

P3707-TH6171

**EFFECT OF FYM, N, P AND K LEVELS ON
GROWTH, UPTAKE OF NUTRIENTS AND
ROOT YIELD OF ASHWAGANDHA
(*Withania somnifera*)**

BY

Miss GAWANDE RAJANIGANDHA VISHWAMBHAR

B.Sc. (Agri.)

**MASTER OF SCIENCE
(Agriculture)**

IN

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,

College of Agriculture, Latur

MKV, PARBHANI 431 402 (M.S.)

2011

**EFFECT OF FYM, N, P AND K LEVELS ON
GROWTH, UPTAKE OF NUTRIENTS AND
ROOT YIELD OF ASHWAGANDHA
(*Withania somnifera*)**

By

Miss GAWANDE RAJANIGANDHA VISHWAMBHAR
B.Sc. (Agri.)

T 6171

DISSERTATION

Submitted to the

Marathwada Krishi Vidyapeeth, Parbhani

In partial fulfillment of the requirements

For the degree of

MASTER OF SCIENCE (AGRICULTURE)

IN

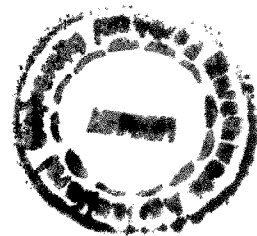
SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,

College of Agriculture, Latur

MKV, PARBHANI 431- 402 (M.S.)

2011



CANDIDATE'S DECLARATION

I hereby declare that the dissertation
or part thereof, has not been
previously submitted by
me for a degree of
any University.

Place : Latur

Date: 30 / 3 / 2011



(R. V. Gawande)

Reg.No. 2009 A/ 41 ML

Dr. V. G. Takankhar

M. Sc., Ph.D.

Programme co-ordinator,

KVK, Tuljapur, Osmanabad,

Marathwada Krishi Vidyapeeth,

Parbhani 431 402 (M.S.)

CERTIFICATE- I

This is to certify that the dissertation entitled, “EFFECT OF FYM, N, P AND K LEVELS ON GROWTH, UPTAKE OF NUTRIENTS AND ROOT YIELD OF ASHWAGANDHA (*Withania somnifera*)” submitted by **Miss Gawande Rajanigandha Vishwambhar** to the **Marathwada Krishi Vidyapeeth, Parbhani** in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **Soil Science and Agricultural Chemistry**, is record of original and bonafide research work carried out by her under my guidance and supervision. It is of sufficiently high standard to warrant its presentation for the award of the said degree.

I also certify that the dissertation or part thereof has not been previously submitted for a degree of any university.

Place: Latur

Date: 30 / 3 / 2011



(Dr. V. G. Takankhar)

Research Guide
and

Chairman Advisory Committee

CERTIFICATE – II

This is to certify that the dissertation entitled “EFFECT OF FYM, N, P AND K LEVELS ON GROWTH, UPTAKE OF NUTRIENTS AND ROOT YIELD OF ASHWAGANDHA (*Withania somnifera*)” submitted by MISS. GAWANDE RAJANIGANDHA VISHWAMBHAR to the Marathwada Agricultural University, Parbhani in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (Agriculture) in the subject of SOIL SCIENCE AND AGRICULTURAL CHEMISTRY has been approved by the student’s advisory committee after viva-voce examination in collaboration with the external examiner.



External Examiner
(D.S.Kide)



(Dr. V.G. Takankhar)
Research Guide & Chairman

Advisory Committee



Prof. S.R. Patil



Prof. R.N. Khandare



Prof. B.G. Kamble



Dr. A.M. Degaonkar



Associate Dean (P.G.)
College of Agriculture,
M.A.U., Parbhani



Associate Dean and Principal
College of Agriculture, Latur

ACKNOWLEDGEMENT

I have immense pleasure in expressing my whole hearted sense of gratitude and getting this privilege of offering my sincere and devoted thanks to my research guide **Dr. V.G. Takankhar**, Programme Co-ordinator, KVK, Tuljapur, for his valuable suggestion, constructive criticism, and constant encouragement throughout investigation.

I want like to place my sincere thanks to my committee members, **Shri. S.R. Patil**, Associate Professor, Department of Soil Science and Agriculture Chemistry, College of Agriculture, Latur. **Shri. R. N. Khandare**, Assistant Soil Physicist, Dry Land Research Station, MKV, Parbhani, **Dr. A. M. Degaonkar** Associate Professor, Department of Economics, College of Agriculture, Latur and **Shri. B.G. Kamble**, Associate professor College of Agricultural, Ambejogai for their valuable suggestion and guidelines during course of research.

I also feel immense pleasure in expressing my sincere thanks to **Dr. D. P. Waskar**, Associate Dean and Principal, College of Agriculture, Latur, MKV, Parbhani and **Dr. U.G. Kulkarni**, **Dr. D. A. Chavhan** Ex. Associate Dean and Principal, College of Agriculture, Latur for availing me facilities for the completion of this research work.

I convey my sincere thanks to Miss. **B. R. Gajbhiye**, Assistant professor, College of Agriculture, Latur for their valuable help during my investigation.

My special thanks are extended to my *seniors, batchmens* and *juniors* and friends **Miss Sukhada, Kanchan, Megha, Minakshi, Geeta, Reshma, Kalyani, Shital, Vidhya, Apesha, Neeta, Sunitadi, Truptidi, Minakshidi, Shilratan, Padmawati.**

My very very special thanks from my bottom of heart to my special batchments **Pranju, Swati, Rohini, Yasmin, Rajendra, Balu , Shailesh, Gajanan, Suresh and Bansi.**

I thankful to **Shri. R.B. Mahajan**, Laboratory Attendant and **Shri Balaji Khude**, for, layout, planting, collecting soil samples and laboratory analysis and **Shri V. G. Tambarwade**, Assistant Librarian, and **Shri Dhanve S. S.** for excavating literature from library.

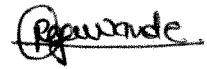
I am also thankful to **Shri. A. D. Bolegave**, for his patience and copounding for typing this dissertation mistake free, cleanly and nearly.

No words are enough to express hearties gratitude to my beloved father **Shri Gawande Vishwambhar Maroti** and mother **Sau. Gawande Savitri Vishwambhar**, uncles **Devraokaka** who have always inspired towards success and moral support for building up of my educational carrier. I convey my special thanks to my brother **Ravi and Avinash** and lovely Sister **Rupali** and cousins **Suraj, Praful** for their everlasting encouragement and support towards me.

Lastly, I express my regards to those names I have forgotten to mention here.

Place: **Latur**

Date : **30/3/2011**



(R. V. Gawande)

CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-17
III	MATERIALS AND METHODS	18-30
IV	RESULTS AND DISCUSSION	31-57
V	SUMMARY AND CONCLUSION	58-60
	REFERENCES	i-x

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1	Metrological data recorded during experimental period	19
2	Physico-chemical properties of the experimental soil	21
3	Treatments details	23
4	Schedule of culture operation	24
5	Mean Plant height as influenced by FYM and Fertilizer levels different crop growth stages	32
6	Number of leaves as influenced by FYM and Fertilizer levels at different crop growth stages of ashwagandha	34
7	No. of branches as influenced by FYM and Fertilizer levels at different crop growth stages of ashwagandha	36
8	Leaf area as influenced by FYM and fertilizer levels at different growth stages	37
9	Effect of FYM and fertilizer levels on 50% flowering and dry matter production of ashwagandha crop	39
10	Effect of FYM and fertilizer levels on seed yield and yield attributes of ashwagandha	42
11	Effect of FYM and fertilizer levels on root yield and root characters of ashwagandha	44
12	Interaction effect of FYM and fertilizer levels on root diameter os ashwagandha	46
13	Effect of FYM and fertilizer of N, P and K concentration and their uptake by ashwagandha	48
14	Interaction effect of FYM and fertilizer levels on N% of ashwagandha	49

TABLE NO.	TITLE	PAGE NO.
15	Interaction effect of FYM and fertilizer levels on N uptake of ashwagandha	50
16	Interaction effect of FYM and fertilizer levels on P uptake of ashwagandha	50
17	Interaction effect of FYM and fertilizer levels on K uptake of ashwagandha	51
18	Effect of FYM and fertilizer levels of soil physicochemical properties	52
19	Effect of FYM and fertilizer levels of available N, P and K content in soil	54
20	Effect of FYM and fertilizer levels of soil available micronutrients	57

LIST OF FIGURES

Figure No.	Title	In between page no.
1	Plant of lay out	23-24
2	Plant height of ashwagandha as influenced by FYM and fertilizer levels at different growth stages	32-33
3	Dry matter production (Kg ha^{-1}) of ashwagandha as influenced by FYM and fertilizer levels	39-40
4	Seed yield (Kg ha^{-1}) as influenced by various treatments of FYM and fertilizer	42-43
5	Fresh and dry root weight (Kg ha^{-1}) as influenced by of FYM and fertilizer levels	44-45
6	Effect of FYM and fertilizer levels on root length and root diameter of ashwagandha	45-46
7	Effect of FYM and fertilizer levels on concentration of N, P and K (%) in ashwagandha plant	48-49
8	N, P and K uptake of ashwagandha as influenced by various treatments of FYM and fertilizer levels	48-49
9	N content (%) of ashwagandha as influenced by interaction effect of fertilizer and FYM levels	49-50
10	Effect of different levels of FYM and fertilizer on organic carbon	52-53
11	Effect of different levels of FYM and fertilizer on calcium carbonate (%) in soil	52-53
12	Effect of different levels of FYM and fertilizer on N, P and K in soil (Kg ha^{-1})	54-55

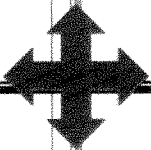
LIST OF PLATES

Sr. No.	Title	Page No.
		(in between)
1.	General view of experimental plot	23-24
2.	Vigorous vegetative growth of plant due to treatment 5 t FYM ha ⁻¹ + 100 % RDF	34-35

ABBREVIATIONS

@	-	At the rate of
cm	-	Centimeter (s)
C.D.	-	Critical difference
CaCO ₃	-	Calcium carbonate
DAS	-	Days after sowing
DAT	-	Days after transplanting
dS m ⁻¹	-	Desicentimol per meter
EC	-	Electrical conductivity
Edn.	-	edition
<i>et al.</i>	-	et alia (And others)
Expt.	-	Experiment
Fig.	-	Figure
FYM	-	Farm yard manure
g	-	Grams(s)
ha ⁻¹	-	Per hectare
Kg	-	Kilogram(s)
Max.	-	Maximum
Met.	-	Meteorological
M	-	Meter(s)
Viz.	-	Namely
N	-	Nitrogen
NS	-	Non-significant
OC	-	Organic Carbon
No.	-	Number(s)
NMPB	-	National medicinal Plants Board
%	-	Per cent
P	-	Phosphorus
PP	-	Page Number
PSB	-	Phosphate Solubilizing bacteria
K	-	Potassium
q	-	Quintal(s)
RDF	-	Recommended dose of fertilizer(s)
RH	-	Relative humidity
Rs.	-	Rupee(s)
Sr.	-	Serial
pH	-	Soil reaction
cm ²	-	Square centimeter(s)
m ²	-	Square meter(s)
S.E.	-	Standard error of mean
t	-	Tones
Temp.	-	Temperature
TDMP	-	Total dry matter production

INTRODUCTION



Chapter I

INTRODUCTION

India is endowed with a rich wealth of medicinal and aromatic plants. These plants have made a good contribution to the development of ancient. In India more than 2,000 species of medicinal plants have been recorded. Ashwagandha is one of such traditional ancient plant whose roots have employed as a valuable drug in Indian traditional systems of medicine ayurveda and unani. Ashwagandha is coined with two words viz., Ashwani and Gandha. Ashwani means horse and Gandha means power. It has horse like power. (Chidambara, 1999).

Withania somnifera Dunal is cultivated only in North Western region of Madhya Pradesh on about 4,000 ha in India (Nigam, 1984). It is grown on marginal land in Mansa, Neemuch and Jawal Tehsil of Mandsur district of Madhya Pradesh. This is also found in the wild state in the mediterian region in North Africa. But the cultivation of ashwagandha in India assumed commercial proposition during the early twentieth century. The estimated production of ashwagandha in India is more than 1500 tonnes and the annual requirement is about 7000 tones. This makes an increase in its cultivation and production a crucial issue (Anonymous, 2009)

Withania somnifera is erect, evergreen tomentose shrub, between 30-75 cm height, under domestication and it is grown for its roots, which are stout, fleshy, cylindrical but not much thick than 1-2 cm diameter, whitish brown in colour. Leaves are simple, ovate, glabrous and opposite. The flowers are inconspicuous, greenish or dull yellow colour found in axillary, umbellate cymes and bisexual. The fruit is small berry, globose, orange/red when matures and is enclosed in persistent calyx. The seeds are small flat yellow and very light in weight. The crop is also known as asgandh, dhorgunj etc.

Ashwagandha is one of the most important medicinal plant, grown during *kharif* season. The seedlings of ashwagandha resembles with seedlings of brinjal. It can be seen in forest areas. Ainslie described bazaar asgund to be of pale colour having little sensible taste or smell. It is seen that, in availability of moisture the plant is continuously growing up to 3 to 4 year due to its perennial habitat (Anonymous,

1995). It is ready to harvest within 150-170 days after transplanting. It grows better on well drained sandy loam or light red soil, having pH of 7.5 to 8.0. It can be grown under dry climate with an average rainfall of 600 to 750mm.

Nitrogen is essential for plant growth and fruiting. It is important component of many important structural, genetic and metabolic compounds in plant cells. In ashwagandha generally it enhances the more vegetative growth. Phosphorus is a constituent of cell membrane, certain proteins, all nucleic acids and nucleotides, and is required for all phosphorylation reactions. Root growth of ashwagandha is increased with increased levels of phosphorus.

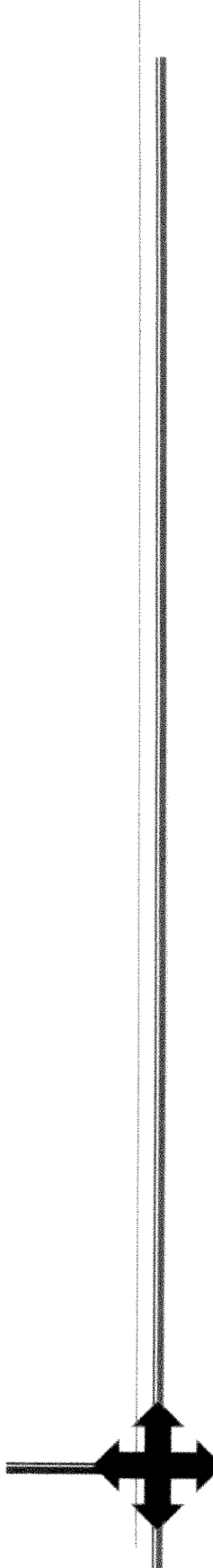
Now a day's use of ayurvedic medicines are increasing in humans due to less side effects. The plant was first mentioned in the English language texts by Van Rheede who called it 'Pevetti' and mentioned that an ointment was prepared from the leaves. Roxburgh (1874) referred to the medicinal uses of ashwagandha and stated that telinga physicians treated the roots as alexipharmic. The authors of Bombay flora described the roots and seeds as diuretic and considered them narcotic and hypnotic respectively.

Maithani (1973) described the root powder of *W. somnifera* is used in pulmonary tuberculosis in the foot hills of Western Garhwal Himalaya region. He also said that the root paste is used in the treatment of glandular swellings of bubonic plague. Sharma *et al.*, (1992) stated that the leaves are heated and applied to painful joints and boils by the Meo community of Gurgaon district in Haryana. Singh and Pandey (1980) also said that the tribal people of Eastern Rajasthan use ashwagandha against lumbago and rheumatism and are given in asthma. In Mysore district the crushed berries along with juice of castor plant are drunk for relieving the poison of a serpent.

Little information regarding cultivation practices of ashwagandha is available. Ashwagandha is an important cash crop for greening the arid and dry land zones and a profit maker crop for the wastelands Very less information is available regarding fertilizer and manure requirement of ashwagandha and in order to improve yield and quality of roots the present investigation entitled "Effect of FYM, N, P and K levels

on growth, uptake of nutrients and root yield of Ashwagandha (*Withania somnifera*)” was carried out with following objectives.

- i. To study the effect of FYM, N, P and K doses on growth and yield of ashwagandha.
- ii. To find out optimum dose of FYM, N, P and K of ashwagandha.
- iii. To study the effect of FYM, N, P and K doses on nutrient uptake by ashwagandha.



**REVIEW OF
LITERATURE**

Chapter- II

REVIEW OF LITERATURE

The present investigation was undertaken to study the “Effect of FYM, N, P and K levels on growth, uptake of nutrients and root yield of Aswagandha (*Withania somnifera*)”. Fertilizers play an important role in plant life. Nitrogen, Phosphorus and Potassium are major elements. Nitrogen is an essential for vegetative growth. It is also the constituent of chlorophyll and protein, phosphorus play an important role in cell division and root development. Potassium imparts stress resistance to plants. The literature available on this crop is very limited. However, an attempt has been made here to review the available literature related to effect of FYM and NPK fertilizer levels on ashwagandha and other medicinal plants like isabgol & root crops like radish, carrot and brinjal under following appropriate heading.

2.1 Effect on vegetative growth

Sharma *et al.* (1980) conducted experiment on sandy loam soils of Lucknow and studied the response of palmarosa to N, P, K and Zn application. They reported that N application increased the green herb in all the harvest of crop. However, the increase was significant in first and fourth harvests. Considering the total yield of all the four harvests of the crop, a significantly linear response to N was obtained up to 150 Kg N ha⁻¹.

Cerna (1981) reported that nutrient deficiency markedly affected leaf development only at reproductive stage. Application of N and P in absence of FYM influenced the formation of vegetative organ and subsequently reproductive organ. FYM also favorably affected vegetative mass, dry weight, plant height, rate of dry matter increment per leaf unit area in capsicum.

Dahatonde *et al.* (1983) recorded significantly maximum height and growth of plant with the application of 30 Kg N ha⁻¹ to ashwagandha.

Abusalecha and Shanmugavelu (1988) observed that numbers of leaves, number of branches per plant in okra were accounted by application of both inorganic and organic form of nitrogen. Among the organic sources 20 Kg N as poultry manure

with 20 Kg N as ammonium sulphate stimulated better response than FYM and horse manure at different levels and combination.

Ramesh *et al.* (1989) studied influence of sowing date and nutrients on growth and yield of Isabgol (*Plantago ovata*) and reported that application of N, P and K at 75, 25 and 30 Kg ha⁻¹, respectively, resulted in significantly highest number of spikes plant⁻¹ and seed yield plant⁻¹.

Sharma and Prasad (1990) in their field study to observed the nitrogen and irrigation requirement of fennel and reported that application of NPK 80:60:40 Kg ha⁻¹ dose significantly increases growth parameters fennel.

Shetty *et al.* (1990) conducted a field experiment on red sandy soil to study effect of nitrogen, phosphorus and potassium on herbage yield of *Datura stromonium* and revealed that plants treated with 90:30:50 Kg NPK exhibited the greatest height, spread, leaf weight (FW and DW.) and number of seeds fruit⁻¹.

Sarkar *et al.* (1991) conducted a field experiment on a sandy loam soil to study the effect of different levels of nitrogen and phosphorus on growth and yield of *Calendula officinalis* var. Lemon Queen and found that significantly highest growth parameters and yield of cut flowers were obtained with application of 400 Kg N ha⁻¹ + 150 Kg P ha⁻¹.

Barman and Pal (1994) studied the effect of nitrogen and phosphorus on seed yield in calendula (*Calendula officinalis*) and reported that plant height and number of leaves increased significantly with increased rate of N and P.

Gagnon and Berrouard (1994) found that in tomato several organic fertilizers produced the best growth and significantly increased shoot dry weight by 57 to 83 per cent compared with non fertilized plants.

Baboo and Rana (1995) conducted a field experiment on a sandy loam soils to study the effect of management of nitrogen and phosphorus on growth and yield of coriander and reported that N at 100 Kg ha⁻¹ and P at 30 Kg ha⁻¹ gave the significantly highest growth parameters of coriander.

A field experiment was conducted on sandy loam soils of National Bureau of Plant Genetic Resources Experimental Farm Issapur, New Delhi by Pareek and Maheshwari (1995) to study the effect of graded levels of N and irrigation on palmarosa. They observed that the application of 25 Kg ha⁻¹ gave higher values of plant height, number of tillers and inflorescence length over control. Although, increasing the N dose from 25 to 50 increased the values of yield of contributory characters but this increase was not translated into dry herbage.

Fugro (1996) reported that the plot applied with chilli crop with variety Vikas 1.5 t ha⁻¹ + 75:25:25 Kg NPK ha⁻¹ gave the maximum number of fruits (324.13 per cent) and higher fruit breadth (0.91 cm).

Increasing levels of nitrogen upto 60 Kg ha⁻¹ significantly increased all growth characters of ashwagandha during both the years of experimentation. Similarly all the growth characters were significantly improved up to higher level of P (30 Kg ha⁻¹) in the same experiment (Annonymus, 1998).

Kumaran *et al.* (1998) revealed that application of organic manures combined with recommended dose of inorganic fertilizers showed superior performance in increasing plant height of tomato.

Maheshwari *et al.* (1998) reported the plant height of ashwagandha was significantly increased with the application of 2.5 tonnes FYM along with 12.5 Kg P₂O₅ per hectare.

Maitra *et al.* (1998) studied the effect of different fertilizer level on ashwagandha and reported that application of 28 g nitrogen, 28 g phosphorus and 28 g potash per 1.3 sq. meter area showed significantly increase in vegetative growth, flowering and fruiting.

Nanthakumar and Veeragavathatham (1999) recorded the higher fruit set in plants fertilized with both organic and inorganic sources than inorganic sources alone and also increased the number of fruits per plant and greater fruit size in brinjal.

Muthumanickam and Balakrishnamurthy (1999) conducted a fertilizer trials at Yercaud (Tamil Nadu, India) on sandy loam soils with the objective of increasing root yield and determining nutrient requirements of *Withania somnifera* and observed that application of 40 Kg nitrogen and 60 Kg phosphorus per ha increased the height of the plant significantly.

Pawar (2000) conducted a research experiment on seed yield, seed quality as influenced by plant density and fertilizer level in ashwagandha (*Withania somnifera*) at Rahuri (Maharashtra) and reported that days to 50 per cent flowering and plant height was significantly higher with 10 tonnes FYM and 80: 40: 20 Kg NPK per hectare.

Chauhan *et al.* (2000) studied the response of N and P fertilization on palmarosa and observed that the total herbage yield was increased with the increasing level of N up to 150 Kg ha⁻¹ in the first year and 200 Kg N ha⁻¹ in second year. However, oil yield of palmarosa was significantly influenced up to 150 Kg N ha⁻¹. The increase in herbage and essential oil yield at this level was 135 and 75 per cent in the first year and 128 and 104 per cent in the second year over no N.

Barekar (2000) observed that application of 150:50:50 Kg NPK ha⁻¹ + 10 t FYM ha⁻¹ in combination with PSB biofertilizers were effective for enhancing height of plant, number of branches per plant and diameter of stem in chilli.

Maryada *et al.* (2001) reported that greatest area of lower, middle and upper leaves were obtained with use of 15 Kg N ha⁻¹ whereas higher nitrogen doses was more effective in the enhancement of vegetative parameters and dry matter production in ashwagandha.

Kaushal *et al.* (2002) conducted a field experiment at Palmpur, Himachal Pradesh, to study the effect of N and P on growth and yield of ashwagandha and indicated that application 15 Kg N increased the number of branches, number of day to 50% flowering, fruit initiation and maturity in ashwagandha.

Chezhiyan *et al.* (2003) studied the effect of organic manures, biofertilizers and plant density on growth, yield and alkaloid content of bhumyamalaki (*Phyllanthus amarus*) and reported that plant height, leaf area index, dry matter production, herbage yield per hectare were highest in *Phyllanthus amarus* when treated with poultry manure + *Azospirillum* + phosphate solubilizing bacteria.

Ram *et al.* (2003) evaluated the effect of integrated nutrient management on growth and yield of geranium at CIMAP Field Station, Pantnagar, and revealed that an application of inorganic fertilizers in the form of NPK @ 150:60:40 Kg ha⁻¹ gave maximum plant height and number of leaves plant⁻¹.

Swarupa -Utgikar *et al.* (2003) conducted a field experiment in rabi season in Akola to determine the effect of N and P rates on the growth and yield of isabgol and reported that N at 50 Kg ha⁻¹ gave the highest number of leaves per plant, number of tillers per plant, number of spikes per plant. In case of P, P at 30 Kg ha⁻¹ gave the highest growth.

Singh and Naeem (2004) conducted a pot experiment to determine the effect of P levels (0, 20, 40, 60, Kg ha⁻¹) on the growth of *Withania somnifera* and found that P application @ 60 Kg ha⁻¹ gave significantly highest fresh weight per plant, dry leaf weight per plant, leaf area.

Singh *et al.* (2005) also conducted a pot experiment in the Aligarh, U. P., India to evaluate the effect of nitrogen application on the physio-morphological characteristics of *Withania somnifera* and observed that at 90 Kg N ha⁻¹ recorded the highest values for growth characters, chlorophyll content, nitrate activity, leaf protein and nitrogen content.

A field experiment was conducted in Hisar by Singh *et al.* (2006) to study the response of coriander to irrigation and nitrogen levels. They reported that all growth and yield parameters were recorded maximum at N application at 75 Kg ha⁻¹ and when irrigation was applied at 21 days interval.

Kumar *et al.* (2006) studied influence of nitrogen and phosphorus along with biofertilizers on yield, constituents of essential oil and soil available nutrients of davana and reported that application of nitrogen at 93.75 Kg ha⁻¹, phosphorus at 93.75 Kg ha⁻¹ and Azospirillum at 2 Kg ha⁻¹ gave the highest herbage yield t ha⁻¹.

Ajay Chauhan and Vijay Kumar (2007) studied the effect of graded levels of nitrogen and VAM on growth and flowering in Calendula (*Calendula officinalis*) and observed that application of N and VAM (100 Kg N ha⁻¹ + 5 g VAM plant⁻¹) significantly increases leaf width, flower diameter, number of branches per plant parameter of calendula.

Pawar *et al.* (2007) conducted a field experiment in Parbhani to study the influence of graded levels of nitrogen on growth and yield of coriander and observed that application of N at 100 Kg ha⁻¹ resulted in the greatest plant height, number of leaves per plant, number of branches per plant, fresh weight of plant and green yield per plant.

Kharbade and Gaikwad (2008) maximum total dry leaf yield and seed yield of senna were obtained with the application of 125% RDF in which 50% N through urea and 50% N through farmyard manure was given. They also reported that application of 100% RDF (50:25:0 NPK Kg ha⁻¹) through inorganic fertilizer to isabgol recorded the highest dry leaf yield and seed yield.

2.2 Effect on seed yield

Gupta (1967) reported that isabgol makes a moderate demand for nutrients. Application of 25 Kg nitrogen and 25 Kg phosphorus per hectare at planting supplemented with 25 Kg of nitrogen as top dressing produces average seed yield of one tonne per hectare.

Bammi and Rao (1982) described the cultivation practices of *Mucuna pruriens* viz., a basal dose of 13-15 tonnes of FYM along with 80 Kg P₂O₅ per ha at preparatory tillage and 75 Kg K₂O per hectare in two equal splits of 30 and 60 days after planting.

Beresniewicz *et al.* (1986) found that application of the mineral fertilizers at the level 400 Kg N ha⁻¹ (200 Kg presowing + 200 Kg topdressing), 400 Kg P and

400 Kg K gave the highest mean yield. The addition of organic fertilizer (lignite or peat) at 25 t FYM ha⁻¹ increased the yield of tomato.

Kardava *et al.* (1986) suggested that application of organo-zeolitic fertilizers (a mixture of clinoptilolite with bird manure) at 20-40 t ha⁻¹ and subsequent top dressing with NPK at 60-80:70-150:60-150 Kg ha⁻¹ had the greatest economic effect when used on tomato and cucumber.

Piven *et al.* (1987) revealed that mineral fertilizers with moderate N content and FYM both alone and in combination had a substantial positive effect on yield and quality. However, raising N component to 240 units produced no yield increase and a fall in dry matter and sugar content. Overall, the combined mineral and organic inputs had the most beneficial effect upon vegetable crop and soil.

Gezerel and Donmez (1988) found that the slow release fertilizers gave significantly higher yields than the commercial fertilizers (CF). Slow release fertilizers gave 50 t ha⁻¹ yields of tomatoes, compared with 42 t ha⁻¹ on plot receiving the CF.

Kharwara *et al.* (1988) conducted a field experiment was conducted in 1979-80 and 1980-81 with *Papaver somniferum* on sandy loam soils of medium fertility for studying the effect of sowing dates, nitrogen and phosphorus levels on yield and quality of *Opium poppy* and observed application of N at 150 Kg ha⁻¹ produced significantly higher opium and seed yield than lower dose of 75 Kg ha⁻¹.

Jain (1990) applied P at 0, 20, 40 or 60 Kg ha⁻¹ as SSP and K at 0, 20, 40 Kg ha⁻¹ as MOP to *Papaver somniferum* and observed that application of up to 40 Kg P appreciably enhanced the seed yield.

Jain *et al.* (1990) conducted a field experiment over 2 years with 5 improved cultivars of *Papaver somniferum* and nitrogen was applied at 30, 60 and 90 Kg ha⁻¹ and observed that N at 90 Kg ha⁻¹ gave 41.2, 37.5 and 58% higher seeds and capsule husk than N at 30 Kg ha⁻¹.

Kahar and Nigam (1990) studied the response of *Opium poppy* to P and K and observed that significant increase in seed yield was produced by p application above 8.8 Kg ha⁻¹.

Annanuriva *et al.* (1992) observed that in tomato, application of Zn (5 kg ha⁻¹) or Cu (3 Kg ha⁻¹) or FYM (30 t ha⁻¹) to the basic NPK (220:160:100 Kg ha⁻¹), NPK alone increased yield plant⁻¹ by 43.4% compared with untreated control and when supplemented with FYM (161.8%).

Patel and Bapna (1993) studied the effect of fertilizer levels of nitrogen (0, 50, 100, and 150 Kg ha⁻¹) and phosphorus (25 and 50 Kg ha⁻¹) on productivity of isabgol and found significant variation in seed yield due to levels of nitrogen. An increasing trend was observed in seed yield due to increasing the level of nitrogen (0 to 150 Kg ha⁻¹). The highest seed yield (19.8 q ha⁻¹) was obtained at 150 Kg N ha⁻¹. Application of higher dose of phosphorus (50 Kg ha⁻¹) also increased the seed yield than lower levels of phosphorus.

Lopez-Camelo *et al.* (1995) reported that total accumulation of N, P and K in coriander was higher in flowers than in seeds and plant dry matter. No significant differences in nutrient accumulation due to sowing date or N fertilizer rate were apparent.

A field experiments was conducted by Tiwari and Banafar (1995) to study the effect of application of nitrogen and phosphorus on seed yield and essential oil of coriander. They reported that N applied at 60 Kg ha⁻¹ as urea and P applied at 45 Kg ha⁻¹ as single superphosphate significantly increases the seed yield.

Moral and Nevarro (1996) revealed that tomato plants when fertilized with sewage sludge and inorganic NPK (at equivalent rates 300 Kg N + 200 Kg P + 300 Kg K) produced the highest yield 1.035 Kg /plant.

Haprbool *et al.* (1996) studied the economics of fertilization of nitrogen and phosphorus on productivity of isabgol and observed that highest net return was obtained with the application of 30 Kg N +15 Kg P₂O₅.

Dixit (1997) revealed that the yield of cabbage increased with increasing N rate and increasing FYM rate. Addition of FYM to N treatments further increased yield in cabbage in presence of FYM + 160 Kg N ha⁻¹.

In ashwagandha, Maitra *et al.* (1998) studied the effect of fertilizer levels on root yield of ashwagandha (*Withania somnifera*) and observed that application of 28 g P₂O₅ and 28 g K₂O per 1.3 Square meter area significantly increased flowering and fruiting.

Shashidharan *et al.* (1998) concluded that the application of 100 per cent RDF together with organic fertilizers like FYM, vermicompost, red gram stalk and biogas slurry increased dry yield of chili significantly over 50 per cent and 0 per cent RDF.

Mahajan (1998) evaluated the effect of different nitrogen level on isabgol at Rahuri and observed that nitrogen application @ 75 Kg ha⁻¹ showed significant effect on seed yield per plant and per hectare, 1000 seed weight and recovery of good seed.

Nanthakumar and Veeraragavathatahm (1999) found that the highest yield per plant in brinjal (1662.41 gm per plant) was registered in the plants fertilized with 100:100:100 NPK Kg ha⁻¹ + FYM + Azospirillum + phosphobacteria, which was followed by (1641.48 gm per plant) 75:75:100 NPK + FYM = Azospirillum + phosphobacteria.

Solanki *et al.* (1999) conducted the experiment on phosphorus management in opium poppy at Udaipur and concluded that the maximum mean seed yield were obtained with 40 Kg P applied in both *kharif* and *rabbi* season.

Solanki and Shaktwar (1999) studied the effect of date of sowing and nitrogen on growth and yield of isabgol and observed that use of N at 30 or 45 Kg ha⁻¹ was best for promoting yield of isabgol.

Pawar (2000) conducted a research experiment on seed yield, seed quality as influenced by plant density and fertilizer level in ashwagandha (*Withania*

somnifera) at Rahuri (Maharashtra) and reported that highest seed yield was obtained with the application of 10 tonnes FYM and 80: 40: 20 Kg NPK ha⁻¹

Prasad (2002) studied the effect of nitrogenous fertilizers on seed yield per plant in *Opium poppy* crop and observed that there was significantly increase in 1000 grain weight and seed yield per plant with increases in the nitrogen input.

Wankhade *et al.* (2005) carried field experiment on response of isabgol on N and P and reported that application of 50 Kg N and 30 Kg P ha⁻¹ recorded the highest yield of 844 and 840 Kg ha⁻¹.

Kharbade and Gaikwad (2008) observed that application of recommended dose of fertilizer in which 50% nitrogen through urea and 50% nitrogen through FYM was significantly superior over all treatment. They also found that application of recommended dose of fertilizer through inorganic fertilizers to isabgol recorded the higher seed yield.

2.3 Effect on root yield

Dahatonde *et al.* (1983) observed that the highest dry root yield (6.81 q ha⁻¹) of ashwagandha was obtained with application of 30 Kg N ha⁻¹ during 1978 -79 and 1980-81 in Vidharbha area.

Kahar *et al.* (1994) observed that fertilizer fortification treatments had shown significant differences on dry root yield of ashgandh 4 Kg.ha⁻¹ super sorb with seed application had recorded dry root yield of 11.88 and 8.19 q.ha⁻¹. Significantly superior yield of 11.70 and 6.88 q ha⁻¹ with fortification of FYM with 60-40-20 Kg NPK.ha⁻¹.

Anon (1998) reported in ashwagandha that the higher dry root yield were obtained with the application of 60 Kg N ha⁻¹ and 30 Kg P₂O₅ ha⁻¹ during both the years of investigation.

Maitra *et al.* (1998) studied the effect of fertilizer levels on root yield of ashwagandha (*Withania somnifera*) and found that application of 28 g N 28 g P₂O₅ and 28 g K₂O per 1.3 sq. m. area showed significant increase in dry root yield of

ashwagandha. Both the fertilizer levels 28 g N, 28 g P₂O₅ and 28 g K₂O and 42 g N, 42 g P₂O₅ and 42 g K₂O were the best for better root yield of ashwagandha.

Maheshwari *et al.* (1998) reported that longer roots are responsible for higher root yield just by applying a moderate dose of 4.5 tonne FYM along with 12.5 Kg N and 25 Kg P₂O₅ to ashwagandha under rainfed condition.

Muthumanickam and Balakrishnamurthy (1999) conducted a fertilizer trials at Yercaud (Tamil Nadu, India) on sandy loam soils with the objective of increasing root yield and determining nutrient requirements of *Withania somnifera* and observed that there was significant improvement in root length, root primaries, root diameter due to application of 40:60:20 Kg NPK ha⁻¹ in ashwagandha.

Maheshwari *et al.* (2000) studied the effect of organic manure and fertilizers on ashwagandha (*Withania somnifera*) and revealed that highest yield was obtained by applying 2.5 tonne ha⁻¹ FYM+12.5 Kg N ha⁻¹ +25 Kg P ha⁻¹. Application of 5 tonne ha⁻¹ FYM alone was also found effective in increasing dry root yield.

Pawar (2000) conducted a research experiment influence of by plant density and fertilizer level of ashwagandha (*Withania somnifera*) at Rahuri (Maharashtra) and reported that highest dry root yield (1335.42 Kg) was recorded with 60:30:15 Kg NPK. ha⁻¹.

Maryada *et al.* (2001) studied the response of *Withania somnifera* to various nitrogen rates at Krishi Vishvavidyalaya, Palampur H.P., India. They observed that treatment of N at 30 and 60 Kg ha⁻¹ resulted in highest dry root yield. They also observed that lower N rate was more effective in enhancement of root parameters.

Muthumanickam *et al.* (2002) observed that the ashwagandha crop in acid soils application of rock phosphorus at 60 Kg ha⁻¹ along with dolomite at 5.688 tonne ha⁻¹ recorded the highest root yield (807.6 Kg ha⁻¹).

Aishwath (2004) studied effect of Nitrogen (0, 30 and 60 Kg ha⁻¹) and phosphorus (0, 20, 40 Kg ha⁻¹) level on the growth, yield and nutrient uptake of

Withania somnifera plant grown in Gujarat, for two consecutive years and found that root yield of ashwagandha was decreased with increase in levels of nitrogen.

Patra *et al.* (2004) were conducted a field experiment at Anand, Gujarat, to investigate the effect of Nitrogen application on dry root yield of ashwagandha and found that root yield was marginally higher under application of 25 Kg ha⁻¹ than other levels of nitrogen.

Ajay *et al.* (2005) observed effect of nitrogen and FYM on root quality of ashwagandha at Bhopal and reported that the quality of root based on the alkaloid content was found to be better at low nitrogen level. However the root yield was maximum at 20 Kg N ha⁻¹.

Kulmi *et al.* (2006) reported that effect of organic and inorganic fertilization on the performance of *Withania somnifera* during the *khariif* season at Mandsaur, M.P. and they observed that highest quality grade and rounded roots were obtained with PM (5 t ha⁻¹), VMC (5 t ha⁻¹) and GM (5 t ha⁻¹) + 50% RDF.

Panchbhai *et al.* (2006) carried a field experiment at Akola, Maharashtra to evaluate the effect of N and P on root yield and quality of *Withania somnifera* Dunal. They observed that maximum root yield was obtained with N at 50 Kg ha⁻¹ (825.6 Kg ha⁻¹) and P at 25 Kg ha⁻¹ (836.7 Kg ha⁻¹).

Dhage *et al.* (2008) studied that response of different row spacing and nutrient management on yield characters of ashwagandha (*Withania somnifera*) at M.P.K.V. Rahuri, and revealed that root yield was significantly higher (738.27 Kg) due to higher level of fertilizer *i.e.*, 75:37.5: 37.5 Kg N, P₂O₅ and K₂O with 5 tonne OR FYM ha⁻¹.

2.4 Effect on nutrient uptake

Pareek *et al.* (1983) reported that an application of 40 Kg ha⁻¹ increased the contents of N, P, K, Ca, Mg and Zn in the produce of palmarosa by 5.4, 11.3, 6.7, 5.5, 3.5 and 10.3 per cent, respectively. Contents of P and S were not affected. An average yield of 108 q ha⁻¹ of dry grass containing 1 per cent essential oil removed

31.6, 7.4, 75, 34.8, 20.6, 20.6, 0.9 and 0.034 Kg N, P, K, Ca, Mg, S, Mn and Zn, respectively.

✓Yadav (1984) reported that the N uptake by Java Citronella (*Cymbopogon winterianus*) increased with increasing rates of N from 0 to 180 Kg ha⁻¹. During first and second harvest, the N uptake was less as compared to third and fourth harvest.

✓A study was undertaken to compare the efficiency of organic versus inorganic forms of nitrogen on growth and yield of brinjal cv. 'MDU-1' by Jose *et al.* (1988). The results indicated that application of half N (50 Kg) as urea increased the dry matter (39.4 to 95 g plant⁻¹) and uptake of N (27.9 to 135.5 Kg ha⁻¹), P₂O₅ (8.5 to 34.0 Kg ha⁻¹) and K₂O (50.9 to 126.3 Kg ha⁻¹).

Beech (1990) studied the effect of different levels of N on lemongrass on sandy loam soil and reported that N, P and K uptake by the harvested herbage increased from 51, 8 and 121 Kg ha⁻¹, respectively without N to 276, 30 and 375 Kg ha⁻¹, respectively, with 900 Kg ha⁻¹. The highest apparent N recovery was 31 per cent at 600 Kg ha⁻¹ annually and decreased with higher N application.

A field study was conducted for two consecutive years on sandy loam soil by Rajeswara Rao *et al.* (1990). They found that an annual application of 160 Kg N ha⁻¹ produced significantly highest amount of biomass, improved the net profit and plant NPK uptake in comparison with 0 or 80 Kg ha⁻¹, there was no further advantage in applying 240 Kg ha⁻¹. The N use efficiency decreased as N rates increased. The apparent recovery of N by the palmarosa crop was low (<35%).

Somani (1990) carried field experiment on Availability and crop utilization of phosphorus in a saline alkali soil amended with inorganic and organic materials and revealed that soil quality was improved most with a combination of organic and inorganic fertilizers.

✓Mallangouda *et al.* (1995) carried out field experiment at Dharwad (Karnataka) to study the effect of NPK and FYM on growth and yield of onions,

garlic and coriander and reported that highest NPK uptake were obtained from the plots treated with the recommended rate of NPK + FYM.

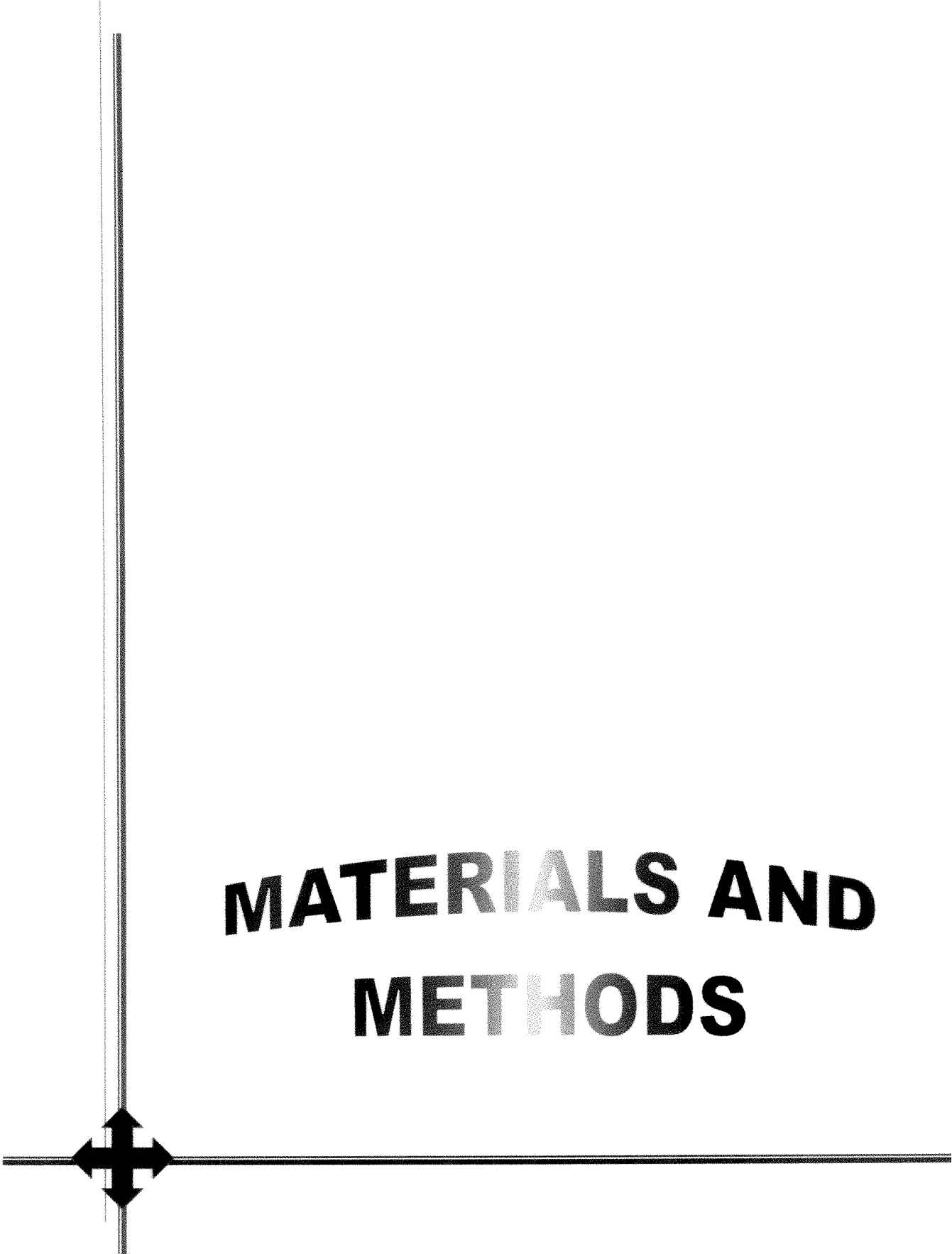
✓ Chavan *et al.* (1997) recorded maximum uptake of N (22.34 Kg ha⁻¹), phosphorus (92.84) and potassium (8.79) by chilli cv. Pusa Jwala when applied 75 Kg N through urea and 75 Kg N through FYM.

✓ An experiment was conducted by Rao *et al.* (1997) at GKVK, Bangalore to study the effect of nitrogen and farm yard manure on yield and nutrient uptake in davana and reported that application of 80 Kg N ha⁻¹ significantly enhanced biomass yield, essential oil yield, and N, P and K uptake in davana.

Mann and Vyas (1999) studied nutrient uptake by isabgol conducted at Udaipur during rabbi season and observed that the application of N upto 45 Kg ha⁻¹ significantly enhanced the uptake by seed and straw both. However P and K uptake by seed increased significantly up to 30 Kg N ha⁻¹ while for straw application of 45 Kg N ha⁻¹ proved significantly superior over lower levels *i.e.*, 0 and 15 Kg N ha⁻¹.

/ Puttanna *et al.* (2005) was conducted a field experiment at in Bangalore, (Karnataka) to test the organic and inorganic sources of nutrients for the cultivation of *Withania somnifera* and observed that uptake of N, P and K was high in case of combination of inorganic and organic fertilizer application than control.

✓ Kubsad *et al.* (2009) carried out a field experiment during rabbi season at Agricultural Research Station, Annegiri to study the effect of spacing and fertilizer level on productivity of ashwagandha (*Withania somnifera*) in Vertisols and revealed that the higher fertilizer level of 24 Kg N and 48 Kg P₂O₅ ha⁻¹ increased the NPK uptake significantly which has superior to other nutrient levels.



**MATERIALS AND
METHODS**

Chapter III

MATERIALS AND METHODS

In order to accomplish the set objectives an experiment was conducted to study the effect of different levels of organic and inorganic doses of fertilizers on growth, uptake, seed and root yield of ashwagandha. The material used and methods followed during experimentation are described in this chapter.

3.1. Materials

3.1.1. Experimental site.

Present experiment was conducted in *Kharif* season of the year 2010-11 at Research farm, College of Agriculture Latur.

3.1.2. Climate and Weather condition

Geographically Latur is situated between 18° 05' to 18° 75' North longitude and between 76° 25' to 77° 25' East longitude. Its height from mean sea level is about 540-634 m and has subtropical climate. The climate of Latur is characterized by a hot summer and general dryness throughout the year except during South West monsoon. The mean annual precipitation is 774 mm. Most of the monsoon rains (92 per cent) receive from June to September.

The metrological data recorded at metrological observatory, Oilseed Research station, Latur pertaining to the period of experimentation during *Kharif season* are presented in table 1. Total rainfall received during crop growth was 959 mm and distributed over 59 rainy days during the course of experimentation.

Table 1 : Metrological data recorded during experimental period.

M.W.	Date	Total rain fall (mm)	Rainy days (No.)	Temp.		Relative Humidity (%)	
				Min.	Max.	I	II
18	30 April -6 May	--	--	16.5	37.5	35	25
19	7-13 May	--	--	19.2	41.1	21	17
20	14-20 May	--	--	20.3	41.8	48	24
21	21-27 May	--	--	19.5	40.5	44	21
22	28 May – 3 June	5.0	1	18.2	39.4	51	27
23	4-10 June	4.5	1	19.3	37.1	51	31
24	11-17 June	36.0	3	15.2	32.7	79	52
25	18-24 June	38.0	3	15.6	32.1	78	54
26	25 June- 1 July	25.5	2	16.2	32.0	73	53
27	2-8 July	109.5	4	14.3	29.6	85	70
28	9-15 July	20.0	2	14.8	29.8	77	63
29	16-22 July	102.0	2	15.9	30.2	82	62
30	23-29 July	63.4	6	14.6	26.8	88	82
31	30 July- 5 Aug.	30.0	4	14.8	27.0	85	77
32	6-12 Aug.	27.0	2	14.3	26.6	81	73
33	13-19 Aug.	120.2	3	15.5	27.8	93	80
34	20-26 Aug.	176.5	6	15.3	27.5	91	76
35	27 Aug. -2 Sept.	29.6	4	17.7	28.2	86	79
36	3-9 Sept.	41.9	5	14.7	27.4	86	76
37	10-16 Sept.	23.6	1	14.6	27.8	84	70
38	17-23 Sept.	54.6	3	14.7	28.0	85	76
39	24-30 Sept.	14	2	14.7	28.5	80	58
40	1-7 Oct.	--	--	14.1	30.5	69	49
41	8-14 Oct.	--	--	11.7	30.9	60	40
42	15-21 Oct.	9.0	2	13.2	29.9	81	61
43	22-28 Oct.	18.5	2	13.3	30.5	72	60
44	29 Oct-4 Nov.	0.5	--	9.5	27.2	69	57
45	5-11 Nov.	4.0	1	13.1	28.9	66	57
46	12-18 Nov.	3.0	--	13.0	30.2	72	48
47	19-25 Nov.	0.5	--	11.7	28.4	74	53
48	26 Nov.-2 Dec.	--	--	11.2	28.9	65	45
49	3-9 Dec.	--	--	11.1	26.3	75	44
50	10-16 Dec.	2.0	--	11.6	27.2	63	42
Total/Mean		958.8	59	14.83	30.85	71.18	54.60

3.1.3. Geology

The black soils of Latur district of Marathwada region were formed from the weathering of trap rock and rich in iron, lime and magnesia but they vary widely both in texture and depth (Gajbe *et. al.* 1975). Soils of Latur district were classified by Challa *et. al.* (1997) as clayey, montriorillonite and isohyperthermic having very gently sloping with moderate erosion. The physiographic position of these soils are North deccan upper plateau. These soils are dark grayish, brown in colour with adequate content of calcium carbonate.

3.1.4. Experimental soil

The experimental soil was medium black with clayey in texture, moderately calcareous nature and slightly alkaline reaction. Before transplanting initial representative soil sample was collected from 0-15 cm depth covering experimental area and which was analyzed for its various physico-chemical properties (Table 2)

The data in table 2 revealed that the experimental soil was low in available N, medium in available P_2O_5 , moderately high in available K_2O , high in iron, medium in zinc and manganese and low in copper.

3.1.5 Manures and fertilizers

Required quantities of nutrients were supplied through urea, SSP and MOP. Required quantity of FYM was brought from Dairy unit of College of Agriculture, Latur and applied in the field as per the treatments. Full dose of phosphorus and potassium along with 50 per cent dose of nitrogen of each treatment was applied as basal dose and remaining 50per cent nitrogen dose of each treatment was given 30 days after transplanting to respective treatment.

Table 2:- Physicochemical properties of the experimental soil.

Sr. No.	Soil parameter	Estimates	Units
A) Physical parameter			
1)	Coarse sand	15.30	Per cent
2)	Fine sand	17.40	Per cent
3)	Silt	24.71	Per cent
4)	Clay	43.24	Per cent
5)	Textural class	Clay	-
6)	Bulk density	1.25	gm cm ⁻³
7)	Particle density	2.44	gm cm ⁻³
8)	Porosity	48	Per cent
B) Fertility parameter			
1)	pH	8.32	-
2)	EC	0.172	dS m ⁻¹
3)	Organic carbon	0.43	Per cent
4)	CaCO ₃	3.62	Per cent
5)	Available nitrogen	188.67	Kg ha ⁻¹
6)	Available phosphorus	21.62	Kg ha ⁻¹
7)	Available potassium	292.93	Kg ha ⁻¹
8)	Micronutrients		
i)	Fe	4.96	mg Kg ⁻¹
ii)	Mn	5.71	mg Kg ⁻¹
iii)	Zn	0.86	mg Kg ⁻¹
iv)	Cu	0.052	mg Kg ⁻¹

3.2 Methods

3.2.1 Raised Bed Preparation

Seedlings were raised on raised bed. Raised seed bed of 15 cm height and size 1.5 x 1.0 m was prepared. Before sowing of seeds on raised seed bed FYM was mixed in soil. After preparation of raised seed bed, sowing of seed was done in 10 cm row to row spacing. Daily water was sprinkled with water can.

3.2.2 Land Preparation

The land was ploughed about 25 cm deep. It was subsequently harrowed thrice with common blade harrow to achieve and friable seed bed. After attainment of desired tilt the field was laid out as per plan and kept ready for transplanting of seedlings. Experimental layout was done manually (fig.1).

3.2.3. Experimental Details

The experiment was laid out in factocorial randomized block design with three replications and twelve treatments. The field experiment was initiated on 9 July, 2010 and completed in 28 November, 2010.

- 1) **Starting of Programme** : - *Kharif*, 2010
- 2) **Crop** : - Ashwagandha (*Withania somnifera*)
- 3) **Experimental design** : - Factorial Randomized Block Design
- 4) **Recommended dose of fertilizer** : - 25: 25: 20 NPK Kg ha⁻¹
- 5) **Treatment combination** : - 12
- 6) **Replication** : - Three
- 7) **No. of Plot** : - 36
- 8) **Plot size** : - Gross: 2.4 x 3.0 m
Net: 1.8 x 2.4 m
- 9) **Spacing** : - 30 x 10 cm

- 10) Method of Sowing : - Transplanting
- 11) Date of sowing : - 2 June, 2010
- 12) Date of transplanting : - 9 July, 2010
- 13) Date of harvesting : - 28 November, 2010

Table 3 : Treatments Details.

Sr. no.	Factors	Detail treatment
A) FYM level		
1)	A ₁	0 tonne FYM ha ⁻¹
2)	A ₂	2.5 tonne FYM ha ⁻¹
3)	A ₃	5.0 tonne FYM ha ⁻¹
B) Fertilizer level		
1)	B ₁	0 Kg N + 0 Kg P ₂ O ₅ + 0 Kg K ₂ O ha ⁻¹
2)	B ₂	12.5 Kg N + 12.5 Kg P ₂ O ₅ + 10 Kg K ₂ O ha ⁻¹
3)	B ₃	25 Kg N + 25 Kg P ₂ O ₅ + 20 Kg K ₂ O ha ⁻¹
4)	B ₄	37.5 Kg N + 37.5 Kg P ₂ O ₅ + 30 Kg K ₂ O ha ⁻¹

3.2.4 Transplanting

Five weeks old healthy seedlings were selected for transplanting and seedlings were transplanted 30 cm apart with 10 cm plant to plant spacing.

3.2.5 Cultural Operation

Cultural operation (Table 4) such as filling was done and plant population was maintained. Periodical operation such as weeding was carried out to maintain cleanliness. Care was taken to protect the crop from seed born diseases by giving seed treatment as per recommendation and crop was harvested at full maturity.

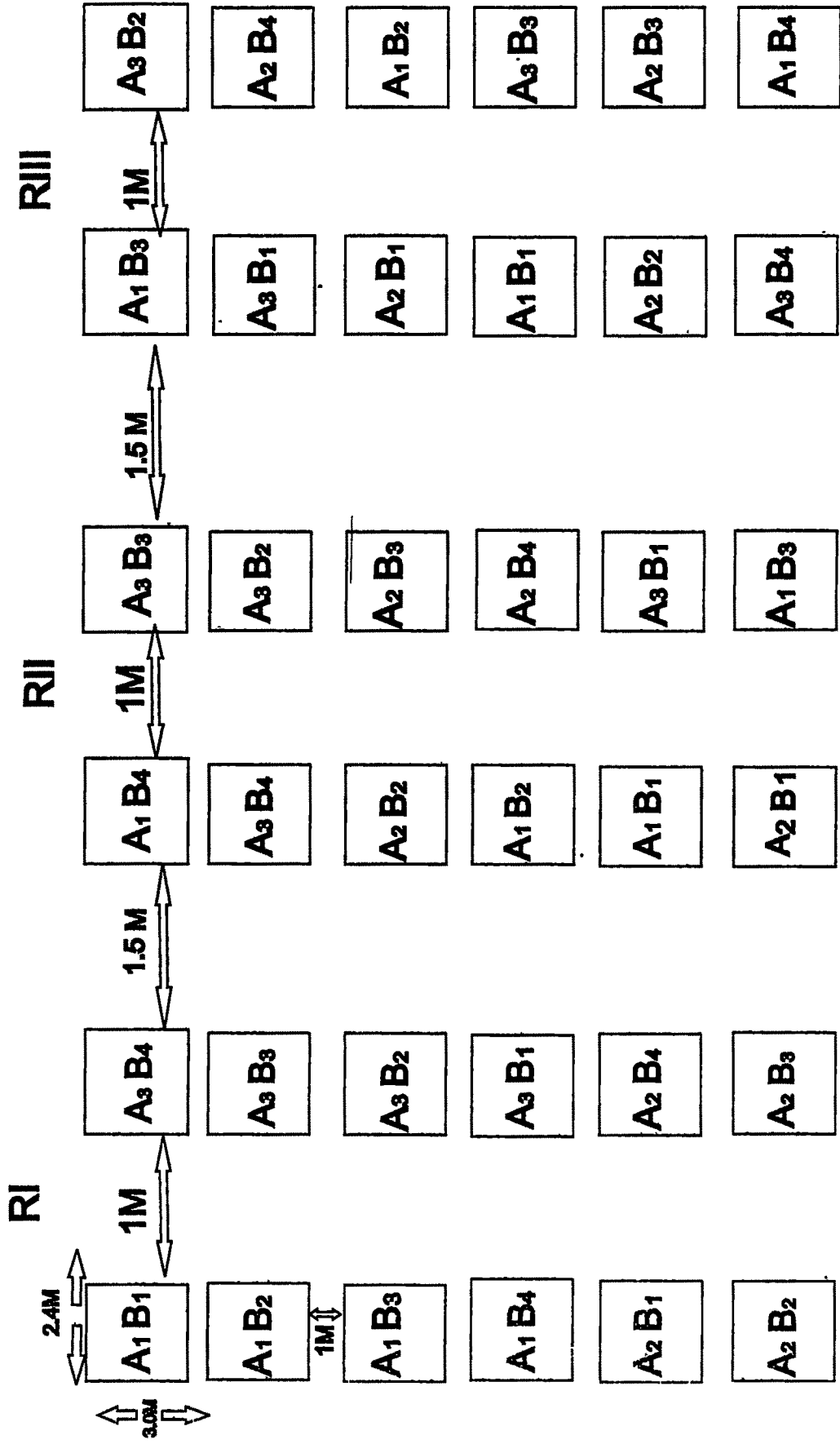


Fig. 1: Plan of Layout

Table 4: Schedule of cultural operation.

Sr. No.	Particulars	Frequency	Date
1)	Ploughing	1	05/03/2010
2)	Harrowing	3	15/04/2010
			08/05/2010
			19/06/2010
3)	Cleaning	1	29/06/2010
4)	Soil sampling	2	
	i) Initial		21/06/2010
	ii) Final		10/12/2010
5)	raised bed preparation	1	21/05/2010
6)	Sowing of seeds on raised bed	1	02/06/2010
7)	Irrigation to seed bed	Daily	-
8)	Layout	1	25/06/2010
9)	Basal dose application	1	08/07/2010
10)	Transplanting	1	09/07/2010
11)	Gap filling	1	16/07/2010
12)	Hand weeding	3	
	1 st weeding		05/08/2010
	2 nd weeding		09/09/2010
	3 rd weeding		10/10/2010
13)	Top dressing	1	07/08/2010
14	Harvesting	1	28/11/2010

3.2.6 Biometric Observation

Five plants from each net plot were randomly selected and used for recording biometric observations at different stages *i.e.* 30, 60, 90, 120 days after transplanting and at the time of harvest. On the basis of five plant observation average value was calculated and recorded.

3.2.6.1 Plant height

Height of plant was recorded from ground level to top of shoot and average value was work out from five plant observation.

3.2.6.2 Number of leaves per plant

Numbers of leaves per plant were counted for five plants and average value was recorded as a number of leaves per plant.

3.2.6.3 Number of branches per plant

Numbers of branches per plant were counted for five plants and average value was recorded as a number of branches per plant.

3.2.6.4 Leaf area per plant

Leaf area per plant was calculated by leaf area meter and average value was worked out from five plant observation.

3.2.6.5 Days to 50% flowering

The number of days required from the data on which 50% plants in plot were flowered and was recorded.

3.2.6.6 Dry matter studies (g plant⁻¹)

Leaves, stem, root and seeds were collected separately from each five plants of each treatments and were dried. After drying the plant sample the weight was taken and average of all these were worked out as g plant⁻¹.

3.2.6.7 Dry biomass yield

The crop was harvested from each net plot. It was sun dried and then in oven at 65⁰ C. dry biomass yield Kg ha⁻¹ was calculated by using following formula

$$\text{Dry biomass yield (Kg ha}^{-1}\text{)} = \frac{\text{Dry biomass yield (Kg/plot)} \times 1000}{\text{Net plot area}}$$

3.2.7 Harvesting

The harvesting was done after 139 days after transplanting. The entire plant was uprooted along with root. The root was separated from the aerial parts by cutting the 1.2 cm above the crown.

3.2.8 Yield parameters

3.2.8.1 Seed yield per hectare (Kg ha⁻¹)

The seed yields obtained from per plot were recorded in Kg and average yield per hectare was calculated.

3.2.8.2 Root yield per plant (g)

The root yield obtained five random plants were weighted in gram and average yield per plant was recorded.

3.2.8.3 Root yield per hectare (Kg ha⁻¹)

The root yield obtained net plots were weighted and average yield per hectare was recorded.

3.2.9. Quality parameters

3.2.9.1 No. of berries per plant

Number of berries per plant was counted from five random plants and average number of berries per plant was estimated.

3.2.9.2 1000 seed weight (g)

This was recorded by measuring the weight of 1000 seed from a sample of seeds from each plot.

3.2.9.3 Root length (cm)

The root length of five selected plant were recorded in centimeter and mean root length was calculated.

3.2.9.4 Root diameter

The diameter of root of five selected plant was measured at the time of harvesting and mean diameter of root was calculated.

3.2.10 Soil analysis

One initial representative soil sample from whole experiment area was collected. Soil samples were also collected separately from each plot after harvest of ashwagandha crop. These soil samples were processed and analyzed for pH, EC, organic carbon, calcium carbonate, N, P, K and micronutrients.

3.2.10.1 Mechanical analysis

Mechanical analysis of the soil was carried out by International Pipette method (Piper, 1966).

3.2.10.2 Soil pH

Soil pH was determined in 1:2.5 soil : water suspension using digital pH meter (Jackson, 1973).

3.2.10.3 Electrical conductivity

It was determined from 1:2.5 soil : water suspension using conductivity bridge (Jackson, 1973).

3.2.10.4 Organic carbon

Organic carbon was determined by the titration method suggested by Walkey and Black (1934).

3.2.10.5 Calcium carbonate

Calcium carbonate was determined by "Rapid titration method" by Bromothymol blue and Bromocresal green indicator as suggested by Puri (1930).

3.2.10.6 Bulk density

Bulk density was determined by clod coating method (Black and Hartge, 1986).

3.2.10.7 Particle density

Particle density of soil was determined by Pycnometer method as given by Black, 1965.

3.2.10.8 Porosity

It was determined by using formula as below

$$\text{Porosity (\%)} = \left(1 - \frac{\text{Bulk density}}{\text{Particle density}} \right) \times 100$$

3.2.10.9 Available nitrogen

It was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956).

3.2.10.10 Available phosphorus

Phosphorus was extracted from the soil with 0.5 M sodium bicarbonate at nearly constant pH 8.5 and phosphorus thus extracted and determined by Olsen's method as described by Jackson (1973) in chloromolybdic acid medium.

3.2.10.11 Available potassium

It was determined with neutral normal NH_4OAC and potassium in extract was determined by flame photometer (Piper, 1966).

3.2.10.12 Micronutrients

Micronutrients from soil were determined by atomic Absorption Spectrophotometer as suggested by Lindsay and Norvell method (1978).

3.2.11 Plant analysis

3.2.11.1 Preparation of plant and seed samples

Collected plants were oven dried and ground in electrically operated grinder to maximum fineness. The ground plant and grain samples were stored in polythene/ paper bags and used for analysis.

3.2.11.2 Nitrogen content

Total nitrogen in plant was determined by Microjeldal's method (Jackson, 1973). For this 0.5 gram of plant sample was digested with 10 ml H₂SO₄, 5 ml H₂O₂, 1 gm K₂SO₄ and 0.5 gm CuSO₄.H₂O and then it was distilled with 40% NaOH. The distillate was collected in boric acid containing mixed indicator. The contents were back titrated with 0.1 N H₂SO₄ till colour was obtained.

3.2.11.3 Phosphorus content

Phosphorus content in plant sample was estimated colorimetrically by Vanadate Molybdate Phosphoric Acid Yellow Colour method (Jackson, 1973).

3.2.11.4 Potassium content

Potassium content in plant sample was determined on flame photometer as suggested by Jackson (1973).

3.2.11.5 Uptake of nutrients

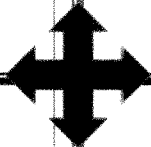
Uptake of nutrients (N, P and K) on dry weight basis of plant was computed by multiplying the respective nutrient concentration to matter yield obtained.

$$\text{Uptake of nutrient} = \frac{\text{Nutrient content(\%)} \times \text{dry matter yield (Kg ha}^{-1}\text{)}}{100}$$

3.2.12 Statistical analysis

Data obtained was statistically analyzed as per the methods given in “Statistical methods for Agricultural workers” by Panse and Sukhatme (1967). Appropriate standards errors (S. E. \pm) were worked out. The critical difference at 5% level is given whether necessary.

RESULTS AND DISCUSSION



Chapter IV

RESULTS AND DISCUSSION

The present investigation was undertaken to study the effect of FYM and fertilizer levels on growth, uptake of nutrients and root yield of ashwagandha. The field experiment was conducted during *kharif* season of the year 2010-2011 with 3 levels of FYM and 4 levels of fertilizers. The results obtained were statistically analyzed, interpreted and presented accordingly.

The following parameters were used to study the effect of FYM, N, P and K levels on ashwagandha crop.

- 4.1 Effect of FYM and fertilizer levels on growth characters of ashwagandha.
- 4.2 Effect of FYM and fertilizer levels on seed yield and yield attributes of ashwagandha.
- 4.3 Effect of FYM and fertilizer levels on root yield and yield parameters of ashwagandha.
- 4.4 Effect of FYM and fertilizer levels on N, P, K content and their uptake by ashwagandha.
- 4.5 Effect of FYM and fertilizer levels on soil chemical properties.
- 4.6 Effect of FYM and fertilizer levels on available N, P and K content in soil.
- 4.7 Effect of FYM and fertilizer levels on available micronutrients in soil.

- 4.1 Effect of FYM and fertilizer levels on growth characters of ashwagandha.

4.1.1 Growth characters

Growth characters *viz.* plant height, number of leaves, number of branches, leaf area, 50 % flowering and total dry matter of plant were recorded during the course of field experiment and results obtained are described here.

T 6171



4.1.1.1 Plant height

Data regarding plant height of ashwagandha at 30 DAT, 60 DAT, 90 DAT, 120 DAT and at harvest are presented in table 5 and depicted in fig 2. Data revealed that plant height was significantly affected by various fertilizers and FYM levels at all the growth stages of observation.

Table 5 Plant height of ashwagandha as influenced by FYM and Fertilizer levels at different crop growth stages.

Treatment	Plant height (cm)				
	30 DAT	60 DAT	90 DAT	120DAT	At harvest
FYM levels (A)					
A ₁	7.45	20.05	32.12	43.66	59.54
A ₂	9.88	21.37	34.10	45.45	61.77
A ₃	11.96	23.35	37.33	48.07	63.64
S.E. ±	0.33	0.26	0.17	0.45	0.62
C.D. at 5 %	0.97	0.77	0.51	0.52	1.84
Fertilizer levels (B)					
B ₁	7.93	19.79	32.67	44.10	59.90
B ₂	9.56	21.15	34.47	45.57	61.50
B ₃	10.06	22.46	35.80	47.01	62.51
B ₄	11.54	22.95	35.20	46.21	62.69
S.E. ±	0.38	0.30	0.20	0.52	0.72
C.D. at 5 %	1.12	0.89	0.59	1.54	2.12
Interaction (A x B)					
S.E. ±	0.66	0.52	0.35	0.91	1.25
C.D. at 5 %	NS	NS	NS	NS	NS
G.M.	9.77	21.59	34.53	45.73	61.65

Among the FYM levels, the treatment A₃ (5 t ha⁻¹) produced taller plants while A₁ (0 t FYM ha⁻¹) produced smaller plants at all the stages of crop growth. The treatment A₃ (5 t FYM ha⁻¹) was significantly superior over the rest of FYM

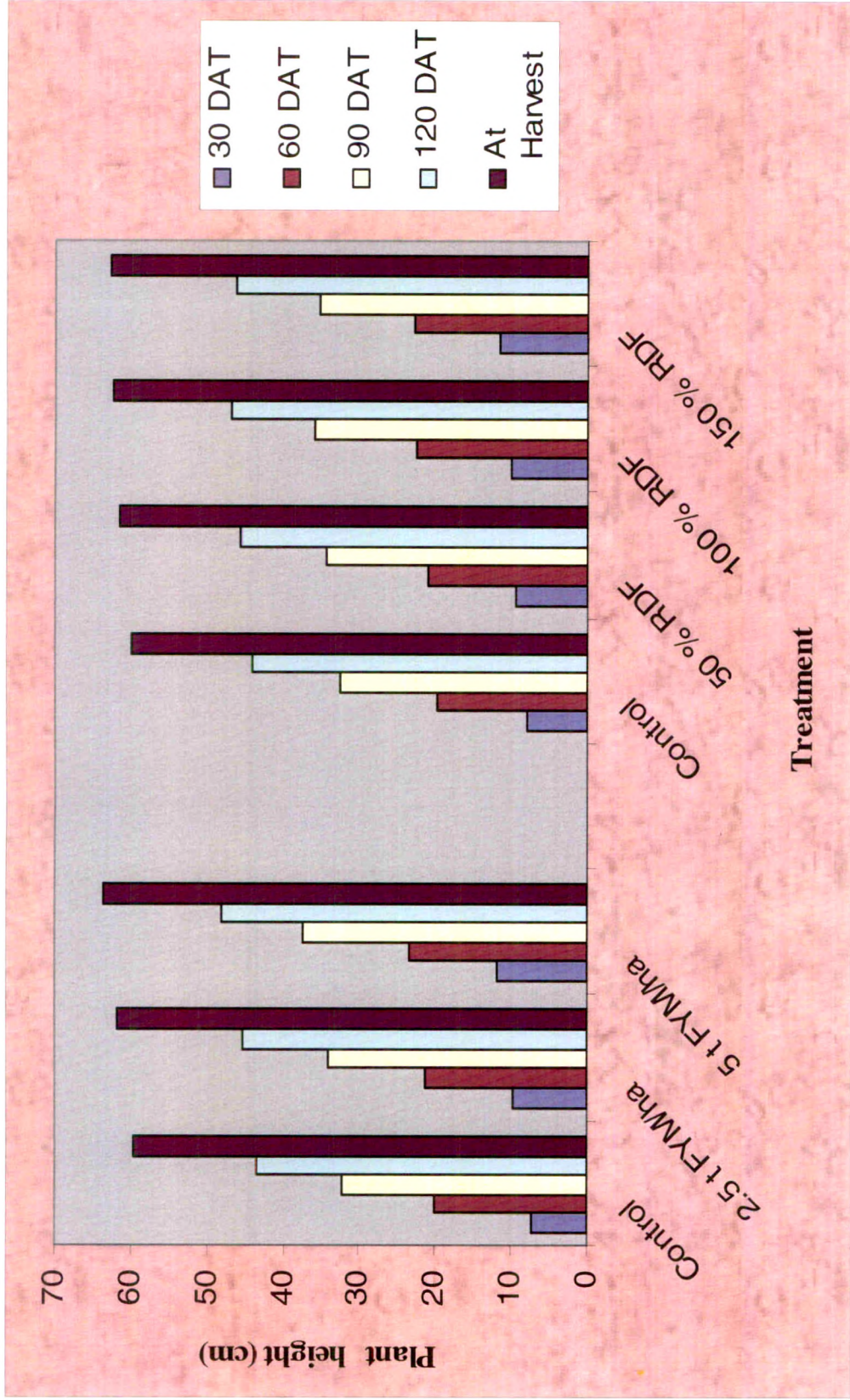


Fig 2: Plant Height of ashwagandha as influenced by FYM and fertilizer levels at different growth stages

treatments at 30 DAT (11.96 cm), 60 DAT (23.35 cm), 90 DAT (37.33 cm), 120 DAT (48.07 cm) and at harvest (63.64 cm).

In case of fertilizer levels taller plants were recorded by the treatment B₄ (150% RDF) at 30 DAT (11.54cm), 60 DAT (22.95 cm) and at harvest (62.69 cm) but it was at par with the treatment B₃ (100 % RDF). Similarly at 90 DAT (35.20 cm) and 120 DAT (47.01 cm) taller plants were observed with the treatment B₃ (100% RDF) but which was par with treatment B₄. While significantly lowest plant height was recorded at treatment B₁.

This increase in plant height might be due to the greater availability of nutrients from organic and inorganic sources of fertilizers which helped in acceleration of various metabolic processes. These results are in conformity with reports of Jose *et al.* (1988).

The interaction effects of FYM and fertilizer levels are seemed to be non-significant with regards to plant height of ashwagandha.

4.1.1.2 Number of leaves

Effects of FYM and fertilizer levels on number of leaves are presented in table 6. FYM and fertilizer levels showed significant effect at 30 DAT, 60 DAT, 90 DAT, 120 DAT and harvest stages of ashwagandha.

The data on number of leaves revealed that significantly higher number of leaves were produced by A₃ (5 t FYM ha⁻¹) treatment at 30 DAT (8.66), 60 DAT (15.46), 90 DAT (31.58), 120 DAT (62.65) and at harvest (83.81) but it was at par with A₂ (2.5 t FYM ha⁻¹) at 60 DAT. Minimum leaves were produced due to treatment A₁.

In case of fertilizer levels the treatment B₃ (100% RDF) produced significantly higher number of leaves at 30 DAT and 90 DAT but it was at par with B₄ at 90 DAT. The treatment B₄ (150% RDF) also produced more number of leaves per plant at 60 DAT (15.87), 120 DAT (57.47) and harvest (75.56), however it was at par with the treatment B₃ (100% RDF). In ashwagandha minimum number of leaves was produced due to B₁ (control).

The interaction effect of FYM and fertilizer levels fails to attain the level of significance for number of leaves.

Table 6 Number of leaves as influenced by FYM and Fertilizer levels during crop growth of ashwagandha.

Treatment	Number of leaves per plant				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
FYM levels (A)					
A ₁	3.74	10.76	21.44	39.21	58.84
A ₂	4.76	14.15	22.86	44.61	63.70
A ₃	8.66	15.46	31.58	62.65	83.81
S.E. \pm	0.32	0.49	1.29	1.52	1.95
C.D. at 5 %	0.94	1.43	3.79	4.45	5.73
Fertilizer levels (B)					
B ₁	3.64	10.59	16.44	38.02	58.09
B ₂	5.32	12.39	25.08	47.12	68.63
B ₃	7.42	14.98	30.07	52.76	72.85
B ₄	6.52	15.87	29.58	57.40	75.56
S.E. \pm	0.37	0.56	1.49	1.75	2.26
C.D. at 5 %	1.08	1.66	4.38	5.14	6.62
Interaction (A x B)					
S.E. \pm	0.64	0.98	2.59	3.04	3.91
C.D. at 5 %	NS	NS	NS	NS	NS
G.M.	5.72	13.46	25.29	48.82	68.78

More number of leaves might be due to increased vegetative growth, balanced nutrition, increased synthesis of carbohydrates and balanced C/N ratio. Similar results are found by Jose *et al.* (1988).



Plate 2 : Vigorous vegetative growth of plant due to treatment 5 t FYM ha⁻¹+ 100% RDF

4.1.1.3 Number of branches

Data concerning to the effect of FYM and fertilizer levels on number of branches per plant are presented in the table 7. The FYM and fertilizer levels significantly affected the number of branches at 30 DAT, 60 DAT, 90 DAT, and 120 DAT and at harvest.

Application of 5.0 tonnes of FYM per ha (A_3) produced maximum number of branches per plant, which was significantly superior over rest of the treatment. However, it was at par with the treatment A_2 ($2.5 \text{ t FYM ha}^{-1}$) at 60 DAT and harvest stage. The treatment A_1 (control) recorded significantly minimum number of branches per plant in ashwagandha.

Whereas in case of fertilizer levels, B_4 (150% RDF) treatment produced more number of branches per plant in ashwagandha. Significant increase in number of branches per plant was observed due to treatment B_4 (150 % RDF) at all stages of growth except at 30 DAT. At 30 DAT the treatment B_3 (100 % RDF) was found significantly superior over rest of the treatment in producing number of branches per plant. The treatment B_4 (150 % RDF) was at par with B_3 (100 % RDF) at 90 DAT, 120 DAT and harvest stage. Further data revealed that the treatment B_1 (control) recorded significantly less number of branches per plant in ashwagandha. The interaction effect of FYM and fertilizer levels was non significant.

This increase in number of branches per plant might be due to the receipt of optimum nutrients through FYM and fertilizers to ashwagandha. Similar findings were also recorded by Shelke *et al.* (1999).

4.1.1.4 Leaf area

Leaf area was recorded at 30 DAT, 60 DAT, 90 DAT, and 120 DAT and at harvest is presented in table 8. The data it was revealed that in the leaf area was significantly influenced by different levels of FYM and fertilizer in ashwagandha.

Among the different levels of FYM, treatment A_3 (5 t FYM ha^{-1}) showed significantly higher over remaining the all FYM treatments at 30 DAT, 60

DAT, 90 DAT, 120 DAT and at harvest while significantly lower leaf area was recorded with the treatment A₁ all the stages of crop growth.

Table 7 No of branches as influenced by FYM and Fertilizer levels of during the crop growth of ashwagandha.

Treatment	Number of branches per plant				
	30 DAT	60 DAT	90 DAT	120DAT	At harvest
FYM levels (A)					
A ₁	0.21	0.35	0.67	2.30	3.10
A ₂	0.32	0.66	1.23	3.91	5.30
A ₃	0.41	0.66	2.07	5.05	5.83
S.E. \pm	0.032	0.069	0.13	0.30	0.29
C.D. at 5 %	0.095	0.204	0.39	0.88	0.85
Fertilizer levels (B)					
B ₁	0.00	0.00	0.55	1.58	2.21
B ₂	0.29	0.55	1.34	3.88	4.56
B ₃	0.51	0.69	1.60	4.55	5.92
B ₄	0.47	0.99	1.80	5.00	6.28
S.E. \pm	0.037	0.080	0.15	0.34	0.33
C.D. at 5 %	0.010	0.236	0.46	1.01	0.98
Interaction (A x B)					
S.E. \pm	0.0665	0.139	0.27	0.60	0.58
C.D. at 5 %	NS	NS	NS	NS	NS
G.M.	0.31	0.56	1.32	3.75	4.74

Table 8 Leaf area of ashwagandha as influenced by FYM and fertilizers levels of ashwagandha crop at different growth stages.

Treatment	leaf area (cm ²)				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
FYM levels (A)					
A ₁	4.83	8.24	13.16	16.04	18.98
A ₂	5.85	11.54	15.14	17.21	20.75
A ₃	10.25	15.49	18.80	18.88	24.60
S.E. ±	0.50	0.47	0.55	0.39	0.48
C.D. at 5 %	1.47	1.40	1.63	1.16	1.41
Fertilizer levels (B)					
B ₁	4.90	10.28	14.20	16.12	19.60
B ₂	6.90	10.89	15.58	17.28	21.08
B ₃	7.87	12.33	15.87	17.73	22.43
B ₄	8.25	13.54	17.14	18.39	22.69
S.E. ±	0.57	0.55	0.64	0.46	0.55
C.D. at 5 %	1.69	1.62	1.89	1.34	1.62
Interaction (A x B)					
S.E. ±	1.00	0.95	1.11	0.79	0.96
C.D. at 5 %	NS	NS	NS	NS	NS
G.M.	6.98	11.76	15.70	17.38	21.45

The data in table 8 further revealed that the treatment B₄ (150 % RDF) recorded significantly higher leaf area than the treatments at all the growth stages in ashwagandha. However, B₄ treatment was at par with B₃ (100 % RDF). Minimum leaf

area was recorded in control in control (B₁) plot. Interaction effect due to FYM and fertilizer was found non significant.

Increased leaf area in ashwagandha was observed that the more number of leaves obtained due to application of 5 tonnes of FYM ha⁻¹ and 100 % RDF or 150 % RDF.

According to Kubsad *et al.*(2009) application of N and P to ashwagandha resulted in increased leaf area index due to increase in leaf number and leaf area under better nutritional environment similar results is observed by Kiruthikadevi, (2000).

4.1.1.5 Number of days to 50 % flowering

Data on results of number of days to 50 % flowering influenced by FYM and fertilizer levels are presented in table 9. From the results it was revealed that the 50 % flowering was significantly affected due to various levels of FYM as well as fertilizer.

FYM treatment A₃ (5 t FYM ha⁻¹) recorded significantly more number of days to 50 % flowering over rest of the treatments and A₁ treatment showed less number of days to 50 % flowering

Whereas, in case of fertilizer levels, the results revealed that the number of days required for 50 % flowering in ashwagandha was increased with increased levels of fertilizers. The treatment B₄ (150 % RDF) showed significantly more number of days to 50 % flowering that the rest of the treatments. Minimum number of days to 50 % flowering was recorded with control treatment.

From results it was cleared that higher dose of fertilizer leads to delay in 50 % flowering. This might be due to nitrogen which imparts more vegetative growth and delay the reproductive growth. Similar results were also found to Mann and Vyas (1999).

Table 9 Effect of FYM and fertilizer levels on 50% flowering and dry matter production in ashwagandha.

Treatment	50 % flowering	Dry shoot weight (Kg ha⁻¹)	Total dry weight (Kg ha⁻¹)
FYM levels (A)			
A ₁	85.58	592.669	2250.3
A ₂	87.50	979.52	3417.7
A ₃	90.58	1278.1	4277.2
S.E. ±	1.04	27.10	63.34
C.D. at 5 %	3.06	79.37	185.52
Fertilizer levels (B)			
B ₁	85.77	721.25	2553.0
B ₂	86.55	912.02	3216.0
B ₃	87.66	1141.0	3776.4
B ₄	91.55	1026.1	3715.0
S.E. ±	1.20	31.29	73.14
C.D. at 5 %	3.53	91.65	214.22
Interaction (A x B)			
S.E. ±	2.09	54.20	126.70
C.D. at 5 %	NS	NS	NS
G.M.	87.88	950.10	3315.1

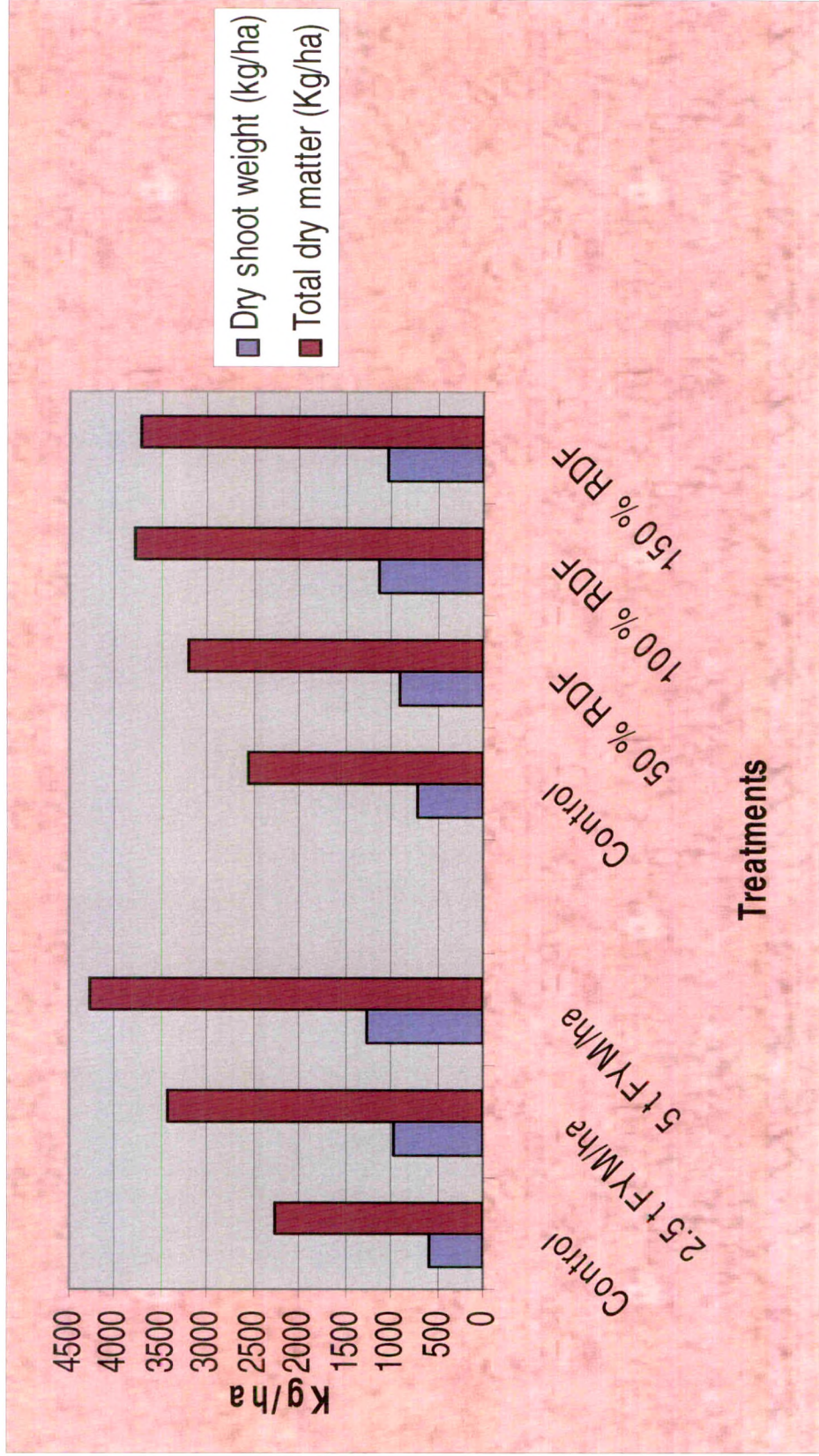


Fig. 3: Dry matter production (Kg ha^{-1}) of ashwagandha as influenced by FYM and fertilizer

4.1.1.6 Dry matter production

The data pertaining to dry shoot weight and total dry weight Kg ha^{-1} as affected by different FYM and fertilizer levels are presented in table 9 and fig. 3. Effect of FYM and fertilizer levels was significant on dry shoot and total dry weight production of ashwagandha.

It is evident from the result that among the levels of FYM, the treatment A_3 (5 t FYM ha^{-1}) recorded the significantly superior results over lower FYM levels in case of shoot as well as total dry weight production in ashwagandha. Lowest yield was produced by A_1 treatment (control).

In case of fertilizer treatments, B_3 (100% RDF) treatment was significantly superior over B_4 (150% RDF), B_2 (50% RDF) and B_1 (Control) for dry shoot weight, and total dry weight as well but the treatment B_3 (100% RDF) was found par with the treatment B_4 (150% RDF). In ashwagandha significantly lower dry matter production was observed in control plot. Interaction effect of FYM and fertilizer levels was non significant.

Increase in dry matter due to balanced quantity of fertilizers with organic manure and proper supply of nutrients resulted in better growth, higher yield of crop. These results are in conformity with Zhang *et al.* (1988). Doikova (1978) reported that application of FYM + NPK increased dry matter production in brinjal; while FYM alone proved less effective.

4.2 Effect of FYM and fertilizer levels on seed yield and yield attributes of ashwagandha.

4.2.1 Seed yield (Kg ha^{-1})

Results regarding the influence of different levels of FYM as well as fertilizer are presented in table 10 and in fig 4. The seed yield Kg ha^{-1} of ashwagandha was significantly affected by FYM as well as fertilizer levels. Data in table 10 revealed that the seed yield Kg ha^{-1} of ashwagandha increased significantly with increased levels of FYM. The treatment A_3 (5 t FYM ha^{-1}) produced significantly

higher seed yield (395.58 Kg ha⁻¹) over rest of the treatment. Significantly lower seed yield was recorded due to A₁ (control) treatment in ashwagandha.

With regards to fertilizer levels, application of 100 % RDF (B₃) to ashwagandha gave maximum seed yield (363.02 Kg ha⁻¹) which was significantly superior over lower levels of fertilizer treatments. Significant difference was not observed in between treatment B₃ and B₄. Significantly lower seed yield of ashwagandha was observed with B₁ treatment (control). The interaction effect between FYM and fertilizer treatment was non significant.

It was attributed to the favorable & correlative influence of FYM in combination with higher dose of fertilizer on yield contributing characters. These results are in accordance with those reported by Kahar *et al.* (1994), Patel & Bapna (1993), Mann & Vyas (1999) & Pawar (2000).

4.2.2. 1000 Seed Weight (g)

The data concerning to effect of FYM and fertilizer levels on 1000 seed weight (g) are presented in table 10. It is revealed from the data that the 1000 seed weight in ashwagandha was significantly affected due to FYM as well as fertilizer levels. Treatments A₃ (5 t FYM ha⁻¹) gave higher 1000 seed weight (9.31 g) which was significantly superior over rest of FYM treatments. Lower test weight of seed was recorded due to treatment A₁ (control).

In ashwagandha, the treatment B₄ (150% RDF) recorded maximum 1000 seed weight (8.46 g) but it was at par with the treatment B₃ (100 % RDF). Both these treatments (B₄ and B₃) were found significantly superior over B₁ (control) and B₂ (50 % RDF). The treatment B₁ (control) give lower weight of 1000 seed (6.95 g). The interaction effect was non significant.

4.2.3 Number of berries per plant

The data on effect of FYM and fertilizer levels on number of berries per plant in ashwagandha are presented in table 10. Results revealed that the FYM as well as fertilizer levels significantly affect the number of berries per plant.

Among the FYM levels the treatment A₃ (5 t FYM ha⁻¹) produced significantly higher number of berries (142.54) per plant than the all other treatments of FYM. Lowest number of berries per plant was recorded in control treatment (A₁).

In case of fertilizer levels more number of berries per plant was observed in the treatment B₃ (100 % RDF). However, it was at par with the treatment B₄ (150 % RDF). Significantly increase in number of berries per plant was observed up to treatment 100 % RDF (B₃).

Table 10 Effect of FYM and fertilizer levels on seed yield and yield attributes of ashwagandha.

Treatment	Seed yield (Kg ha⁻¹)	1000 seed weight (g)	Number of berries/ plant
FYM levels (A)			
A ₁	214.57	7.12	98.80
A ₂	290.29	7.50	126.98
A ₃	395.58	9.13	142.54
S.E. ±	8.67	0.20	2.28
C.D. at 5 %	25.39	0.59	6.70
Fertilizer levels (B)			
B ₁	201.70	6.95	91.64
B ₂	275.76	7.80	116.47
B ₃	363.02	8.45	142.02
B ₄	360.11	8.46	140.98
S.E. ±	10.01	0.23	2.64
C.D. at 5 %	29.31	0.68	7.74
Interaction (A x B)			
S.E. ±	17.34	0.40	4.57
C.D. at 5 %	NS	NS	NS
G.M.	300.12	7.91	122.78



Fig. 4: Seed yield (Kg/ha) as influenced by various treatments of FYM and fertilizer

Mallangouda *et al.* (1995) reported that application of the recommended dose of NPK + FYM improved the yield and yield components of onions, garlic and corianders

4.2 Effect of FYM and fertilizer levels on root yield and root parameters of ashwagandha.

4.3.1 Fresh root weight (Kg ha⁻¹)

The results regarding the fresh root weight of ashwagandha are presented in table 11 and depicted in fig 5. From the results it was observed that the FYM as well as fertilizer levels were significantly affected the fresh root weight of ashwagandha.

Among the FYM levels, treatment A₃ (5 t FYM ha⁻¹) gave higher fresh root weight (1983 Kg ha⁻¹) which was significantly superior over rest of treatments. Lowest weight of fresh root yield was produced due to treatment A₁ (control).

Fresh root weight Kg ha⁻¹ of ashwagandha was also significantly influenced by fertilizer levels. Treatment B₃ (100 % RDF) gave significantly higher weight of fresh root (1730 Kg ha⁻¹) over rest of treatments except B₄ (150 % RDF) which was at par with B₃ (100 % RDF). Interaction effect of FYM and fertilizer levels are seemed to be non significant.

4.3.2 Dry root weight (Kg ha⁻¹)

In table 11 data regarding dry root weight (Kg ha⁻¹) of ashwagandha are presented. It was revealed that data FYM as well as fertilizer levels significantly affected the dry root weight of ashwagandha (fig 5).

The treatment A₃ (5 t FYM ha⁻¹) gave significantly higher root yield (1310.5 Kg ha⁻¹) than all the other levels of FYM. The data further revealed that the root yield of ashwagandha was increased with increased levels of FYM significant differences were observed among the treatment of FYM.

Table 11 Effect of FYM and fertilizer levels on root yield and root characters of ashwagandha.

Treatment	Fresh root weight (Kg ha⁻¹)	Dry root weight (Kg ha⁻¹)	Root Length (cm)	Root diameter (cm)
FYM levels (A)				
A ₁	1022.3	816.3	5.83	0.44
A ₂	1668.0	1082.5	6.53	0.96
A ₃	1983.0	1310.5	7.36	1.33
S.E. ±	28.53	24.23	0.24	0.06
C.D. at 5 %	83.57	70.95	0.72	0.18
Fertilizer levels (B)				
B ₁	1329.0	846.3	6.01	0.65
B ₂	1496.1	1076.3	7.06	1.08
B ₃	1730.0	1209.3	7.63	1.11
B ₄	1676.0	1147.3	5.58	0.80
S.E. ±	32.95	27.97	0.28	0.07
C.D. at 5 %	96.49	81.93	0.84	0.21
Interaction (A x B)				
S.E. ±	57.07	48.46	0.49	0.12
C.D. at 5 %	NS	NS	NS	0.37
G.M.	1557.8	1069.8	6.57	0.91

Among the fertilizer levels, application of 100% RDF (B₃) recorded significantly higher root yield (1209.3 Kg ha⁻¹) than the rest of the treatments however the treatment B₃ was at par with B₄ (150% RDF). The treatment B₁ (control) recorded significantly lower root yield (846.3 Kg ha⁻¹) over rest of the treatments. Interaction effect between FYM and fertilizer levels are non significant.

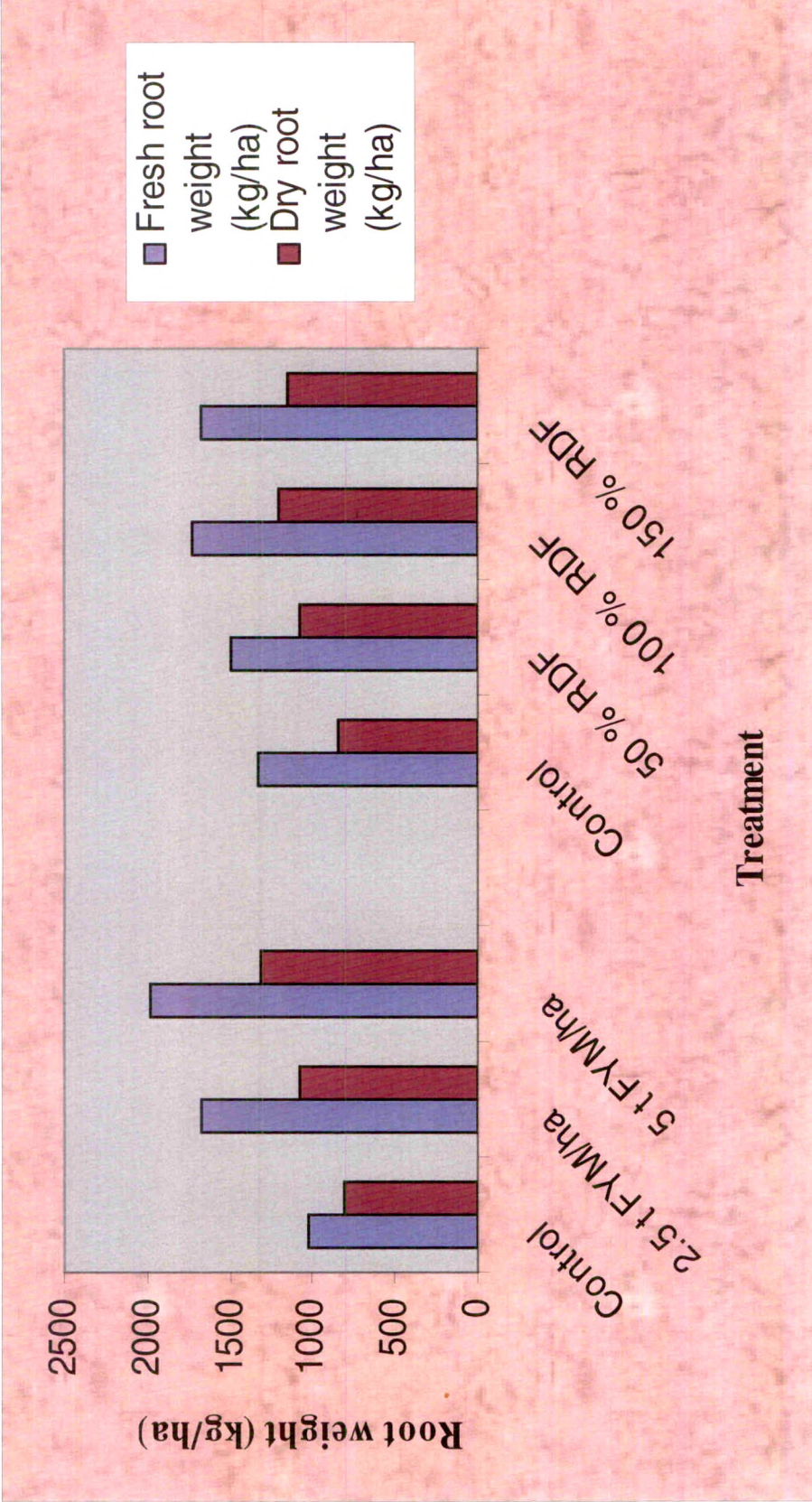


Fig.5: Fresh and dry root weight (kg/ha) as influenced by various treatments of FYM and fertilizer

4.3.3 Root length

Data regarding effect of FYM and fertilizer levels on root length are presented in table 11 and depicted in fig. 6. The data revealed that the root length in ashwaganda was significantly affected due to FYM and fertilizer levels.

Root length in ashwaganda was increased with increased levels of FYM. It was significantly higher in the treatment A₃ (5 t FYM ha⁻¹).

However, in case fertilizer levels, B₃ (100% RDF) treatment produced significantly higher root length (1.11 cm) and it were significantly superior over rest of the treatments but it was at par treatment B₄ and B₂. The interaction effects were non significant.

4.3.3 Root diameter (cm)

Data regarding root diameter of ashwagandha was presented in table 11 and depicted in fig. 6. The root diameter of ashwagandha was significantly affected due to FYM as well as fertilizer levels. It is revealed from the data that treatment A₃ (5 t FYM ha⁻¹) FYM was significantly superior over rest of the treatments in increasing root diameter (1.33 cm). Lower root diameter was recorded with the treatment A₁ (control).

Whereas, in case of fertilizer levels maximum root diameter (1.11 cm) was observed due to treatment B₃ (100 % RDF) and which was significantly superior over treatment B₁, but it was at par with the treatment B₂ and B₄. Minimum root diameter was recorded due to treatment B₁ (control)

Interaction effects of FYM and fertilizer levels are able to gain the level of significance. The results regarding the interaction effect of FYM and fertilizer levels are presented in table 12.

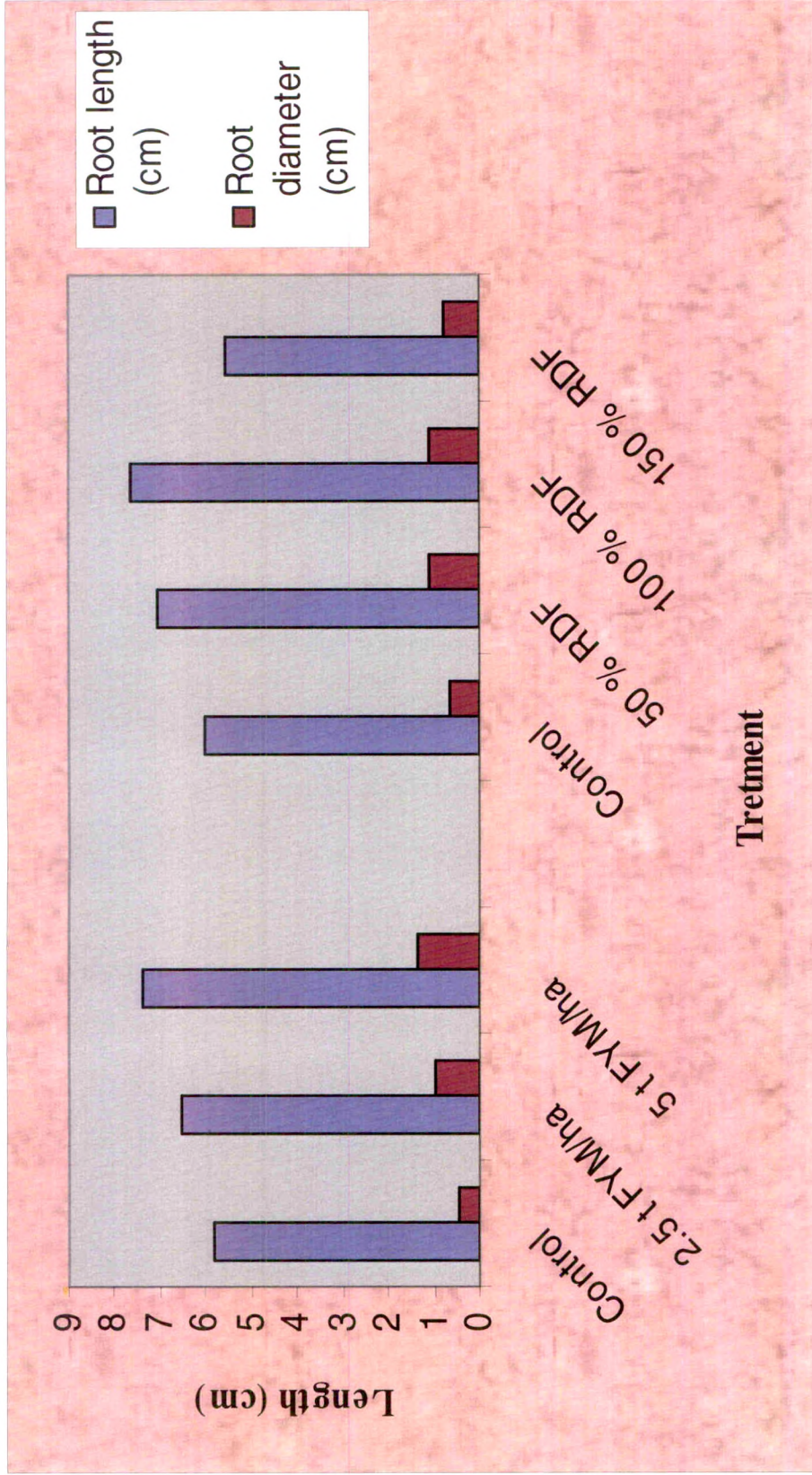


Fig. 6: Effect of FYM and fertilizers levels on root length and root diameter of ashwagandha

Table 12 Interaction effect of FYM and fertilizer levels on root diameter (cm) of ashwagandha.

FYM levels	Fertilizer Levels				Mean
	B ₁	B ₂	B ₃	B ₄	
A ₁	0.27	0.44	0.46	0.62	0.44
A ₂	0.78	1.23	1.01	0.82	0.96
A ₃	0.90	1.58	1.86	0.98	1.33
S.E. ±	0.12				
C.D. at 5 %	0.37				
Mean	0.65	1.08	1.11	0.80	0.91

From the data it was clear that the interaction effect of A₃ x B₃ (1.86 cm) was found significantly superior over all interaction in increasing root diameter of ashwagandha but it was at par with the interaction effect of treatment A₃ x B₂ (1.58 cm).

Increasing in root character of ashwagandha was observed due to use of 5 t FYM ha⁻¹ and recommended dose of fertilizer. This might be due to balanced nutrition and better environment to ashwagandha. Similar findings were reported by Maheshwari *et al.* (1998). They reported that higher root yield of ashwagandha was obtained due to application of moderate dose of 4.5 t FYM along with 12.5 Kg N and 25 Kg P₂O₅ ha⁻¹ under rainfed condition. Such results were also reported by Kulmi *et al.* (2006) and Maryada *et al.* (2001),

At lower nitrogen rates root parameters was more significant this might be due to lower nitrogen rates was more effective in enhancement of root parameters. These similar results are obtained by Maryada *et al.* (2001) and Patel *et al.* (2004).

Increasing fertilizer levels increased root parameters *viz* root weight, root length, root diameter, with increased levels may be ascribed to the overall improvement in plant vigor and production of sufficient photosynthates owing to higher availability of nutrients, resulting in better manifestation of yield attributes. These are in accordance with those of Maryada *et al.* (2001).

4.3 Effect of FYM and fertilizer levels on N, P, K concentration and their uptake by ashwagandha.

4.4.1 Concentration of N, P and K

Results regarding concentration of N, P and K in dry matter of ashwagandha influenced by FYM and fertilizer levels are presented in table 13 and depicted in fig 7.

The data revealed that FYM as well as fertilizer levels applied to ashwagandha significantly influenced the concentration of N, P and K. Among the FYM levels the treatment A₃ (5 t FYM ha⁻¹) recorded significantly higher N, P and K concentration in plant. However, the treatment A₂ (2.5 t FYM ha⁻¹) was at par with A₃ in case of phosphorus content in plant. The N, P and K content in ashwagandha plant was increased with increased levels of FYM. Lower N, P and K concentration in plant was recorded due to treatment A₁ (control).

Data in table 13 further revealed that the concentration of N, P and K was increased with increased levels of fertilizers upto B₃ (100 % RDF) level. The treatment B₃ recorded significantly higher concentration of P (0.263 %) and K (1.38 %) than the rest of the treatment but it was at par with treatment B₄ (150 % RDF). In case of nitrogen concentration in plant, the treatment B₄ (150 % RDF) recorded maximum concentration however it was at par with the treatment B₃ (100 % RDF). Significantly lower concentration of N, P and K was observed with treatment B₁ (control).

Interaction effect (table 14, fig 8) between FYM and fertilizer levels was found significant in case of nitrogen concentration but it was not significant in case of P and K concentration in plant. It was observed from the results that the interaction A₃ x B₃ recorded significantly highest N concentration (1.49 %) than the rest of the treatments. However, it was at par with A₃ x B₄, A₃ x B₂ and A₂ x B₄

When FYM added to soil, complex nitrogenous compounds slowly break down and make steady N, P and K supply throughout growth period of crop, which might be attributed to more N availability. N application enhance biomass yield this might be attributes to more uptake of nitrogen. These results are in conformity with the Rao *et al.* (1997).

Table 13 Effect of FYM and fertilizer levels on N, P and K concentration and their uptake by ashwagandha.

Treatment	Concentration (%)			Uptake (Kg ha ⁻¹)		
	N	P	K	N	P	K
FYM levels (A)						
A ₁	1.145	0.226	1.26	25.52	5.51	28.96
A ₂	1.36	0.255	1.32	45.95	8.55	45.37
A ₃	1.46	0.268	1.42	61.14	11.37	60.96
S.E. ±	0.01	0.004	0.02	0.16	0.08	0.45
C.D. at 5 %	0.03	0.013	0.06	0.48	0.24	1.33
Fertilizer levels (B)						
B ₁	1.24	0.236	1.28	31.97	6.07	32.93
B ₂	1.30	0.250	1.31	42.28	8.04	42.66
B ₃	1.35	0.263	1.38	51.55	10.08	53.20
B ₄	1.39	0.251	1.38	51.01	9.73	51.60
S.E. ±	0.01	0.005	0.02	0.19	0.09	0.52
C.D. at 5 %	0.04	0.016	0.07	0.56	0.28	1.54
Interaction (A x B)						
S.E. ±	0.02	0.009	0.04	0.33	0.16	0.91
C.D. at 5 %	0.07	NS	NS	0.97	0.48	2.66
G.M.	1.32	0.250	1.33	44.20	8.48	45.10

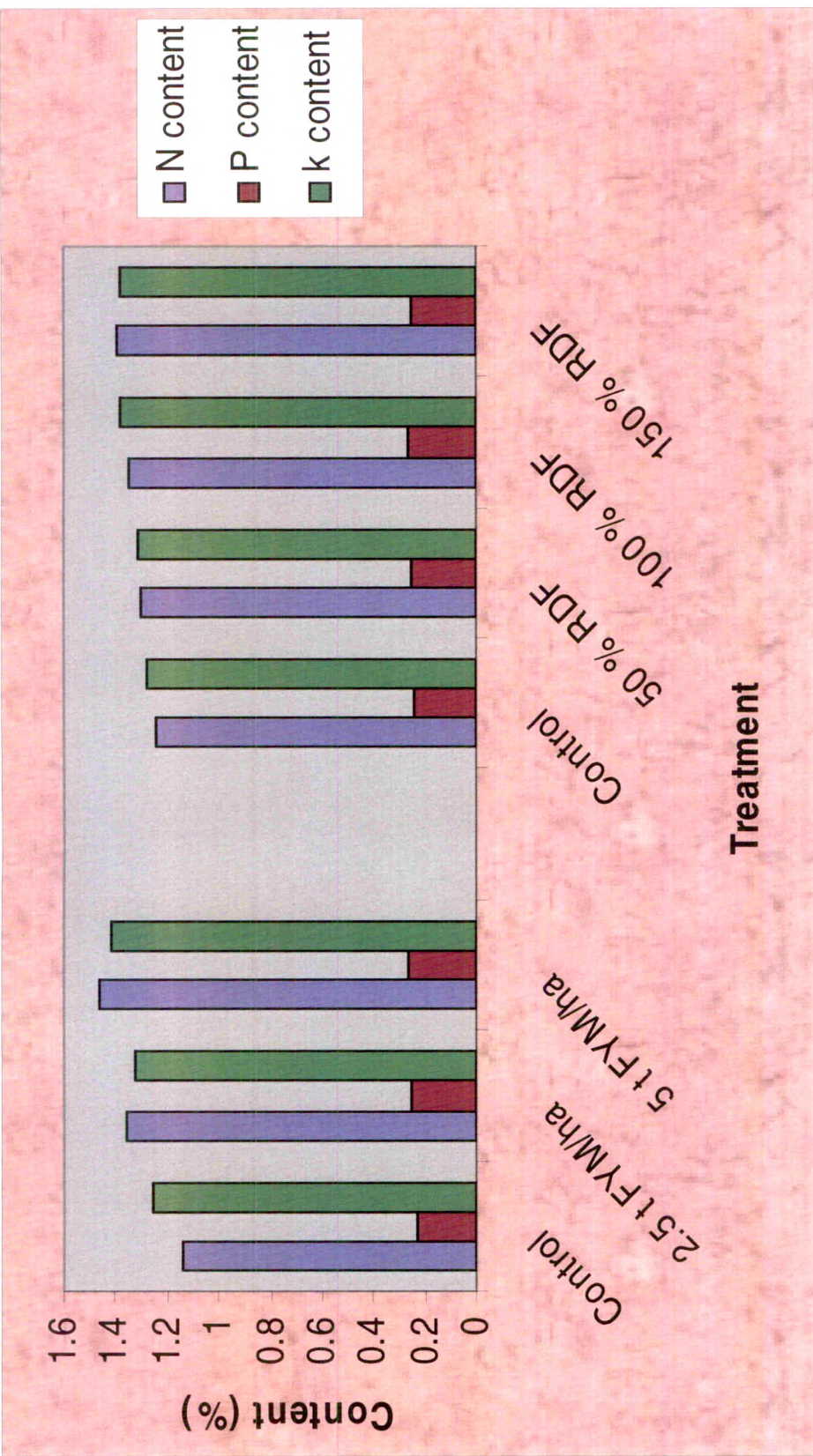


Fig. 7: Effect of FYM and fertilizer levels on N, P and K % in plant

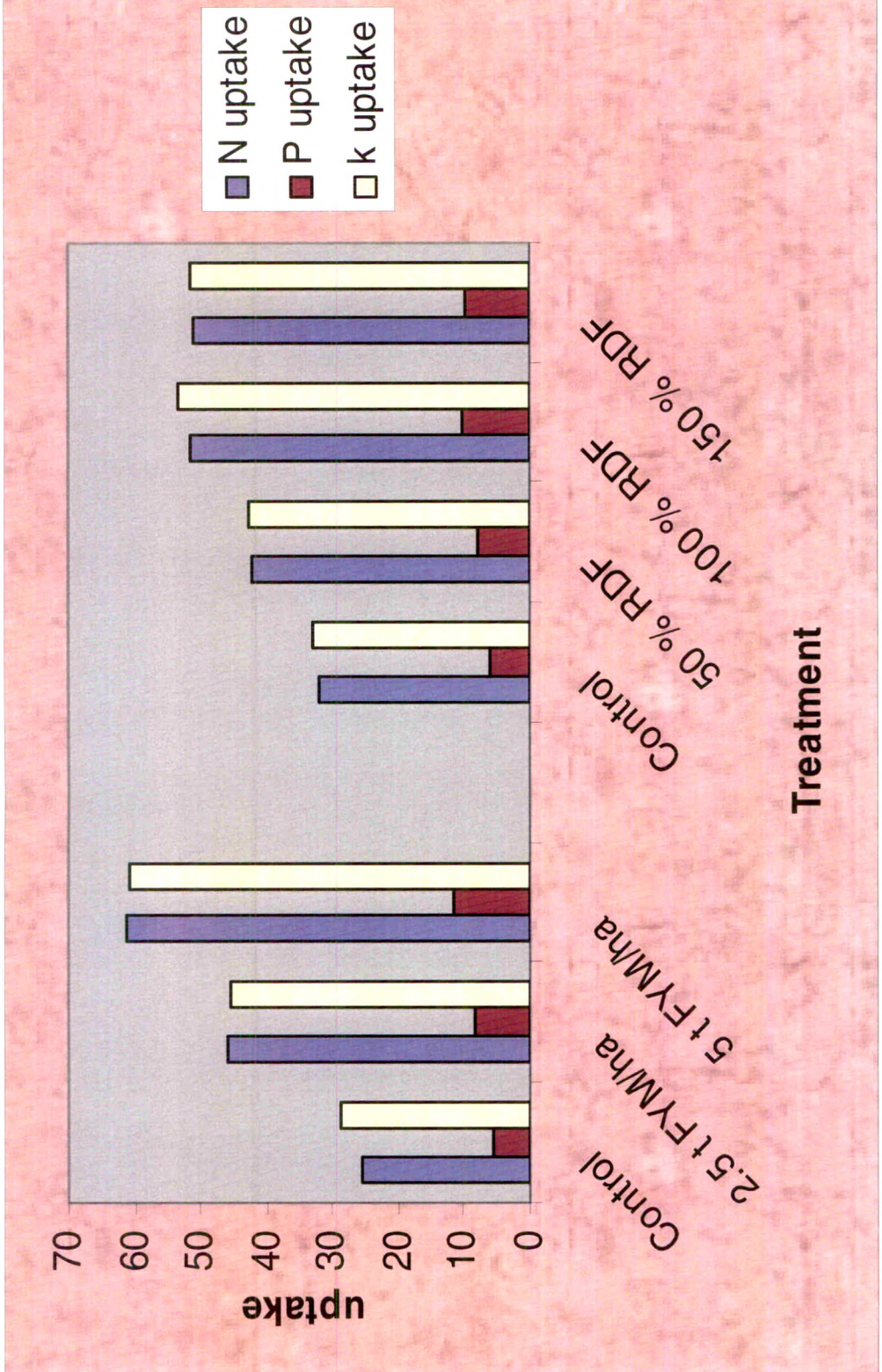


Fig. 8: N, P and K uptake of ashwagandha as influenced by various treatments of FYM and fertilizer levels

Table 14 Interaction effect of FYM and fertilizer levels on N% of ashwagandha.

A/B	B ₁	B ₂	B ₃	B ₄	Mean
A ₁	1.09	1.07	1.15	1.26	1.14
A ₂	1.23	1.37	1.41	1.44	1.36
A ₃	1.42	1.46	1.49	1.47	1.46
S.E. ±	0.02				
C.D.	0.07				
Mean	1.24	1.30	1.35	1.39	1.32

4.4.2 Uptake of N, P and K

The uptake of N, P and K was presented in table 13 and depicted fig. 9. N, P and K uptake by ashwagandha was significantly affected due to FYM and fertilizer levels.

Among the FYM levels, the treatment A₃ (5 t FYM ha⁻¹) gave significantly higher uptake of N (61.14 Kg ha⁻¹), P (11.37 Kg ha⁻¹) and K (60.96 Kg ha⁻¹). Significantly lower uptake of these nutrients was noted with the treatment A₁ (control)

With respect to fertilizer levels, the uptake of N (51.55 Kg ha⁻¹), P (10.08 Kg ha⁻¹) and K (53.20 Kg ha⁻¹) was significantly superior due to treatment B₃ (100 % RDF) over rest of the treatments. However, it was at par with the B₄ (150 % RDF) in case of N uptake only. The uptake of N, P and K was increased with increasing levels of fertilizers upto B₃ (100 % RDF). Further increase in fertilizer dose decreased the uptake of N, P and K by ashwagandha. Lowest N, P and K uptake in control plot.

Interaction effect between FYM and fertilizer levels was significant on N, P and K uptake and presented in table (15, 16 and 17)

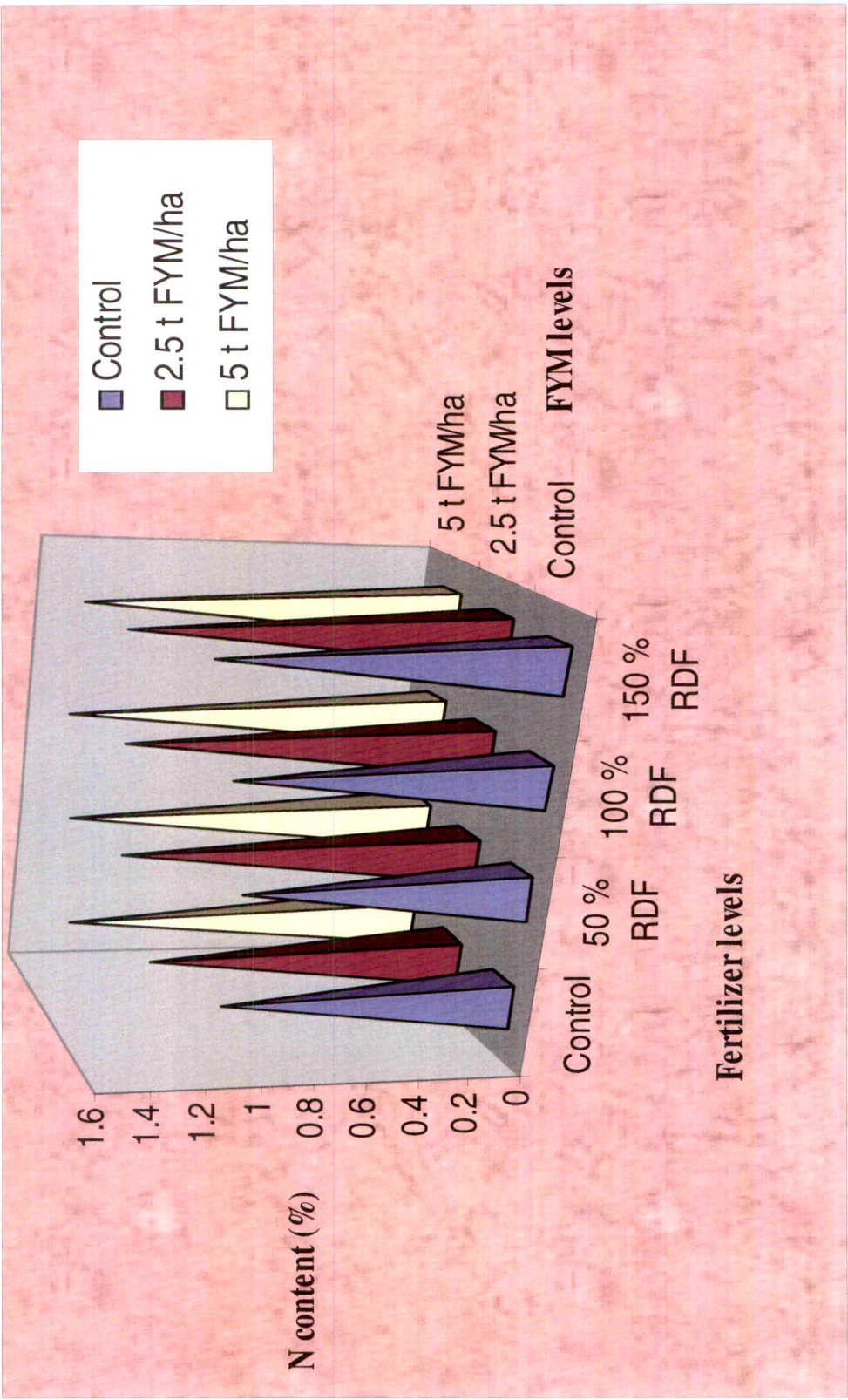


Fig. 9: N content (%) of ashwagandha as influenced by interaction effect of fertilizer and FYM levels

Table 15 Interaction effect of FYM and fertilizer levels on N uptake Kg ha⁻¹ of ashwagandha.

FYM levels	Fertilizer levels				Mean
	B ₁	B ₂	B ₃	B ₄	
A ₁	13.86	21.37	32.86	34.02	25.52
A ₂	30.42	44.71	53.25	55.42	45.95
A ₃	51.63	60.76	68.56	63.61	61.14
S.E. ±	0.33				
C.D. at 5 %	0.97				
Mean	31.97	42.28	51.55	51.01	44.20

Interaction effect of FYM and fertilizer levels on N, P and K uptake was present in table 15, 16 and 17 respectively. From the data it was revealed that interaction effect of A₃ x B₃ was significant on uptake of N (68.56 Kg ha⁻¹), P (13.15 Kg ha⁻¹) and K (70.94 Kg ha⁻¹) over remaining all the interactions. Significantly lower uptake of N, P and K was recorded due to treatment interaction A₁ x B₁ (control).

Table 16 Interaction effect of FYM and fertilizer levels on P uptake Kg ha⁻¹ of ashwagandha.

FYM levels	fertilizer Levels				Mean
	B ₁	B ₂	B ₃	B ₄	
A ₁	3.08	4.73	7.04	7.19	5.51
A ₂	5.83	8.34	10.03	10.01	8.80
A ₃	9.29	11.05	13.15	11.99	11.37
S.E. ±	0.16				
C.D. at 5 %	0.48				
Mean	6.07	8.04	11.08	9.73	8.48

Phosphorus uptake had also similar pattern as to that of N which might be attributed to more solubilization of native phosphate from the soil due to action of

various organic acids liberated during decomposition of FYM. These results are accordance to Chavan *et al.* (1997). More uptakes of nutrients might be due to more vigorous vegetative growth of plants due to better nutritional supply to the plant. These results are in accordance with Kubsad *et al.* (2009). Beneficial effect of FYM on improving soil physical properties in terms of better penetration of roots might have also helped in increasing biomass and NPK uptake as observed by Nair and Peter (1990) and Kaminwar and Rajagopal (1993).

Table 17 Interaction effect of FYM and fertilizer levels on K uptake Kg ha⁻¹ of ashwagandha.

FYM levels	Fertilizer levels				Mean
	B ₁	B ₂	B ₃	B ₄	
A ₁	17.27	25.58	37.30	35.70	28.96
A ₂	31.73	43.75	51.36	54.67	45.37
A ₃	49.81	58.67	70.94	64.43	60.96
S.E. ±	0.91				
C.D. at 5 %	2.66				
Mean	32.93	42.66	53.20	51.60	45.10

4.4 Effect of FYM and fertilizer levels on soil physicochemical properties.

Data pertaining to soil physicochemical properties *viz.* pH, EC, CaCO₃, OC and bulk density as influenced by FYM and fertilizer levels are given in table 18 and figure 10, 11. The data regarding residual effect of ashwagandha on physicochemical properties of soil. Influenced significantly due to FYM and fertilizer levels. However, the effect is non significant in pH only.

Table 18 Effect of FYM and fertilizer levels of soil physicochemical properties.

Treatment	pH	EC dS m⁻¹	CaCO₃ (%)	O.C. (%)	B.D. gm cm⁻³
FYM levels (A)					
A ₁	8.21	0.166	3.43	0.46	1.21
A ₂	8.23	0.155	3.06	0.54	1.11
A ₃	8.15	0.145	2.62	0.66	1.04
S.E. ±	0.02	0.001	0.13	0.01	0.03
C.D. at 5 %	NS	0.003	0.40	0.04	0.10
Fertilizer levels (B)					
B ₁	8.27	0.162	3.42	0.51	1.14
B ₂	8.21	0.154	3.12	0.54	1.27
B ₃	8.15	0.150	2.68	0.59	1.00
B ₄	8.17	0.155	2.93	0.57	1.07
S.E. ±	0.02	0.001	0.15	0.01	0.04
C.D. at 5 %	NS	0.004	0.46	0.04	0.12
Interaction (A x B)					
S.E. ±	0.05	0.002	0.02	0.02	0.07
C.D. at 5 %	NS	NS	NS	NS	NS
G.M.	8.20	0.155	3.04	0.55	1.12
Initial status	8.32	0.172	0.42	3.62	1.25

With regards to residual effect of FYM levels on EC, (0.17) calcium carbonate (3.41) and bulk density of soil. The treatment A₁ (control) was significantly higher than the rest of treatment. The data further revealed that EC, CaCO₃ and bulk density of soil was decreased with increased in FYM levels. However, in case of organic carbon the treatment A₃ (0.66%) recorded significantly higher organic carbon in soil than the rest of treatment. Organic carbon content in the soil was significantly low in control plot.

Among the fertilizer levels the treatment B₁ (control) recorded higher value for EC and CaCO₃ higher the treatment B₃ (100 % RDF) noted significantly lower

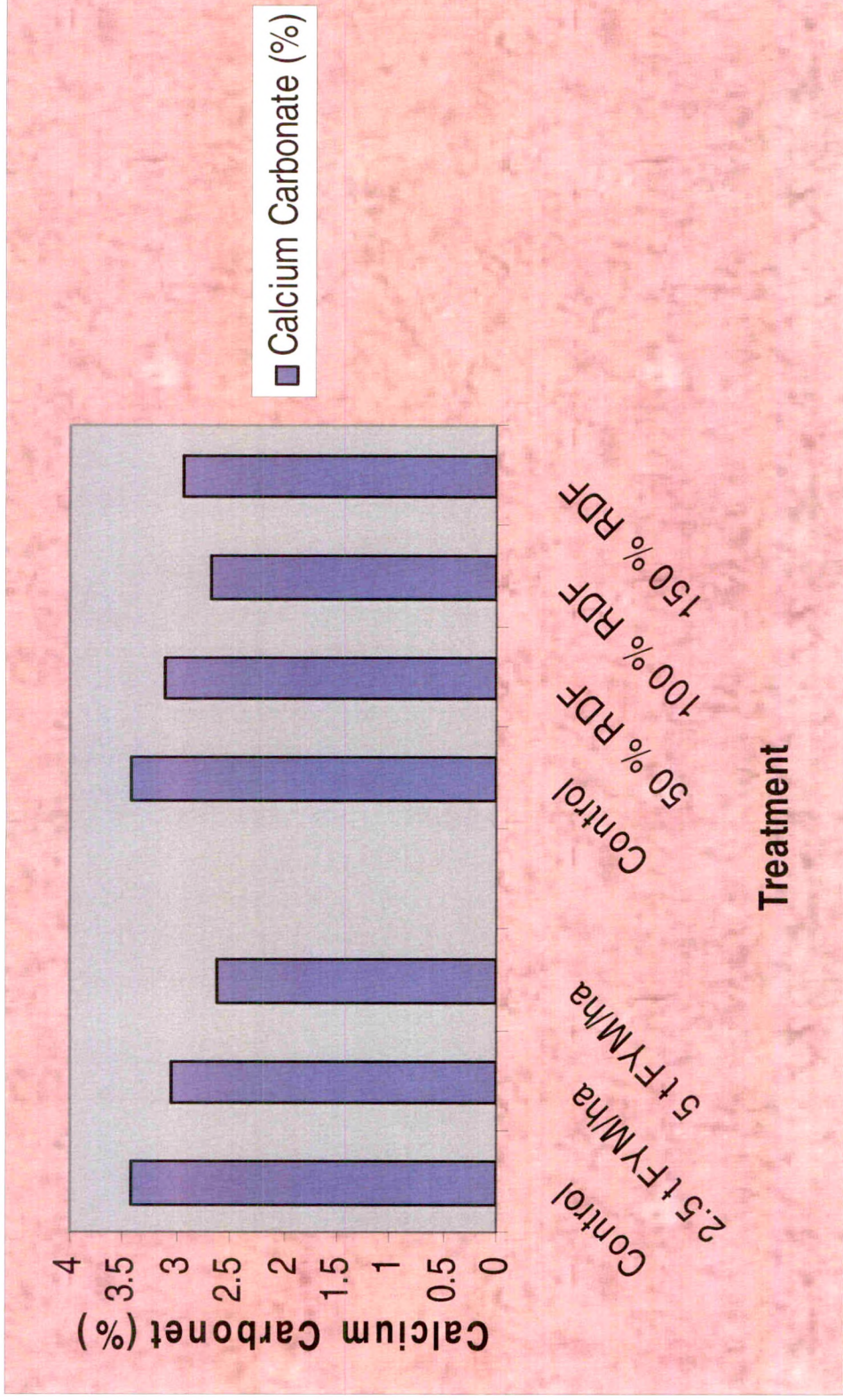


Fig. 11: Effect of different levels of FYM and fertilizer on calcium carbonate (%) in soil

values for, CaCO_3 and bulk density but it was at par with B_4 (150 % RDF). The treatment B_3 recorded significantly lowest EC but it was at par with B_2 (50 % RDF).

Further, it was observed from the data that the organic carbon contain in soil after harvest of ashwagandha increased in soil as compared in initial soil. This increase in organic carbon over initial soil might be due to application of N and leaf fall during crop growth as well as application of FYM in soil which increases the organic carbon content in soil. These results are in conformity with the results of Tiwari and Banafar (1995).

Interaction effect due FYM fertilizer levels was not reached to the levels of significance.

4.5 Effect of FYM and fertilizer levels on available N, P and K content in soil.

Available nutrients viz, N, P and K were also analyzed from representative soil samples collected from different plots after harvest of ashwagandha crop and their analytical results are presented in table 19 and depicted in fig. 12. The data on available nutrient revealed that the FYM and fertilizer levels significantly affected available N, P and K in soil.

From the different FYM levels application of 5 t FYM ha^{-1} (A_3) observed significantly higher content of available N, P and K than the rest of the treatments but it was at par with the FYM level 2.5 t FYM ha^{-1} (A_2) in case of available N only. The data further revealed that available N, P and K contains in soil was increase with increased levels of FYM. Poor fertility status was observed in control plot as compared to other treatments.

Among the fertilizer levels the treatment B_3 (100 % RDF) recorded significantly higher values for available N, P and K but it was at par with the treatment B_4 (150 % RDF) Very low available N, P and K was observed in B_1 (control) plots. Interaction effect of FYM and fertilizer levels was non significant on available N, P and K.

Table 19 Effect of FYM and fertilizer levels of available N, P and K content in soil.

Treatment	Available N (Kg ha⁻¹)	Available P (Kg ha⁻¹)	Available K (Kg ha⁻¹)
FYM levels (A)			
A ₁	193.91	24.56	304.47
A ₂	217.31	27.71	307.14
A ₃	225.23	29.77	310.48
S.E. ±	4.56	0.42	1.23
C.D. at 5 %	13.36	1.23	3.62
Fertilizer levels (B)			
B ₁	196.89	22.48	296.17
B ₂	111.70	27.54	308.45
B ₃	221.89	29.94	312.82
B ₄	218.65	29.43	312.02
S.E. ±	5.27	0.48	1.42
C.D. at 5 %	15.43	1.42	4.18
Interaction (A x B)			
S.E. ±	9.12	0.84	2.47
C.D. at 5 %	NS	NS	NS
G.M.	307.36	27.35	212.15
Initial status	188.67	21.62	292.93

Generally the availability of phosphorus in soil was increased due to application of nitrogen and phosphorus levels recorded significant effect on availability of phosphorus which released phosphorus and become available to growing crop. Application of essential nutrients in adequate amount through fertilizer to the crop helps in growing crops but also there is enhancement in the availability of nutrients in soil

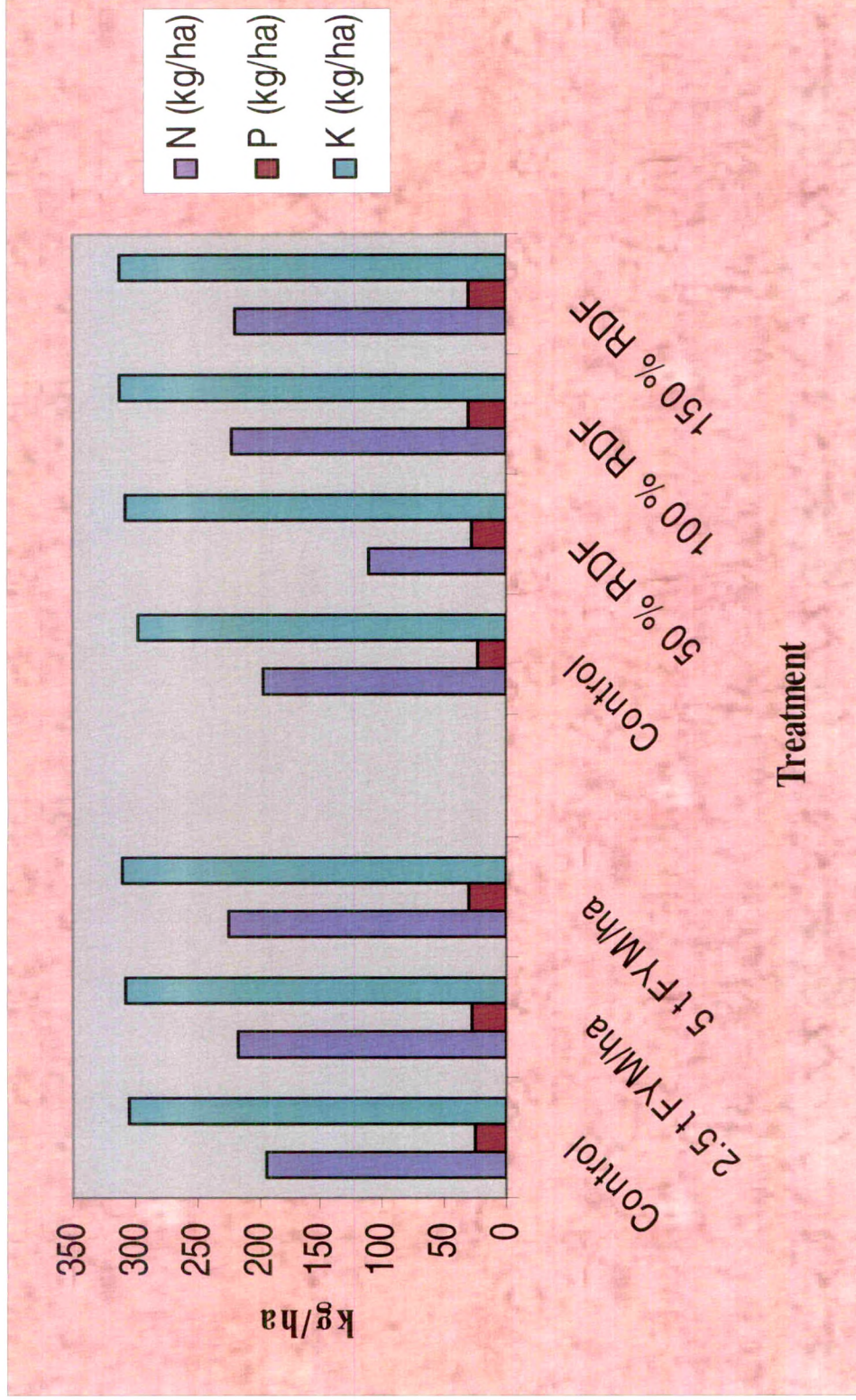


Fig. 12: Effect of different levels of FYM and fertilizer on N, P and K in soil (kg/ha)

Zhange *et al.* (1988) reported that combined use of NPK fertilizers along with organic manures improved the supply and availability of nutrients in balanced manner and resulted in better growth, higher yield and better fruit quality of tomato plant.

According to Tiwari and Banafar (1995) N application increased the post harvest soil organic carbon content and Olsen's extractable P, but P application increased only extractable P.

Subramanian and Kumarswamy (1989) concluded that available nitrogen status was highest under 100 % optimum NPK plus organic manure treatment. Results showed an appreciable build up of available N status might be due to continuous cropping with 100 % NPK plus organic manure application.

The appreciable built up in available P status in NPK plus organic manure treated plots may be attributed to the influence of organic manure in increasing available P in soil through complexing of cations like Ca^{+2} , Mg^{+2} , Fe^{+3} and Al^{+3} , which are mainly responsible for the fixation of phosphorus. This result is conformity with Kardos, (1964).

4.6 Effect of FYM and fertilizer levels on available micronutrients in soil.

In tables 20, data regarding micronutrients content in soil is presented. It was revealed from the data that the FYM as well as fertilizer levels significantly affected the micronutrients contents in soil.

From the different FYM levels, application of 5 t FYM ha^{-1} (A_3) observed significantly higher micronutrients content than the rest of treatments but it was at par with the treatment A_2 (2.5 t FYM ha^{-1}) in case of Fe and Zn content in soil. The data further revealed that micronutrients content in soil was increased with increased levels of FYM.

Among the fertilizer levels the treatment B_3 (100 % RDF) recorded significantly higher values for micronutrients content in soil but it was at par with the treatment B_4 (150 % RDF). Except B_3 (100 % RDF) was significantly superior over

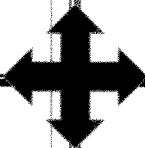
all remaining fertilizer treatment in case of Zn content. Interaction effect of FYM and fertilizer levels was non significant on micronutrient content in soil.

Due to application of FYM and fertilizers levels pH of soil tends towards the neutrality. Due to neutral pH of soil, there might be a favorable microbial activity which might leads to decomposition of organic matter resulting in release of organic acids so that this might be reason to increase in available micronutrients such as iron (Fe), zinc (Zn), manganese (Mn) and copper (Cu) in soil. The results are in agreement with the finding of Yogananda *et al.* (2004) reported that an increase in available iron, zinc, copper and manganese with the application of manures and fertilizer.

Table 20 Effect of FYM and fertilizer levels of soil available micronutrients

Treatments	Fe (mg kg⁻¹)	Mn (mg kg⁻¹)	Zn (mg kg⁻¹)	Cu (mg kg⁻¹)
FYM levels (A)				
A ₁	4.45	5.132	0.838	0.039
A ₂	4.88	5.572	0.849	0.044
A ₃	4.88	6.002	0.853	0.049
S.E. ±	0.11	0.15	0.004	0.0008
C.D. at 5 %	0.34	0.44	0.012	0.002
Fertilizer levels (B)				
B ₁	4.39	5.186	0.823	0.041
B ₂	4.69	5.541	0.844	0.043
B ₃	5.02	5.957	0.875	0.047
B ₄	4.85	5.589	0.845	0.045
S.E. ±	0.13	0.17	0.004	0.0009
C.D. at 5 %	0.40	0.51	0.014	0.002
Interaction (A x B)				
S.E. +	0.23	0.30	0.008	0.001
C.D. at 5 %	NS	NS	NS	NS
G.M.	4.742	5.568	0.847	0.044
Initial status	4.21	5.124	0.816	0.038

**SUMMARY AND
CONCLUSION**



Chapter V

SUMMARY AND CONCLUSION

Present investigation was carried out to study the effect of FYM and fertilizer levels on growth, root yield and uptake of ashwagandha. A field experiment consisting of 3 FYM levels (0, 2.5 and 5 t FYM ha⁻¹) and 4 fertilizer levels (0, 50, 100 and 150 % RDF) with 12 treatment combinations in factorial randomized block design and 3 replication was conducted at Research Farm, College of Agriculture, Latur. The results pertaining to growth, root yield, nutrient concentration and uptake of nutrients along with soil properties have been summarized in the present chapter.

5.1 Growth

Among the FYM treatment application of 5 t FYM ha⁻¹ was found significantly superior over rest of the FYM levels in case of plant height, number of branches, leaf area, and 50 % flowering. Similar results were observed in case of dry matter production of ashwagandha.

Application of 150 % RDF to ashwagandha recorded significantly higher plant height, number of leaves, number of branches, leaf area, 50 % flowering over rest of fertilizer treatment at all the crop growth stages except at 30 DAT. However it was at par with the treatment 100 % RDF. The treatment 100 % RDF produced maximum dry matter production than the other treatment.

5.2 Seed yield

From different levels the treatment A₃ (5 t FYM ha⁻¹) produced maximum seed yield (395.58 Kg ha⁻¹), 1000 seed weight (9.13g) and number of berries per plant (142.54), than the lower levels of FYM.

Among various levels of fertilizer significantly higher seed yield (363.02 Kg ha⁻¹ and 1.21 g plant⁻¹), and number of berries per plant (142.02) was observed due to 100 % RDF.

5.3 Root yield

Use of 5 t FYM ha⁻¹ to ashwagandha recorded maximum fresh root weight (1983 Kg ha⁻¹), dry root weight (1310.5 Kg ha⁻¹), root length (7.36 cm) and root diameter (1.33 cm).

Significantly higher fresh root weight (1730 Kg ha⁻¹), dry root weight (1209.3 Kg ha⁻¹), root length (7.63 cm) and root diameter (1.11 cm) were recorded with the treatment 100 % RDF than the all other fertilizer levels.

5.4 Nutrient uptake

The uptake of nutrients viz., N (61.14 Kg ha⁻¹), P (11.37 Kg ha⁻¹) and K (60.96 Kg ha⁻¹) by ashwagandha was significantly higher due to application of 5 t FYM ha⁻¹ in comparison to lower levels of FYM.

Similarly, N (51.55 Kg ha⁻¹), P (10.08 Kg ha⁻¹) and K (53.20 Kg ha⁻¹) uptake by ashwagandha was maximum with 100 % RDF and it was decreased with further increased levels of fertilizer.

5.5 Soil properties

After harvest of ashwagandha crop the pH (8.15), EC (0.145dS m⁻¹), CaCO₃ (2.62 %) and bulk density (1.04 gm cm⁻³) of soil was decreased with increased levels of FYM. Whereas organic carbon (0.66 %) content of soil was increased with increased levels of FYM. It was maximum due to application of 5 t FYM ha⁻¹.

5.6 Nutrient content in soil

Residual effect of ashwagandha on N (225.23 Kg ha⁻¹), P (29.77 Kg ha⁻¹) and K (9310.48 Kg ha⁻¹) content in soil was increased with increased levels of FYM. Micronutrients status of experimental soil was also improved due to application of FYM.

Application of 100 % RDF (25:25:20 NPK kg ha⁻¹) to ashwagandha improved the fertility status of soil by increasing N (221.89 Kg ha⁻¹), P (29.94 Kg ha⁻¹) and K (312.82 Kg ha⁻¹) content in soil. Micronutrients content in soil after harvest of ashwagandha crop were decreased significantly.

Conclusion:

From the results summarized above following conclusions are drawn.

- 1) All the growth parameter of ashwagandha were improved with the application of 100 % RDF (25:25:20 NPK Kg ha⁻¹) and 5 t FYM ha⁻¹.
- 2) For achieving higher shoot and root yield, ashwagandha crop should be fertilized with 5 t FYM ha⁻¹ + 25:25:20 NPK Kg ha⁻¹.
- 3) Application of 5 t FYM ha⁻¹ along with 100 % RDF (25:25:20 NPK Kg ha⁻¹) improved seed and root characters in ashwagandha.
- 4) Use of 5 t FYM ha⁻¹ with 100 % RDF (25:25:20 NPK Kg ha⁻¹) increased N, P and K content as well as their uptake by ashwagandha.
- 5) Application of 5 t FYM along with 100 % RDF to ashwagandha improved the fertility status of soil after harvest of crop.

LITERATURE CITED



LITERATURE CITED

- Abusalecha and Shanmugavelu (1988). Studies on the of organic Vs inorganic source of nitrogen on growth, yield and quality of okra (*Abelmoschus esculentus* L.). *Indian J. Hort.*, **48**: 312-318.
- Acharya, C.N. and Rajagopalan, K. (1956). *J. Indian Soc. Soil Sci.*, **4** : 111.
- Aishwath, O.P. (2004). Mineral nutrition and growth of *Withania somnifera.*, *J. Trop. Med. Pl.*, **5**:111-118 .
- Ajay Chauhan and Vijay Kumar (2007). Effect of graded levels of nitrogen and VAM on growth and flowering in calendula (*Calendula officinalis* Linn.). *J. Ornam. Hort.*, **10**(1) : 61-63.
- Ajay, Ramesh, P., Reddy, K.S., Ramana, S. and Maj, B. (2005). Effect of nitrogen and farm yard manures on physiological parameters on ashwagandha (*Withania somnifera*) under vertisol soil types. *Indian J. Pl. Physiology.*, **10**(4): 389-393.
- Annonuriva, M.A., Rozyeva, M. Tailqkov and Slavinskaya (1992). Effect of fertilizers on some physiological process and fruit quality in tomato. *Lzvestiya Akademij Nauk Tukenistana seriya Bioloccheskikh Nauk*, **3**: 49-52.
- Anonymous (1995). Nityapayogi aushadhi va sughandhi vanaspati. Publication of Directorate of Extension Education, Dr. Punjabrao Krishi Vidhyapeeth, Akola., Page 19-21.
- Anonymous (1998). Effect on soil fertility levels on yield of ashwagandha. Annual report of National Research centre for Medicinal and Aromatic Plants Boriavi Anand. Gujrat.:159-162.
- Anonymous. (2009). planning.up.nic.in/innovations/inno3/ma/ashwagandha.htm.
- Avtar Singh, yadav, A.C., Mehla, C.P., Jape Singh and Singh, V.P. (2006). Response of coriander to irrigation and nitrogen levels. *Hariyana J. Hort. Sci.*, **35** (3/4) : 312.
- Aykroyd, W.R. (1963). Composition of tomato fruit. *JCMR Special Series.* : **42**.

- Baboo, R and Rana, N.S. (1995). Effect of cutting management, nitrogen and phosphorus on growth and yield of coriander (*Coriandrum sativum*). *Indian J. Agron.*, **40** (2) : 253-255.
- Barman, D and Pal, P. (1994). Effect of nitrogen and phosphorus on seed yield in calendula (*Calendula officinalis*). *Orissa J. Agric. Res.*, **7**(1/2): 17-21.
- Bammi, R.K. and Gangadhar Rao, G. (1982). Cultivation of *Micuna pruriens*. In cultivation and utilization of medicinal plants (C.K. Atal and B.N Kapoor, ed.) CSRI, Jammu-Tawi. PP. 447-449.
- Barekar, N.N., (2000). Effect of integrated nutrient management on growth and yield of chilli (*Capsium annum* L.) M. Sc. (Agri.) Thesis, Dr. PDKV, Akola (M.S.)
- Beresniewicz, A., Nowosielski, O. and Radzikowska A. (1986). Effect of increasing levels of mineral fertilizers with simultaneous application of organic fertilizers and liming on vegetable yield and soil salinity part IV, *Tomatoes Biuletyn Warzwnictwa*. **29**: 125-138.
- Biswas, T.D., Pharande, K.S. and Naskar, G.C. (1967). *J. Indian Soc. Soil Sci.*, **15** : 289.
- Blake, G. R., Hartge, K. H. (1986): Bulk Density. Methods of Soil Analysis, Part 1, *Soil Sci. Soc. America.*, 363-376, Madison, WI, USA.
- Cerna, K. (1981). Effect of fertilizers application on capsicum growth, *vedecke prace vyskumneho asl achtitel sheke Ustva Zeleniny a specialnych plodin V. Hurbanove*. (2): 17-27.
- Challa, O., Gajbhiye, K.S. and Velayutham M. (1997). *Soil series of Maharashtra*, NBSS. PP:177
- Chauhan, D.D, Singh, K. and Singh, H.B. (2000). Response of palmarosa (*Cymbopogon martini* var. Motia) to N and P fertilization in Uttar Pradesh foot hills of Himalayas. *Indian Perfumer*, **44** (2) : 61-64.
- Chavan, P.J., Syed Ismail, Rudrahsha, G.B., Malewar, G.U. and Baig, M.I. (1997). Effect of various nitrogen levels through FYM and urea on yield, uptake of nutrient and ascorbic acid content in chilli (*Capsicum annum* L.). *J. Indian Soc. Soil Sci.*, **45** ; 833-835.

- Chezhiyan, N, Sarawathy, S. and Vasumathi, R. (2000). Studies on organic manures, biofertilizers and plant density on growth, yield and alkaloid content of bhumyamalaki (*Phyllanthus amarus*). *J. South Indian Hort.*, **51** (1/6) : 96-101.
- Chidambara, S. (1999). Siddha system of life. **4** (7) : 1-4.
- Dahatonde, B.N., Joshi, B.G., and Vitkare, D.G., (1983). Studied on the response of Nitrogen fertilizer in the root yield of the ashwagandha (*Withania somnifera*) *P. K. V. Res. J.*, **7(1)**: 3-7.
- Dhage, V.J., Patil, J.B. and Barve U.V.(2008). Response of different row spacing and nutrient management on yield characters of ashwagandha (*Withania somnifera* Dunal), *Ann. Pl. Physiol.*, **22** (2): 186-188.
- Dixit, S.P. (1997). Effect of nitrogen and farm yard manure on the productivity of cabbage in dry temperate high hill zone of Himachal Pradesh. *Ann. Agric. Res.*, **18(2)**: 258-261.
- Doikova, M. (1978). *Hort. Abstrs.*, **48** : 498, No. 5612.
- Elwell, E.T. and Gridley, P. (1967). Atomic Absorption Spectrophotometer. pergamon press Ltd. London.
- Fugro, P.A. (1996). Role of organic pesticides and manures in management of some important chilli disease. *J. Myco. Pl. Pathl.*, **30(1)**: 96-97.
- Gagnon, B. and Berrouard, S. (1994). Effect of several organic fertilizers on growth of greenhouse tomato transplants. *Canadian J. Pl. Sci.*, **74(1)**: 167-168.
- Gajbe, M.V., Lande, M.G. and Varade, S.B. (1975). Soils of Maharashtra. *J. Maharashtra Agric. Univ.*, **2** (6): 55-59.
- Gezerel, O. and Donmez, F. (1988). The effect of slow release fertilizers on yield and fruit quality of vegetable crop growing in the Mediterranean areas of Turkey. *Acta. Hort.*, **22** : 63-69.
- Gupta, R. (1967). Medicinal and Aromatic plants. Handbook of Agriculture (3rd Ed) ICAR, New Delhi, 1192-1193.
- Haprbol Singh, Sharma, O.L. and Pakesh Kumar (1996). Economics of nitrogen and phosphorus fertilization in Isabgol (*Plantago ovata* Forsk). *Crop Res.*, **11(2)**: 246-247.

- Jackson, M.L. (1973). Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi.
- Jain, P.M., Gaur, B.L. and Gupta, P.C. (1990). Response of opium poppy varieties to nitrogen. *Indian J. Agron.*, **35**(3): 243-245.
- Jain, P.M. (1990). Effect of phosphorus and potassium on yield of opium poppy. *Indian J. Agron.*, **35**(3): 238-239.
- Joshi, B.G., Gupta, R., Kakade, J.R. and Dahatonde B.N. (1984) Investigation medicinal properties of *Withania somnifera*. Paper presented at 4th All India Seminar on Medicinal and Aromatic Plant at Madurai., 31st Aug. to 3rd Sept. 1981.
- Jose Darley, Shanmugavelu, K.G. and Thamburaj, S. (1988). Studies on efficiency of organic v/s inorganic form of nitrogen in brinjal. *Indian J. Hort.*, **45**(1-2): 100-103.
- Kahar, L.S., Tomar, S.S. and Pathan. (1994). Effect of plant population, varieties and fertility levels on dry root yield of asgand. 10th All Indian coordinated research project on medicinal and aromatic plants. (Jan 17- 20) 1994.
- Kahar, L.S. and Nigam, K.B. (1990). Response of opium poppy (*Papaver somniferum*) to phosphorus and potassium. *Indian J. Agric. Sci.*, **60** (6): 417-418.
- Kaminwar, S.P. and Rajagopal, V. (1993). *Ferti. News*, **38** (7) :21.
- Kardava, M.A., Tsitsistiviti, G.V., Andronikashivilli, T.G., Kovalchuk, M.A. and Oniani, C.G. (1986). Some economic consideration of using of organo-zeolite, fertilizers in vegetable cultivation *Izvestiya Akademi nauk Gruzinskoi SSR khimicheskaya*, **12929** :133-136.
- Kardos, L.T. (1964). *Chemistry of Soil* (F.E. Bear, Ed.), Reinhold Publishing Corporation, New York, p. 369.
- Kaushal, S.K., Kumar, S., and Upadhyay, R.G. (2002). Response of Nitrogen and Phosphorus on growth development and seed yield of the Ashwagandha (*Withania somnifera*) under mid-hill condition of H. P. *Res. on Crops*, **3**(2) :376-379.

- Kaushal, S.K., Mardiyada and Usha-Rana. (2006). Response of Nitrogenous fertilizers and pruning on the regulation on Photosynthesis partitioning in Ashwagandha (*Withania somnifera* L.) *International J. Pl. Sci.*, **1**(2): 147-149.
- Kharbade, S.H. and Gaikwad, C.B. (2008). Nutrient management in seena (*Cassia angustifolia*) isabgol (*Plantago ovata*) cropping sequences. *J. Maharashtra Agric. Uni.*, **33** (2): 181-183.
- Kharwara, P.C., Awasthi, O.P and Singh, C.M. (1988). Effect of sowing dates, nitrogen and phosphorus levels on yield and quality of Opium poppy. *Indian J. Agron.*, **33**(2): 159-163.
- Kiruthikadevi, V. (2002). Nutritional studies on root yield and quality of ashwagandha (*Withania somnifera* Dunal). M. Sc. thesis, Periyakulam, Tamil Nadu Agricultural University.
- Kubsad, V.S., Palled, Y.B. and Mansur, C.P. (2009). Effect of spacing and fertilizer levels on physiological parameters in relation to productivity of ashwagandha (*Withania somnifera*). *Indian J. Agric. Sci.*, **79**(7) : 501- 505.
- Kulmi, G.S., and Tiwari, P.N.(2006). Integrated Nutrient management in asgandh (*Withania somnifera*). *Res. on Crops*, **7**(3) : 895-899.
- Kumar, T.S, Swaminathan, V., Sadasakthi, A. and Balasubramanian, R. (2006). Influence of nitrogen and phosphorus alonge with biofertilizers on yield, constituents of essential oil and soil available nutrients of davana (*Artemisia pallens*). *J. Med. Arom. Pl. Sci.*, **28**(2): 182-186.
- Kumaran, S., Natarajans, S. and Thamburaj, S. (1998). Effect of organic and inorganic fertilizer on growth yield and quality of tomato. *South Indian Hort.*, **46** (3-4): 203-205.
- Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA soil test for Zn, Fe, Mn, and Cu. *Soil. Sci. Soc. America. J.*, **42** : 421-428
- Lopez Camelo, heredia, O.S. and Gil, A. (1995). Nitrogen, phosphorus and potassium accumulation in coriander (*Coriandrum sativum*). *J. Herbs Spices Med. Pl.*, **3**(4): 35-40.

- Mahajan, R.S. (1998). Seed yield, seed quality of Isabgol (*Plantago ovata* Forsk) as influenced by sowing methods, seed rates and nitrogen levels. M. Sc. (Agri.) thesis submitted to MPKV, Rahuri.
- Maheshwari, S.K., Sharma, R.K. and Gangrade, S.K. (2000). Response of Ashwagandha (*Withania somnifera*) to organic manures and fertilizers in a shallow black soil under rainfed condition. *Indian J. Agron.*, 45 (1) : 214-216.
- Maheshwari, S.K., Sharma, R.K. and Gagurde. S.K. (1998). Response of asgand to manures in verisol (rainfed) 12th India workshop at CCS Haryana Agril. Uni. Hissar, (Oct. 27-30) 1998.
- Maithani, B.P. (1973). Medicinal plants of western Garhwal. *Khadi Gramodyog* 19 : 269-278.
- Maitra, S., Janab, K. and Debnath, S. (1998). Response of plant nutrient on growth and alkaloid content of Ashwagandha (*Withania somnifera*). *J. Interacademia*, 2(4):243-246.
- Mann, P.S. and Vyas, A.K. (1999). Effect of date of sowing and nitrogen levels on growth and nutrient uptake by Isabgol (*Plantago ovata*). *Ann. Agric. Res.*, 20(4): 517-518.
- Mallangouda, B., Sulikeri, G.S., Hulamani, N.C., Murthy, B.G. and Madageri, B.B. (1995). Effect of NPK and FYM on growth parameters of onions, garlic and coriander. *Current Res. Uni. Agric. Sci.*, 24 (11) : 212-213.
- Maryada, Kaushal, S.K. and Kaistha, B.T. (2001). Response of Ashwagandha (*Withania somnifera*) to Nitrogen fertilizer under mid-hill conditions of H.P. *Himachal J. Agric. Res.*, 27 (1/2) : 77-80.
- Moral , R. and Nevarro, J.N. (1996). Tomato fruits yield and quality are affected by organic and inorganic fertilization and cadmium pollution. *J. Pl. Nutrient*, 1493-1498.
- Muthumanickam, D. and Balakrishnamurthy, G. (1999). Studies on nutritional requirement for the Ashwagandha (*Withania somnifera*) in shevory hills of Tamil Nadu, India. *J. Spices and Aroma. Crops*, 8 (2) : 179-183.

- Muthumanickam, D., Murugesan and Sumaiyah. (2002). Effect of different Phosphorus sources and amendments on quality of the Ashwagandha (*Withania somnifera*) under acid soils. *J. Spices and Aroma. Crops*, **11**(2) : 118-121.
- Nair, M. and Peter, K.V. (1990). *Veg. Sci.*, **17** 710.
- Nanthakumar, S. and Veeraragavathatham, D. (1999). Effect of integrated nutrients management on yield and yield attributes of brinjal (*Solanum melongena*) cv. PLR-1. *South Indian Hort.*, **47**(1-6):42-48.
- Nigam, K.B. (1984). Ashwagandha cultivation. *Indian Hort.*, **28** (4) : 39-41.
- Panchbhai, D.M., Bachkar, B.R., Deokar, P.L. and Wankhede, S.G. (2006) Effect of Nitrogen and Phosphorus on root yield and quality of Ashwagandha (*Withania somnifera*). *Advances in Pl. Sci.*, **19**(1): 89-92.
- Panse, V.G., and Sukhatme, P.V., (1967). Statistical Methods for Agricultural Workers. 2nd Edn. IARI, New Delhi.
- Pareek, S.K., Maheshwari, M.L., Singh, K.D. and Gupta, R. (1983). Nutrient Uptake and dry matter production of palmarosa oil grass under different levels of N, P and k fertilizers. *Intr. J. Trop. Agric.*, **1**(3) : 203-209.
- Pareek, S.K. and Maheshwari, M.L. (1995). Effect of nitrogen vis-à-vis irrigation and weed management in palmarosa cultivation in Indai. *Indian Perfumer*, **39** (1) :19-25.
- Patel, D.H. and Bapna, J.S. (1993). Annual report AICRP on Medicinal and Aromatic Plants: 37-40.
- Patel, D. H., Upadhyay, P.N., Patel, K.V., Patel, J.B. and Patel, K.B. (2004) Effect of methods of Sowing, time of harvesting and Nitrogen on dry root yield of Ashwagandha (*Withania somnifera*). *J. Med. Aroma. Pl. Sci.*, **26**(2): 288-293.
- Patra, D.D., Singh, K. Misra, H.O., Gupta, A.K., Singh, J., Singh, S.C. and Khanuja, S.P.S. (2004). Agro technologies of ashwagandha (*Withania somnifera*) *J. Med. Arom. Pl. Sci.*, **26**: 332-335
- Pawar, V.N. (2000). Seed yield, seed quality as influenced by plant density and fertilizers levels in ashwagandha. M. Sc. Thesis submitted to MPKV, Rahuri: 53-54.

- Pawar, P.M. Naik, D.M., Damodhar, V.P., Shinde, V.N. and Bhalerao, R.V. (2007). Influence of graded levels of spacing and nitrogen on growth and yield of coriander (*Coriandrum sativum*). *Asian J. Hort.*, **2**(1) : 58-60.
- Piper, C.S. (1966). Soil and plant analysis. Hans publication Bombay.
- Piven, P.Y., Grishkevich, M.I., Koryagina, C.A., Mikhailovskaya, N.A. and Moroz, G.V. (1987). The influence of fertilizers on the productivity of vegetable crop in a rotation and on biological activity of droropozolisoil. *Agron. Khimija*, **2** :49-53.
- Prasad, S.V.K. (2002). Effect of nitrogenous fertilizers on the yield of opium poppy and seed in opium poppy crop. *J. Phytological Res.*, **15**(1): 77-80.
- Puri, B.N. (1930). A new method for estimating total carbonate in soil. *Imp. Agric. Pusa. Bull.* 206, pp. 7
- Puttanna, K., Rao, E.V.S.P., Chandrashekara, R.S. and Rao, R.S.G. (2005). Organic and inorganic nutrition for *W. somnifera*. *J Trop. Med. Pl.*, **6**(2) : 215-219.
- Rajeswara Rao, B.R., Singh, K., Kaul, P.N., Bhattacharya, A.K. and Singh, K. (1990). Response of palmarosa (*Cymbopogon martinii*) to plant spacing and fertilizer application. *International J. Trop. Agric.*, **8** (3) : 177-183.
- Ram, P., Patra, N.K., Kumar, B., Verma, R.S. and Srivastava, N. (2003). Integrated nutrient management in rose scented geranium (*Pelargonium graveolens*) under tarai condition of Uttranchal. *J. Med. Arom. Pl. Sci.*, **25** : 50-53.
- Ramesh, M.N., Farouqi, A.A. and Thilak Subbaiah. (1989). Influence of sowing date and nutrients on growth and yield of Isabgol (*Plantago ovata*). *Crop Res. Hisar.* **2**(2): 169 s-174.
- Rao, E.V.S.P., Narayana, M.R. and Rao, B.R.R. (1997). The effect of nitrogen and farm yard manure on yield and nutrient uptake in davana (*Artemisia pallens*). *J. Med. Arom. Pl. Sci.*, **5**(2): 39-48.
- Roxburgh, W. (1874). Flora Indica (Carey's edition), London.
- Sarkar, D., Bandopadhyaya, A. and Pal, P. (1991). Effect of different levels of nitrogen and phosphorus on growth and yield of *Calendula officinalis* var. Lemon Queen. *Hort. J.*, **4** (1):57-60.

- Sharma, M.P., Ahmad, J., Hussain, A. and Khan, S. (1992). Folklore medicinal plants of Mewat (Gurgaon district), Hariyana, India. *Int. Pharmacognosy*, **30** : 129-134.
- Shelke, S.R. Adsule, R.N. and Amrutsagar, V.M. (1999). *J. Maharashtra Agric. Univ.*, **24** : 297-298.
- Shelke, S.R. Adsule, R.N. and Amrutsagar, V.M. (2001). Effect of conjunctive use of organic sources with urea fertilizer on soil chemical properties, yield and quality of brinjal. *J. Indian Soc. Soil Sci.*, **49** : 506-508.
- Sharma, R.N. and Prasad, R. (1990). Nitrogen and irrigation requirement of fennel. *Indian J. Agron.*, **35**(4): 449-451.
- Sharma, S.N., Singh, A. and Tripathi, R.S (1980). Response of palmarosa to nitrogen, phosphorus, potassium and zinc. *Indian J. Agric. Sci.*, **25** (4) : 719-723.
- Shashidharan, G.B., Basavaraja, R.K., Basavarajappa, R., Jagadeesha, R.C. and Nadagouda, V.B. (1998). Water and nutrient management for sustainable production and quality of spices; proceedings of the national seminar, Madikeri Karnataka, 5-6 october, 59-61.
- Shetty, S., Farooqi, A.A. and Subbaiah, T.K. (1990). Effect of nitrogen, phosphorus and potassium on herbage and alkaloid content in *Datura stramonium*. *Crop Res. Hisar*, **3**(2) : 294-298.
- Singh, M., and Naeem, M. (2004). Effect of Phosphorus application on the Ashwagandha (*Withania somnifera*) *Bionotes*, **6**(4) :103
- Singh, M., Naeem, M., and Khan M.N. (2005). Physiomorphological response of *Withania somnifera* as affected by Nitrogen fertilizers. *Advances in Pl. Sci.*, **18**(2) : 669-673.
- Singh, P., Jain, K.K. and Sharma, S.K. (2003). Effect of sowing dates and nitrogen levels on nutrients uptake and quality of Isabgol (*Plantago ovata*). *Ann. Agric. Res.*, **24**(1): 197-199.
- Singh, V. and Pandey, R.P. (1980). Medicinal plant Lore of the tribals of Eastern Rajasthan (India). *J. Res. Ind. Med. Yoga and Homoeo.*, **14** : 49-54.
- Solanki, N.S., Sharma, O.L. and Subu, M.P. (1999). Phosphorus management in Opium poppy (*Papaver somniferum*) based on cropping system. *Indian J. Agron.*, **44** (3): 499-503.

- Solanki, N.S. and Shaktwar, R.P.S. (1999). Effect of date of sowing and nitrogen on growth and yield of Isabgol (*Plantago ovata*). *Crop Res. Agric. Sci.*, **2**(2): 169-174.
- Somani, L.L. (1990). Availability and crop utilization of phosphorus in a saline alkali soil amended with inorganic and organic materials. *Acta Agronomia Hungarica*. **39** (3-4): 210- 218.
- Subbiah, B.V. and Asija, A.L. (1956). A rapid procedure for the determination of available nitrogen in soils *Current Sci.*, **25** : 259-260.
- Subramanian, K.S. and Kumaraswamy, K. (1989). Effect of continuous cropping and fertilization on chemical properties of soil. *J. Indian Soc. Soil Sci.*, **37** : 171-173.
- Swarupa Utgikar, Sadawarte, S.T. and Wankhede, S.G. (2003). Growth and yield of Isabgol (*Plantago ovata*) as influenced by nitrogen and phosphorus levels. *Agric. Sci. Digest*, **23**(1): 77-78.
- Tiwari, R.J. and Banafer, R.N.S. (1995). Effect of nitrogen and phosphorus on seed yield and essential oil of coriander (*Coriandrum sativum*). *Indian Cocoa Arecanut and Spices J.*, **19**(2): 253-255.
- Walkey, A. J. and Black, I.A. (1934). Method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.*, **37** : 29-38.
- Wankhede, R., Khode, P.P, Wanjari, S.S, Paturde, J.T and Kale, M.R. (2005). Response of Isabgol (*Plantago ovata*) to nitrogen and phosphorus. *Agric. Sci. Digest*, **25**(2): 121-123.
- Waranke, D.D. and Barber, S.P. (1974). Root development and nutrient uptake by corn grown in solution culture. *Agron. J.*, **66** : 544.
- Yoganda, S.R., Reddy, V.C. and Sudhir, K. (2004). Effect of urban compost and inorganic fertilizers on soil nutrient status and grain yield of hybrid rice. *Mysore J. Agric. Sci.*, **38** (4) : 454-458.
- Zhange C.L. (1988). *J. Soil Sci.*, **19** : 276-278.

**Department of Soil Science and Agricultural Chemistry,
College of Agriculture, Latur**

**Research Title: Effect of FYM, N, P and K Levels on Growth, Uptake of
Nutrients and Root Yield of Ashwagandha (*Withania
somnifera*).**

Name of Guide: Dr. V.G. Takankhar Name of Student : R.V. Gawande
Programme coordinator, KVK, Tuljapur Reg. No. : 41ML/2009A

ABSTRACT

Experiment was conducted in *Kharif* season during the year 2010-2011 on fine texture Vertisols at Research Farm, College of Agriculture, Latur. The experiment was laid in Factorial Randomized Block Design with 3 replications and twelve treatments. The experiment consist of 3 levels of FYM (0, 2.5 and 5.0 t FYM ha⁻¹) and 4 levels of fertilizer (0, 50, 100 and 150% RDF).

The results of field experiment revealed that the all growth and yield contributing characters of ashwagandha were significantly increased with increased levels of FYM. However incase of fertilizer levels it was increased up to 100 % RDF.

Application of 5 t FYM ha⁻¹ along with 100 % RDF recorded significantly higher plant height, no. of braches per plant, no. of leaves, and leaf area of ashwagandha. Similar trend was observed in case of yield contributing characters. Among the FYM and fertilizer levels significant increase in seed yield and dry matter production in ashwagandha was observed due to 5 t FYM ha⁻¹ as well as 100 % RDF.

Nutrient content and uptake of nutrients was also increased with increased levels of FYM and fertilizer. N, P and K content in plant and their uptake was significantly increased due to application of 5 t FYM ha⁻¹ along with 100 % RDF.

Soil properties and available nutrients status of experimental soil was improved due to residual effect of ashwagandha. After harvest of crop, fertility status of soil was increased with increased levels of FYM and fertilizer. Under rainfed conditions of Marathwada, for achieving higher yields of medicinally important parts of ashwagandha plant *viz.* root and shoot, the crop should be fertilized with 5 t FYM ha⁻¹ and 100 % RDF (25:25:20 Kg ha⁻¹).
