha	1.33
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	1.02
T_5 50% RDF + VC	0.79
T_6 50% RDF + BF	0.85
T_7 50% RDF + FYM	0.81
T_8 75% RDF	0.65
T 9100% RDF (100:80:60 N: P:K)	0.41
T_{10}Control (no manures and fertilizers	1.80
SEm±	**0.0633**
C.D. (5%)	**0.2291**

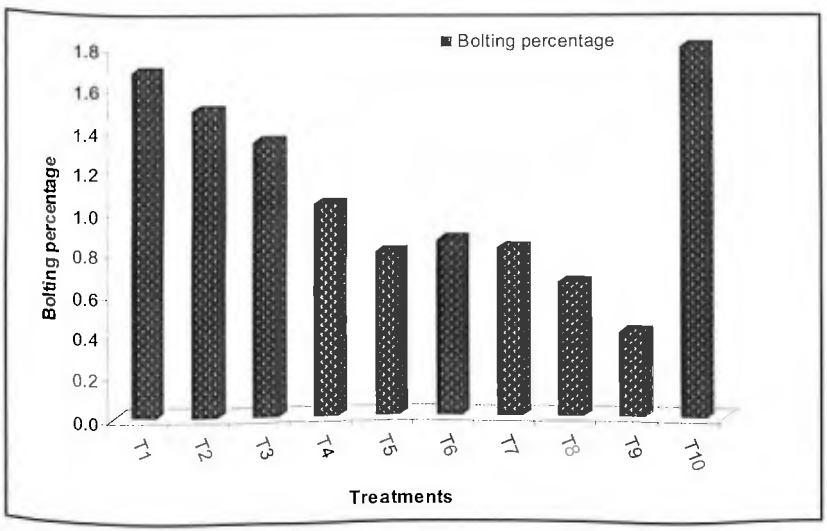


Fig. 4.6 Mean of bolting percentage of onion before harvesting stage as influenced by different treatments

4.2. Post harvest observations:

4.2.1 Fresh weight of bulb:

The data on fresh weight of bulb are presented in Table 4.7 and depicted in Fig 4.7 (Appendices XV) amongst the various treatments, inorganic fertilizer, 100% RDF resulted insignificantly higher fresh weight (62.57g) of onion bulb over control and most of the other treatments. This was followed by 75% RDF (50.30g), 50% RDF+FYM (44.84g), 50%RDF + VC (44.66g) which were at par with 50% RDF+BF. Thereafter, all other treatments showed significantly lower values of fresh weight of onion bulb. The lowest fresh weight only 32.68 g was recorded in the control treatment.

Table 4.7 Mean fresh weight of bulb of onion at different growth stage as influenced by different treatments

Treatments	Fresh weight of bulb (g)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	36.87
T_2 Vermi compost-5t/ha	40.69
T_3 FYM 20 t/ha	41.43
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	42.15
T_5 50% RDF + VC	44.66
T_6 50% RDF + BF	44.60
T_7 50% RDF + FYM	44.84
T_8 75% RDF	50.30
T_9 100% RDF (100:80:60 N: P:K)	62.57
T_{10} Control (no manures and fertilizers	32.68
SEm±	**1.9836**
C.D. (5%)	**7.18**

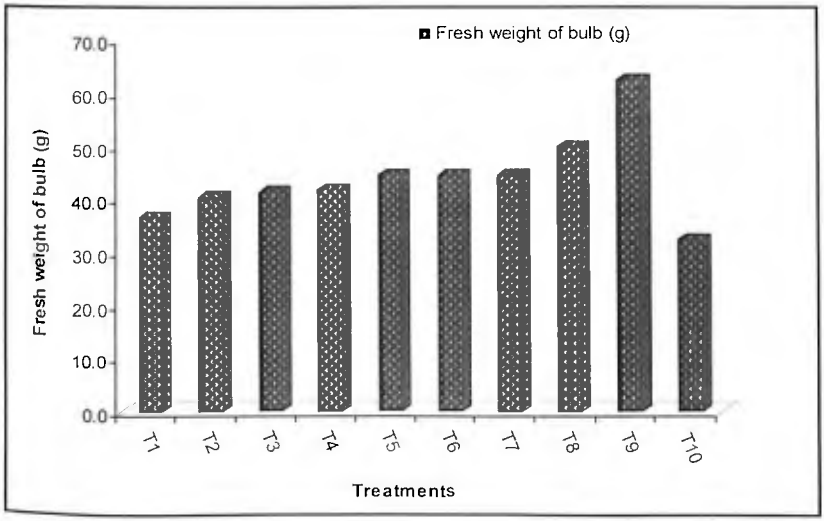


Fig. 4.7 Mean fresh weight of bulb of onion at different growth stage as influenced by different treatments

4.2.2. Dry matter of bulb

The data recorded on dry weight of bulb are presented in Table 4.8 and illustrated diagrammatically in Fig 4.8, (Appendix XVI). The RDF treatment results in significantly higher dry weight of bulb over T_1 to T_8 and control (8.30g). Amongst these treatments NPK application gave the maximum dry matter percentage of bulb up to 12.08g which was significantly higher to those of T_1 to T_8 and T_{10} (control) treatments.

That means 50% RDF its combination with organic manures (T_5 to T_7) was at par to N_{100} P_{80} K_{60} in their effect 50% RDF with each of the organic manures attained equally higher position (9.76 to 10.00 g dry weight of bulb).The PSB and control treatment s gave the lower effect.

Table 4.8 Mean dry matter of bulb/100g fresh weight of onion at different growth stage as influenced by different treatments

Treatments	Dry weight of bulb (g)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	9.00
T_2 Vermi compost-5t/ha	9.25
T_3 FYM 20 t/ha	9.36
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	9.44
T_5 50% RDF + VC	9.97
T_6 50% RDF + BF	9.76
T_7 50% RDF + FYM	10.00
T_8 75% RDF	10.24
T_9 100% RDF (100:80:60 N: P:K)	12.08
T_{10} Control (no manures and fertilizers	8.30
SEm±	**0.488**
C.D. (5%)	**1.76**

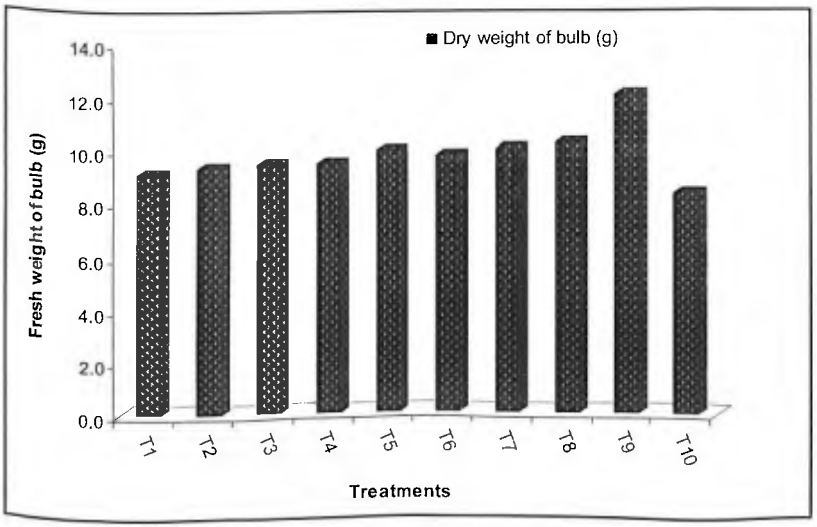


Fig. 4.8 Mean dry matter of bulb/100g fresh weight of onion at different growth stage as influenced by different treatments

4.2.3 Diameter of bulb

The diameter of onion bulb was found to change significantly due to organic manures, inorganic fertilizers and their combinations as revealed from Table 4.9 and Fig 4.9 (Appendix XVII).

Application of organic manures with 50% PM+50 % GM resulted in significantly higher diameter of onion of bulb over control (3.35cm). Among the treatments, 100% RDF application recorded the maximum diameter of bulb up to 6.98 cm, being significantly higher to all the treatments. The application of 75% RDF (5.20 cm) was identical to that of 50% RDF+ FYM (5.11 cm). These were significantly superior to control (3.35 cm). PSB, VC and FYM treatments also performed identically (4.36 to 4.52 cm). The control and only organic manure treatments gave equally lower influence upon this parameter.

Table 4.9 Mean bulb diameter (cm) of onion at different growth stage as influenced by different treatments

Treatments	Bulb diameter (cm)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	4.36
T_2 Vermi compost-5t/ha	4.49
T_3 FYM 20 t/ha	4.52
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	4.57
T_5 50% RDF + VC	4.98
T_6 50% RDF + BF	4.73
T_7 50% RDF + FYM	5.11
T_8 75% RDF	5.20
T_9 100% RDF (100:80:60 N: P:K)	6.98
T_{10} Control (no manures and fertilizers	3.35
SEm±	0.29
C.D. (5%)	1.060

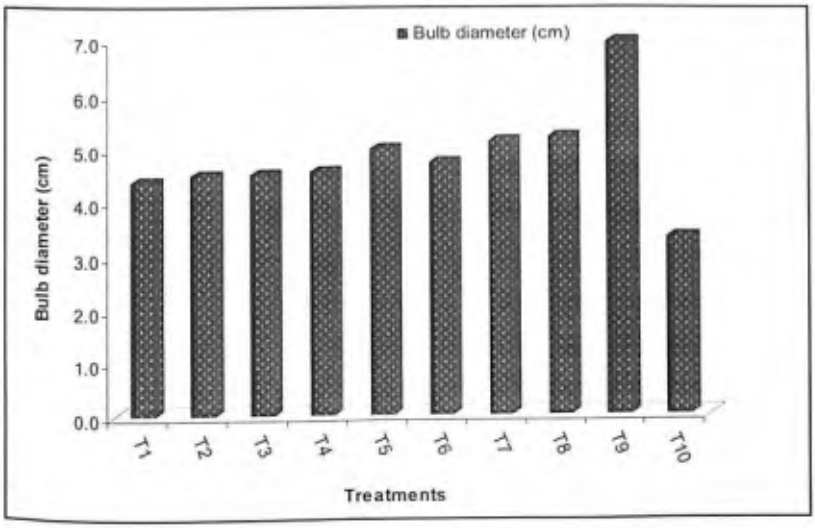


Fig. 4.9 Mean bulb diameter (cm) of onion at different growth stage as influenced by different treatments

4.2.4 No. of roots/bulb

The root counts/plant were recorded in each treatment and the data after statistical analysis are shown in Table:-4.10, Fig:-4.10 appendix (XVIII). The data revealed that the number of roots increased with the successive harvesting stage of onion bulb. The root numbers in different treatments ranged from 34.31 to 73.31. Amongst the organic manures, inorganic fertilizers and their combinations N_{100} P_{80} K_{60} application brought about significantly higher number of roots over control and all other treatments at the observation stages. The maximum root number at harvesting stage was 73.31 per bulb in case of NPK application. This was at par with 75% RDF (67.50 roots/bulb).However, the third best was 50% RDF+FYM (55.50) and then 50% RDF + VC (53.75) and being significantly superior to few treatments. The organic manures alone like bio -fertilizer, farmyard manure and vermi-compost were found equally less effective in the formation of roots /bulb. The lowest numbers of roots plant were recorded in case of control treatment at harvesting stage with respect to this parameter.

Table 4.10 Mean number of roots/bulb of onion at harvesting stage as influenced by different treatments

Treatments	No. of roots/bulb
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	37.09
T_2 Vermi compost-5t/ha	39.88
T_3 FYM 20 t/ha	44.88
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	48.38
T_5 50% RDF + VC	53.75
T_6 50% RDF + BF	51.31
T_7 50% RDF + FYM	55.50
T_8 75% RDF	67.50
T_9 100% RDF (100:80:60 N: P:K)	73.31
T_{10} Control (no manures and fertilizers	34.31
SEm±	1.747
C.D. (5%)	6.32

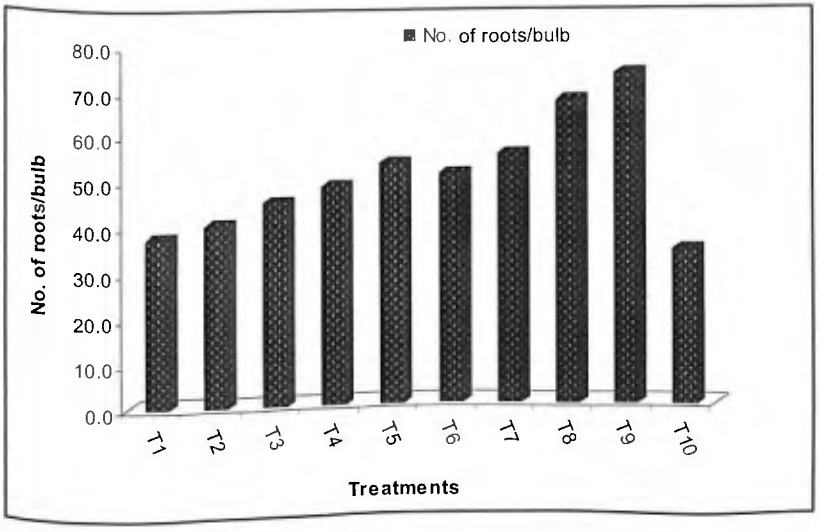


Fig. 4.10 Mean number of roots/bulb of onion at harvesting stage as influenced by different treatments

4.2.5 No. of scalpes/ bulb

The scaples counts/bulb were recorded in each treatment and the data after statistical analysis are shown in Table:-4.11, Fig:-4.11 appendix (XIX). The data revealed that the number of scaples in different treatments ranged from 8.44 to 15.13. The maximum scales number at after harvesting stage was 15.13 per bulb in case of 100% RDF, NPK application. This was at par with 75% RDF (13.02 scalpes /bulb). However, the third best was 50%RDF+FYM (12.97) and then 50% RDF +VC (12.44) and being significantly superior to few treatments. The organic manures alone like bio -fertilizer, farmyard manure and vermi-compost were found equally less effective in the formation of scalpes /bulb. The lowest numbers of scalpes/bulb were recorded in case of control treatment at after harvesting stage with respect to this parameter.

Table 4.11 Mean number of scalpes/bulb of onion after harvesting stage as influenced by different treatments

Treatments	No. of scalpes/bulb
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	**8.69**
T_2 Vermi compost-5t/ha	**9.56**
T_3 FYM 20 t/ha	**9.75**
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	**10.70**
T_5 50% RDF + VC	**12.44**
T_6 50% RDF + BF	**12.13**
T_7 50% RDF + FYM	**12.97**
T_8 75% RDF	**13.02**
T_9 100% RDF (100:80:60 N: P:K)	**15.13**
T_{10} Control (no manures and fertilizers	**7.63**
SEm±	0.7044
C.D. (5%)	2.55

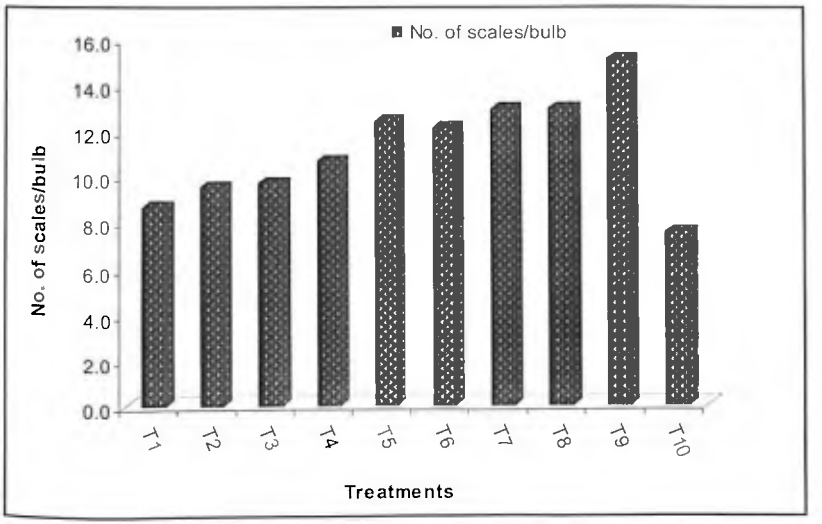


Fig. 4.11 Mean number of scalpes/bulb of onion after harvesting stage as influenced by different treatments

4.2.6 Bulb yield per hectare

The bulb yield of onion var. Agrifound Light Red was influenced significantly due to organic manures, inorganic fertilizers and their combinations as indicated in Table 4.12 and exhibited Fig 4.12, (Appendix XX).

Table 4.12 Mean bulb yield (q/ha) of onion at after harvesting stage as influenced by different treatments

Treatments	Bulb yield (q/ha)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	**150.63**
T_2 Vermi compost-5t/ha	**183.70**
T_3 FYM 20 t/ha	**192.76**
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	**200.64**
T_5 50% RDF + VC	**206.58**
T_6 50% RDF + BF	**210.09**
T_7 50% RDF + FYM	**212.76**
T_8 75% RDF	**226.41**
T_9 100% RDF (100:80:60 N: P:K)	**255.36**
T_{10} Control (no manures and fertilizers	**144.33**
SEm ±	7.45
C.D. (5%)	26.99

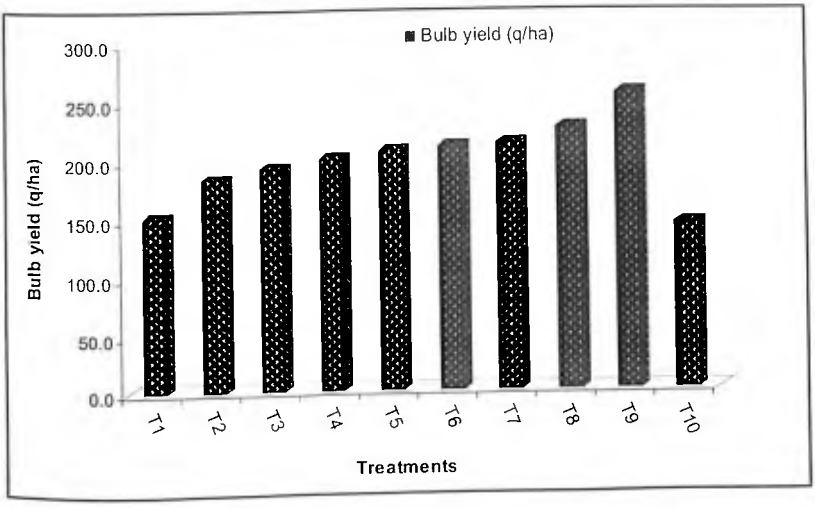


Fig 4.12 Mean bulb yield (q/ha) of onion at after harvesting stage as influenced by different treatments

Application of 100% RDF ($N_{100}P_{80}K_{60}$) resulted in significantly higher yield of onion bulb over rest of the treatments. This fertility level from inorganic fertilizers produced the maximum yield of bulbs (255.36 q/ha) this was, however followed by 75% RDF (226.41 q/ha), 50% RDF +FYM (212.76q/ha) and then 50%RDF +BF (210.09). The influence of 50% PM+50% (200.64 q/ha) was significantly higher to that of PSB (150.63 q/ha) but lower to 100% RDF (255.36 q/ha). The lowest bulb yield (144.33 q/ha) was obtained from the control treatment.

4.2.7 Grade of onion bulbs (%)

The grading of bulbs was done treatment wise, the data obtained under A, B and C grades were subjected to statistical computation. The mean values are presented in Table 4.13 and Fig 4.13. (Appendix XXI, XXII, XXIII).

Table 4.13 Grade of onion bulbs (%) as influenced by different treatment

Treatments	Grade of onion bulb (%)		
	A	B	C
T_1 : Bio fertilizer (BF) (PSB) 100 g/ha	45.65	26.68	27.67
T_2 : Vermi compost-5t/ha	49.35	21.15	31.06
T_3 : FYM 20 t/ha	46.07	22.87	31.66
T_4 : Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	59.38	16.52	24.03
T_5 : 50% RDF + VC	66.72	18.23	14.80
T_6 : 50% RDF + BF	55.66	26.27	17.82
T_7 : 50% RDF + FYM	61.01	19.04	19.63
T_8 : 75% RDF	69.97	18.49	13.54
T_9 : 100% RDF (100:80:60 N: P:K)	79.68	12.96	7.28
T_{10} : Control (no manures and fertilizers	31.37	33.96	34.65
SEm±	3.870	1.182	0.9486
C.D. (5%)	14.013	4.282	3.434

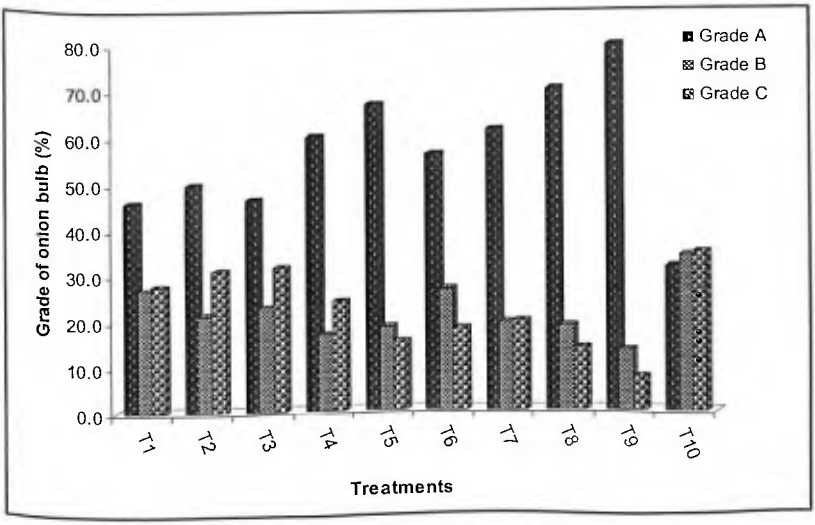


Fig. 4.13 Grade of onion bulbs (%) as influenced by different treatment

The data revealed that the grade of onion bulbs was significantly deviated due to different treatments. The 100% RDF produced higher percentage of grade 'A' onion bulbs (79.68%), followed by 75% RDF (69.97%) and then 50% RDF + VM or 50% RDF + FYM (66.72 to 61.01 %) and the lowest (31.37%) in the control treatment. The remaining treatments produced ''A'' grade bulbs under the intermediate range. On the other hand the onion bulbs of 'B' and 'C' grades were produced higher due to control treatment with out manures and fertilizers (33.96 to 34.65%).

Fertility up to 100% RDF produced the minimum B grade bulbs (12.96 %) and C grade bulbs 7.28%. The 75% RDF and 50% RDF + VC also produced the lower C grade bulbs (13.54% to 14.80 %), followed by 50% RDF +B F (17.82%).

DISCUSSION

Chapter –V

DISCUSSION

The significant findings of the present investigation have been interpreted and discussed in this chapter in the light of the research work already done by the scientists in our country and abroad. The discussion comprises the relevant topics viz. growth, quality and yield attributing characters in case of onion var.Agrifound Light Red.

5.1 Effect of different treatments of organic, inorganic and Bio-fertilizer on Morphological characters of onion

The plant height, number of leaves, leaf Area index and neck diameter of onion was, in general increased with the successive growth and age of plant up to 90 days after transplanting. All four characters increase steadily right from initial 30 DAT stage up to other advanced growth of 90 DAT stage in all the treatment s (Summary Table 6.1). The steady or consistent rise in these parameters in case of onion var.Agrifound Light Red may be due to the fact that the growth of plant is genetically governed and this may vary in different varieties due to variable genetic inheritance among the varieties.

As regards with the treatments effect plant height, number of leaves/plant, leaf Area index and neck diameter were influenced significantly due to various treatments at every stage of observation. Amongst the organic manures and their combination with inorganic fertilizer treatments $N_{100}P_{80}K6_0$ application resulted in significantly higher in these four growth characters overall other treatments having organic with manures with or without 50% and 75% RDF. Accordingly, the maximum height, leaf number, leaf Area index and neck diameter were recorded due to N100P80K60 application. The increase in these vegetative growth parameters may be due to increased availability of heavy dose of nitrogen on nitrogen and other nutrients through inorganic fertilizers which promoted plant growth by ensuring higher number of green leaves with increased photosynthesis and foaming longer and stronger roots to absorb sufficient water and nutrients. Similar findings have been reported by several workers (Serrano *et al.*, 1995; Singh and Kohli, 1999; Singh *et al.* 2001-02; Gowda *et al.* 2002; Dhruv *et al.*

2002; Abbey and Kanton 2003; Mondal *et al.* 2004; Singh *et al.* 2006, Pandey *et al.* 2007;El-Tantawy and El-Beik 2009; and Deb *et al.2009).* On the other hand, the NPK plant nutrients from organic sources are slowly available to the plants as compared to those from inorganic chemical fertilizers.

In case of 100% RDF, application of 80 kg P_2O_5/ha along with N_{100} also proved beneficial in these growth characters. It is obvious that phosphorus is a constituent of chlorophyll and is involved in many physiological processes including cell division, development of meristematic tissue, photosynthesis, metabolism of carbohydrates, fats and proteins etc. Similar results have also been reported by many workers (Singh and Kohli 1999, Geerha *et al.* 2000; Dhruv *et al.* 2002; Jayathilake *et al.* 2002; Alkaff *et al.* 2002; and Gowda *et al.* 2002; Pandey *et al*, 2007; and Jahan *et al.*2010;).

The increased supply of potash (60 kg K_2O/ha) from 100% RDF might have brought about formation of more chlorophyll and carbohydrates and regulated proper translocation of photosynthates and stimulated enzyme activity in the growing plants of onion.

Among the organic manures, PSB vermicompost, poultry manure, goat manure and FYM exerted equally higher influence over others in increasing these growth parameters. It also contains a lot of beneficial soil microorganism as well as humic acid contributing to plant growth and soil fertility. The beneficial effect of vermicompost, poultry manure, goat manure on growth characters of onion have also been reported by Samawat *et al.* (2001); Jayathilake *et al.* (2002); Subba Rao and Ravi Sankar (2002); Prabhakaran and Pitchaai (2002); Prabakaran *et al.* (2002); and Kannan *et al.* (2006).

Chlorophyll content index

Among the organic manures and inorganic fertilizers and their combination, 100% RDF ($(N_{100}P_{80}K_{60})$ resulted in significantly higher chlorophyll content index (CCI) over the remaining treatments at 60 DAT stage (29.30). The water and CO_2 in the presence of sunlight give rise to the chlorophyll formation in which nitrogen is also a constituent there by in the adequate nitrogen supply conditions (N_{100}). The chlorophyll formation was up to the maximum extent, there by more production of photosynthetic for better plant

growth and development. On the other hand, the decreased N supply in case of 50, 75% RDF and organic manures, the chlorophyll formation was also affected accordingly there by significantly lower CCI in different treatments.

5.2 Quality, Yield and physiological attributing parameters

The results on yield attributing parameters are also summarized in the same Table 6.1. The fresh and dry matter of bulb, number of roots and scales of bulb, bolting% and bulb diameter were recorded maximum due to application of recommended dose of $N_{100}P_{80}K_{60}$. These were significantly higher to that of control treatment as well as some other treatments. This may be due to increased supply of major plant nutrients, which are required in larger quantities for the growth, and development of plants. The application of nitrogen at optimum level attributed to acceleration in development of growth and reproductive phases. Moreover, higher content of nitrogen might have accelerated protein synthesis thus promoting the bulb development. These results are in confirmation with Terran *et al.* (1994) and Mondal *et al* (2004) who reported that yield characters like bulb diameters significantly influenced with higher level of nitrogen , phosphorus and potassium application in onion. These results are in close agreement with the findings of Geerha *et al.* (2000), Singh *et al.* (2001-02), Lal *et al.* (2002), Jayanthilake *et al.* (2002), Khalil *et al.* (2002), Alkaff *et al.* (2002), Abbey and Kanton (2003), Prabu *et al.* (2003), Vimala *et al.* (2006), Ahmed (2009), and Deb *et al. (2009);*

After $N_{100}P_{80}K_{60}$ the second , third and fourth best treatments were 75% RDF,50% RDF + FYM and 50% RDF+VC respectively which exerted statistically identical performance in comparison to 100 % NPK application.

This may be due to nutritional effect and improved soil microbial and physical environments which were responsible to enhancing the yield attributing characters.

The beneficial effect of earthworms on plant growth may be due to the presence of macro as well as micronutrients in vermicasts and in their secretions in considerable quantities. It is also the effect of metabolites produced by the earthworms, which are responsible for stimulating the plant growth. It is also

for onion growers, would also be increased quality of onion bulb, ultimately, and increased crop productivity. The higher number of roots and scales / bulb from these organic manures combination with inorganic fertilizer may be due to higher growth and yield attributing characters in these treatments as compared to those of other treatments like organic manures on some other treatments. These findings are in close agreement with those of other with workers.

Although the vermicompost and FYM the lower productivity and consequently lower bulb yield per hectare over NPK but still these organic sources are considered very beneficial particularly for maintaining the soil fertility sustainable productivity and for a better soil health . Because, the organic sources of fertilizer not only supply the essential plant nutrients but also brought about the sound physio-chemical properties and biological activities of the soil on a sustained basis. On the other hand, only 100% NPK applied soil the population of beneficial soil microorganisms and their activities would also be decreased in a due course of time, ultimately, causing the decline in crop productivity.

believed that the earth worm release certain vitamins and similar substances into the soil which may be vitamins B or some pro vitamins D or free amino acids.

The beneficial effect of vermicompost, are in close conformity with the findings of may workers (Chee, 1998; Mowla *et al.* 1999; Samawat *et al.* 2001; Jayathilake *et al.* 2002; Gunadi *et al.* 2002; Prabakaran *et al.* 2002 and Renuka and Ravi Sankar 2002; Kannan *et al* 2006; Singh *et al.* 2006; Bahadur *et al* 2007;Hari *et al.* 2009; and Rao *et al.*2010).

Amongst the organic manures their combination with inorganic fertilizers (inorganic source of nutrients) 100% NPK performed the best which resulted in maximum percent of A grade onion bulbs (79.68%), followed by 75% RDF (69.97%) and then 50% RDF + VC or 50% RDF + FYM (66.72 to 61.01 %).

The summary Table 6.1 further indicates that the application of 100% RDF i.e. recommended dose of fertilizers ($N_{100}P_{80}K_{60}$) resulted in significantly higher yield of onion bulb over rest the treatments. However, this was followed by 75% RDF, 50% RDF + FYM and 50% RDF + BF. This may be due to regular and increased supply of plant nutrients in proper available forms as well as other added advantage provided by these organic and inorganic sources over control treatments.

Amongst the organic with inorganic sources of nutrients 100% NPK performed the best and results in maximum bulb yield up to 255.36 q/ha, being significantly higher to rest of the treatments. This may be due to maximum increase in growth and yield attributing characters 100% in NPK fertilizer treatment as compared to all other treatments. These findings are in close conformity with those of Terran *et al.* (1994), Geerha *et al.* (2000), Singh *et al.* (2001-02), Lal *et al.*(2002) ,Jayanthilake *et al.* (2002), Khalil *et al.* (2002),Alkaff *et al.* (2002). Abbey and Kanton (2003), Prabu *et al.* (2003) and Mondal *et al.* (2004) Bahadur *et al.* (2007) Pandey *et al.* (2007). Pawar *et al.* (2009). *and Singh et al. (2011).* After 100% NPK, the better performance was given by 75% RDF, 50 % RDF + FYM and then 50% RDF + BF applications. Consequently, the number of roots and scales/bulb also followed the same trend. The lowest bolting % was obtained by 100% RDF, followed by 75% RDF, 50 %RDF + VC. On the other hand, lowest number of bolted plants has beneficial

SUMMARY, CONCLUSION AND SUGGESTIONS

Chapter – VI

SUMMARY, CONCLUSION AND SUGGESTIONS

6.1 SUMMARY

The experiment entitled "Studies on integrated nutrient management in onion (*Allium cepa* L.) CV Agrifound Light Red". Was conducted during rabi season of 2010-11 at the Horticulture Department, College of Agriculture, Rewa (M.P.) with the following objectives:

Objective

1. To study the effect of organic, inorganic and biological sources of nutrients.
2. To determine the efficacy of INM on quality of onion.
3. To find out the response of nutrients separately and combined.
4. To find out the appropriate ratio of inorganic and organic sources of nutrients on growth and yield of onion.

The soil experimental area was clay loam rich in organic matter and had good water holding capacity. The soil having pH 7.15 was low in available nitrogen (233.2 kg/ha) and available phosphorus (12.54 kg/ha) and high in potassium content (229.6 kg/ha). Organic carbon 0.53% and electrical conductivity 0.30 ds/m. The weather conditions including temperature etc. were favorable for the plant growth and development, and the entire season was almost congenial. The treatments comprised of ten organic and inorganic fertilizer treatments (Bio fertilizers (PSB), FYM – 20 t/ha, vermi-compost – 5 t/ha, poultry manure-1.5 t/ha + goat manure-1.5 t/ha, 50% RDF + BF , 50% RDF + FYM , 50 % RDF+VC , 75% RDF, 100% RDF (100:80:60 and control i.e. no manures and fertilizers). The experiment was laid out in randomized block design with four replications. The onion was Agrifound light Red was sown transplanted on 2 January, 2011. The crop was harvested on 28 May, 2011.

The salient findings of the present experiment are being summarized as below:

6.1.1 Effect of different treatment of organic, inorganic and Bio-fertilizer on Morphological characters of onion

The data in summary Table 6.1 reveal that the plant height, number of leaves, leaf area index and neck diameter of onion was in general, enhanced with the successive growth and age of plant up to 90 days after transplanting (DAT). All these five characters increased steadily right from 30 DAT stage up to the 90 DAT stage in all the treatments.

As regards with the treatments effect, plant height , leaves per plant , and neck diameter and chlorophyll content index were influenced significantly due to various treatments at every stage of observation. Among the organic manures and their combination with inorganic fertilizer treatments 100% $N_{100}P_{80}K_{60}$ application resulted in significantly higher all these growth characters over control and few other treatments having organic manures. Accordingly at 90 DAT the maximum height was 59.31 cm, leaves 13.70 /plant, leaf area index (1.02) and neck diameter 2.68 cm ,chlorophyll content index 29.30 due to 100% NPK application. This was however, equally followed by 75% RDF and, 50% RDF + FYM.

6.1.2 Quality, Yield and physiologicaI attributing parameters

The results on Quality, Yield and physiological attributing parameters are also summarized in the same Table 6.1 The fresh and dry weight of bulb, number of roots and scales / bulb, and bulb diameter were recorded maximum (62.57 g, 12.08 g , 73.31 , 15.13 and 6.98 cm respectively) due to application of 100% recommended dose of fertilizers ($N_{100}P_{80}K_{60}$). These were significantly higher to that of control treatment as well as some treatments. After 100 % NPK (RDF) the second and third best treatments were 75% RDF, 50% RDF+ FYM respectively which exerted statistically identical performance in comparison to 100% NPK application. The fresh weight ranged from 44.84 to 62.57 g, dry weight 10.00 g to 12.08 g, number of roots 55.50 to 73.31 and scales of bulb 12.97 to 15.13, bulb diameter 5.11 cm to 6.98 cm among the second and third best treatments.

Amongst the organic manures their combination with inorganic fertilizers and inorganic source of nutrients, 100% NPK performed the best and resulted in

maximum percent of A grade onion bulbs (79.68%) followed by 75% RDF (69.97)and then 50% RDF +VC (66.72) or 50% RDF + FYM (61.01 %).

The summary Table 6.1 further indicate that the application of 100% RDF (100:80:60) resulted in higher yield of onion bulb over rest of the treatments. Among these treatments $N_{100}P_{80}K_{60}$ produced the maximum bulb yield (255.36 q/ha), being significantly higher to some rest of treatments. This was, however, followed by 75% RDF (226.41 q/ha), 50% RDF + FYM (212.76 q/ha) and then 50% RDF + BF (210.09 q/ha)

Consequently the 100% RDF $N_{100}P_{80}K_{60}$ application gave the minimum bolting percentage (0.41%). This was, however, followed by 75% RDF (0.65 %), 50 % RDF +VC (0.79).

6.2 Conclusion

Amongst the organic manures and inorganic fertilizers 100% RDF i.e. $N_{100}P8_0K6_0$ application alone proved the most beneficial for growing onion var Agrifound Light Red in this region. It yielded the maximum onion bulbs (255.36 q/ha), lowest bolting percentage (0.41%) with number of scales /bulb is maximum (15.13). The second best treatments was 75% RDF (226.41 q/ha) yield, 0.65% bolting and 13.02 number of scales /bulb. The third best treatment was 50% RDF + FYM (212.76 q/ha) yield, 0.81% bolting and 12.97 number of scales /bulb.

6.3 SUGGESTIONS

1. The experiment should be repeated for a few more years to confirm the present findings and also see the combination effect of organic manures and inorganic fertilizers under the different locations.
2. The experiment needs to be strengthened with few more organic types of manure along with eco friendly products like plant growth regulators, so that the addition of much more chemical fertilizers may be economized.
3. Quality parameters of the produce due to effect of organic nutrition may be tested in the future investigation.

Table 6.1 Growth, yield-components and Physiological parameters of onion as influenced by organic manures and inorganic fertilizers

Treatments	Plant height (90/DAT) (cm)	Leaves /plant (90 DAT)	neck diameter (cm) at 90 DAT	Chlorophyll content index	Leaf area index at 90 DAT	Bolting%	Fresh weight of bulb (g)	Dry matter percentage	Diameter of bulb (g)	NO. of roots/bulb	No.of scalpes/bulb	Bulb yield (q/ha)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	44.03	10.99	1.66	16.15	0.55	1.67	36.87	9.00	4.36	37.09	8.69	150.63
T_2 Vermi compost-5t/ha	45.49	11.24	1.75	18.65	0.79	1.48	40.69	9.25	4.49	39.88	9.56	183.70
T_3 FYM 20 t/ha	45.38	11.23	1.79	17.95	0.72	1.33	41.43	9.36	4.52	44.88	9.75	192.76
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	47.53	11.31	1.80	19.15	0.8	1.02	42.15	9.44	4.57	48.38	10.70	200.64
T_5 50% RDF + VC	48.98	11.58	1.84	20.60	0.88	0.79	44.66	9.97	4.98	53.75	12.44	206.58
T_6 50% RDF + BF	49.78	11.55	1.88	19.87	0.83	0.85	44.60	9.76	4.73	51.31	12.13	210.09
T_7 50% RDF + FYM	50.65	11.91	1.90	20.94	0.84	0.81	44.84	10.00	5.11	55.50	12.97	212.76
T_8 75% RDF	56.61	12.83	2.03	22.97	0.91	0.65	50.30	10.24	5.20	67.50	13.02	226.41
T_9 100% RDF (100:80:60 N: P:K)	59.31	13.70	2.68	29.30	1.02	0.41	62.57	12.08	6.98	73.31	15.13	255.36
T_{10} Control (no manures and fertilizers	42.28	9.13	1.31	14.46	0.49	1.80	32.68	8.30	3.35	34.31	7.63	144.33
SEM±	1.85	0.5148	0.077	1.23	0.03	0.0633	1.98	0.488	0.29	1.7471	0.70	7.455
C.D. (5%)	6.70	1.8638	0.28	4.48	0.11	0.229	7.181	1.76	1.0600	6.32	2.55	26.99

Table 6.1 Growth, yield-components and Physiological parameters of onion as influenced by organic manures and inorganic fertilizers

Treatments	Plant height (90/DAT) (cm)	Leaves /plant (90 DAT)	neck diameter (cm) at 90 DAT	Chlorophyll content index	Leaf area index at 90 DAT	Bolting%	Fresh weight of bulb (g)	Dry matter percentage	Diameter of bulb (g)	NO. of roots/bulb	No.of scalpes/bulb	Bulb yield (q/ha)
T_1 Bio fertilizer (BF) (PSB) 100 g/ha	44.03	10.99	1.66	16.15	0.55	1.67	36.87	9.00	4.36	37.09	8.69	150.63
T_2 Vermi compost-5t/ha	45.49	11.24	1.75	18.65	0.79	1.48	40.69	9.25	4.49	39.88	9.56	183.70
T_3 FYM 20 t/ha	45.38	11.23	1.79	17.95	0.72	1.33	41.43	9.36	4.52	44.88	9.75	192.76
T_4 Poultry manure (1.5 t/ha)+ Goat manure (1.5 t/ha)	47.53	11.31	1.80	19.15	0.8	1.02	42.15	9.44	4.57	48.38	10.70	200.64
T_5 50% RDF + VC	48.98	11.58	1.84	20.60	0.88	0.79	44.66	9.97	4.98	53.75	12.44	206.58
T_6 50% RDF + BF	49.78	11.55	1.88	19.87	0.83	0.85	44.60	9.76	4.73	51.31	12.13	210.09
T_7 50% RDF + FYM	50.65	11.91	1.90	20.94	0.84	0.81	44.84	10.00	5.11	55.50	12.97	212.76
T_8 75% RDF	56.61	12.83	2.03	22.97	0.91	0.65	50.30	10.24	5.20	67.50	13.02	226.41
T_9 100% RDF (100:80:60 N: P:K)	59.31	13.70	2.68	29.30	1.02	0.41	62.57	12.08	6.98	73.31	15.13	255.36
T_{10} Control (no manures and fertilizers	42.28	9.13	1.31	14.46	0.49	1.80	32.68	8.30	3.35	34.31	7.63	144.33
SEM±	1.85	0.5148	0.077	1.23	0.03	0.0633	1.98	0.488	0.29	1.7471	0.70	7.455
C.D. (5%)	6.70	1.8638	0.28	4.48	0.11	0.229	7.181	1.76	1.0600	6.32	2.55	26.99

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APPENDIX

APPENDICES

Appendix – I

Plant height at 30 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	10.9551	3.651701067	0.938628	2.96
Treatment	9	382.049	42.44989684	10.91126*	2.25
Error	27	105.043	3.890467363		
Total	39	498.047			

Appendix – II

Plant height at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	3.52243	1.174142358	0.136083	2.96
Treatment	9	1398.19	155.3545252	18.00556*	2.25
Error	27	232.96	8.628139766		
Total	39	1634.67			

Appendix – III

Plant height at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	50.3146	16.77153667	1.220659	2.96
Treatment	9	1059.97	117.7741489	8.571792*	2.25
Error	27	370.973	13.73973481		
Total	39	1481.25			

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Error	27	370.973	13.73973481		
Total	39	1481.25			

Appendix – IV

Number of leaves/plant 30 at days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.00243	0.334143333	2.059496	2.96
Treatment	9	6.41874	0.713193333	4.395775*	2.25
Error	27	4.38062	0.162245185		
Total	39	11.8018			

Appendix – V

Number of leaves/plant at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.28221	0.4274025	0.641315	2.96
Treatment	9	49.9221	5.5469025	8.323097*	2.25
Error	27	17.9941	0.666446944		
Total	39	69.1984			

Appendix – VI

Number of leaves/plant at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	5.11707	1.705689167	1.608882	2.96
Treatment	9	51.3485	5.705389167	5.381576*	2.25
Error	27	28.6246	1.060170648		
Total	39	85.0902			

Appendix – IV

Number of leaves/plant 30 at days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.00243	0.334143333	2.059496	2.96
Treatment	9	6.41874	0.713193333	4.395775*	2.25
Error	27	4.38062	0.162245185		
Total	39	11.8018			

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Number of leaves/plant at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.28221	0.4274025	0.641315	2.96
Treatment	9	49.9221	5.5469025	8.323097*	2.25
Error	27	17.9941	0.666446944		
Total	39	69.1984			

Appendix – VI

Number of leaves/plant at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	5.11707	1.705689167	1.608882	2.96
Treatment	9	51.3485	5.705389167	5.381576*	2.25
Error	27	28.6246	1.060170648		
Total	39	85.0902			

Appendix – VII

Neck diameter of bulb at 30 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.02483	0.008275833	2.909567	2.96
Treatment	9	0.31387	0.034874722	12.26104*	2.25
Error	27	0.0768	0.002844352		
Total	39	0.4155			

Appendix – VIII

Neck diameter of bulb at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.03603	0.012009167	0.181891	2.96
Treatment	9	4.1155	0.457278056	6.925939*	2.25
Error	27	1.78265	0.066023981		
Total	39	5.93418			

Appendix – IX

Neck diameter of bulb at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.01684	0.005613333	0.231686	2.96
Treatment	9	4.26704	0.474115556	19.56879*	2.25
Error	27	0.65416	0.024228148		
Total	39	4.93804			

Appendix – X

Chlorophyll content Index at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	7.29689	2.432295833	0.395809	2.96
Treatment	9	594.912	66.10133028	10.7567*	2.25
Error	27	165.919	6.145131019		
Total	39	768.127			

Appendix – XI

Leaf area index at 30 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.00422	0.001406667	1.402511	2.96
Treatment	9	0.28874	0.032082222	31.98744*	2.25
Error	27	0.02708	0.001002963		
Total	39	0.32004			

Appendix – XII

Leaf area index at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.00873	0.00291	1.140845	2.96
Treatment	9	0.29191	0.032434444	12.7157*	2.25
Error	27	0.06887	0.002550741		
Total	39	0.36951			

Appendix – XIII

Leaf area index at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.05721	0.01907	5.1187	2.96
Treatment	9	0.93095	0.103438889	27.76469*	2.25
Error	27	0.10059	0.003725556		
Total	39	1.08875			

Appendix – XIV

Bolting Percentage before harvesting stage

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.0527	0.017566667	1.095761	2.96
Treatment	9	7.75241	0.861378889	53.73046*	2.25
Error	27	0.43285	0.016031481		
Total	39	8.23796			

Appendix – XV

Fresh weight of bulb (g) after harvesting stage

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	22.7639	7.587969167	0.482111	2.96
Treatment	9	2343.43	260.3812114	16.54363*	2.25
Error	27	424.955	15.73905806		
Total	39	2791.15			

Appendix – XVI

Dry weight of onion bulb per 100 g fresh weight of bulb

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	5.54525	1.848416667	1.939716	2.96
Treatment	9	35.8333	3.981478889	4.178138*	2.25
Error	27	25.7291	0.952931481		
Total	39	67.1077			

Appendix – XVII

Bulb diameter (cm)

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	2.76439	0.9214625	2.686802	2.96
Treatment	9	30.3226	3.369180278	9.823863*	2.25
Error	27	9.25989	0.342958796		
Total	39	42.3469			

Appendix – XVIII

Number of roots /bulb after harvesting stage

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	49.7245	16.57483333	1.357478	2.96
Treatment	9	5746.12	638.4573333	52.28963*	2.25
Error	27	329.67	12.21001852		
Total	39	6125.51			

Appendix – XIX

Number of Scalpes /bulbs after harvesting stage

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.70532	0.56844	0.286351	2.96
Treatment	9	193.45	21.49438889	10.82777*	2.25
Error	27	53.5982	1.985117778		
Total	39	248.753			

Appendix – XX

Bulb yield per ha (q)

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	288.453	96.15116	0.432499	2.96
Treatment	9	39587.6	4398.627657	19.78551*	2.25
Error	27	6002.52	222.3155767		
Total	39	45878.6			

Appendix – XXI

Grading of bulb to A grade

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	88.3761	29.45868333	0.491573	2.96
Treatment	9	7047.32	783.03581	13.0664*	2.25
Error	27	1618.04	59.92743148		
Total	39	8753.74			

Appendix – XXII

Grading of bulb to B grade

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	34.0437	11.34788667	2.027468	2.96
Treatment	9	1320.89	146.7652567	26.22178*	2.25
Error	27	151.121	5.597073704		
Total	39	1506.05			

Appendix – XXIII

Grading of bulb to C grade

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	1.44562	0.481873333	0.133858	2.96
Treatment	9	2937.68	326.4091378	90.6724*	2.25
Error	27	97.1966	3.599873333		
Total	39	3036.32			

VITA

VITA

The author of this Thesis Mr. Devendra kumar Tembhare, son of Smt. Leelawati and Shri Pannalal Tembhare was born on 10 April 1984 in Balaghat, Madhya Pradesh. He passed his Intermediate from Govt. Higher Secondary School, Balaghat (Madhya Pradesh) in the year 2002.

The author joined College of Agriculture, Jabalpur campus in the year 2003 and completed the B.Sc. (Ag.) Degree in the year 2007 with an OGPA of 7.56 out of 10 point scale.

After graduation he joined M.Sc. (Horticulture) Vegetable Science from Jawaharlal Nehru Krishi Vishwavidyaya, Jabalpur in the year 2009, and cleared all the courses with first division (8.0 OGPA at 10 point scale) in the year 2010- 2011.

He worked for his postgraduate degree under the able and erudite guidance of Dr.U.S.Bose, Associate Professor Department of Horticulture, College of Agriculture,Rewa, J.N.K.V.V. Jabalpur(M.P.).

Appendix – VII

Neck diameter of bulb at 30 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.02483	0.008275833	2.909567	2.96
Treatment	9	0.31387	0.034874722	12.26104*	2.25
Error	27	0.0768	0.002844352		
Total	39	0.4155			

Appendix – VIII

Neck diameter of bulb at 60 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.03603	0.012009167	0.181891	2.96
Treatment	9	4.1155	0.457278056	6.925939*	2.25
Error	27	1.78265	0.066023981		
Total	39	5.93418			

Appendix – IX

Neck diameter of bulb at 90 days after transplanting

Source of variance	d.f.	S.S.	M.S.S.	F cal	F tab at 5%
Replication	3	0.01684	0.005613333	0.231686	2.96
Treatment	9	4.26704	0.474115556	19.56879*	2.25
Error	27	0.65416	0.024228148		
Total	39	4.93804			