MANAGEMENT OF POWDERY MILDEW OF ROSE UNDER POLYHOUSE CONDITION

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI-413 722, DIST: AHMEDNAGAR
MAHARASHTRA (INDIA)

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

PLANT PATHOLOGY

By

UDAWANT SHILPA NANDKISHOR
Reg. No. 01216

DEPARTMENT OF PLANT PATHOLOGY,
COLLEGE OF AGRICULTURE,
PUNE 411 005
MAHARASHTRA (INDIA)

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Approved by

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DEPARTMENT OF PLANT PATHOLOGY,
COLLEGE OF AGRICULTURE,
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MAHARASHTRA (INDIA)
2003

CANDIDATE'S DECLARATION

I hereby declare that this thesis entitled **"Management of powdery mildew of rose under polyhouse condition"**, or part there of has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma.

Place : Pune

Date : २५ / ०६ / 2003

(Shilpa N. Udawant)

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Chairman and Research Guide,
Professor of Plant Pathology,
College of Agriculture, Pune - 5,
Maharashtra State, India.

CERTIFICATE

This is to certify that the thesis entitled, "**MANAGEMENT OF POWDERY MILDEW OF ROSE UNDER POLYHOUSE CONDITION**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT PATHOLOGY**, embodies the results of a piece of *bonafide* research work carried out by **MISS SHILPA NANDKISHOR UDAWANT**, under my guidance and supervision, and that no part of the thesis has been submitted for any other Degree or Diploma.

The assistance and the help received during the course of this investigation have been acknowledged.

Place : Pune
Date: 25/ 6 / 2003

(N. B. Pawar)
Chairman, Research Guide

Dr. R. V. Wuike
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CERTIFICATE

This is to certify that the thesis entitled, **"MANAGEMENT OF POWDERY MILDEW OF ROSE UNDER POLYHOUSE CONDITION"**, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **PLANT PATHOLOGY**, embodies the results of a piece of *bonafide* research work carried out by **MISS SHILPA NANDKISHOR UDAWANT**, under the guidance and supervision of **Dr. N. B. PAWAR**, Professor of Plant Pathology, College of Agriculture, Pune-5 and no part of the thesis has been submitted for any other degree or diploma.

Place : Pune

Dated : 30 / 6 / 2003

(R. V. Wuike)

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Place- Pune

Date-25/06/2003

SNUdawant

(Udawant S.N.)

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LIST OF ABBREVIATIONS

@	At the rate of
C. D.	Critical difference
cm	centimeter (s)
et al.	*et alli* (and others)
etc	and so forth
Fig.	Figure
ha	hectare
kg	kilogram
mm	Millimeter
μ	Micron
No.	Number
pp	Pertaining page (s)
S.E.	Standard Error
Sp.	Species
Viz.,	Videlicet (namely)
^{0}C	Degree Celsius
WP	Wettable powder
%	per cent

ABSTRACT

"MANAGEMENT OF POWDERY MILDEW OF ROSE UNDER POLYHOUSE CONDITION "

By

UDAWANT SHILPA NANDKISHOR

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

PLANT PATHOLOGY

2003

Research Guide	**: Dr. N. B. Pawar**
Department	**: Plant Pathology**

The present investigation entitled "Management of powdery mildew of rose under polyhouse condition", was conducted at Department of Plant Pathology and Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune, during August, 2002 to March, 2003.

The studies were undertaken with a view, to evaluate the effect of newer fungicides and biocontrol agents in management of powdery mildew of roses, their effect on yield and quality of flowers and also to know the most effective and economical management schedule to control powdery mildew of roses.

The experiment was laid out in the Randomized Block Design with thirteen treatments. The results revealed that Difencanozole (0.05%) was the most effective, followed by Carbendazim (0.05%), Penconazole (0.05%), Hexaconazole (0.05%) and Wettable Sulphur (0.07%).

The bio-control agents *viz., Trichcderma viride* (0.2%) and *Trichoderma harzanium* were also observed to control the disease up to the extent of 70.27 and 71.58 per cent, respectively. The garlic cloves extract could not exhibit significant effectiveness in controlling the disease as compared to fungicides and bioagents. The quality parameters *viz.,* length of shoot and diameter of flower bud were also observed to be significantly influenced by different treatments indicating impressing the marketing value of the rose flowers.

The yield of flowers per plant and per square meter were also significantly increased by different treatments. The highest flower yield could be realized in of Carbendazim treatment followed by Difencanozole, Penconazole and Hexaconazole.

The aforesaid discussions indicated that the fungicides, Carbendazim (0.05%), Wettable Sulphur (0.05%), Difencanozole (0.05%), Penconazole (0.05%) and Hexaconazole (0.05%) were found to be the most effective and economical.

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INTRODUCTION

1. INTRODUCTION

Rose is one of the nature's beautiful creations and is universally acclaimed as "King of Flowers". No other flower is a better symbol of love, adoration, innocence and other virtues than the rose and not in our time only, but so, it has been for thousands of years. It is said that rose came first and man afterward. Fossils of the rose found in Oregon and Colorado (USA) are estimated to be more than thirty million years old. The history of man and rose is linked together for about 5000 years (Dhua, 1999).

The rose, because of its utility occupies a pre-eminent place amongst the flower crops and is one of the oldest fragrant flowers to be cultivated by man. Its different types having beautiful flowers of exquisite shape, different sizes, bewitching colours and most delightful fragrance has made it an important flower for its varied uses.

Ancestors of modern roses are the wild roses that grow over wide areas in the world. There are about 120 identified and documented species under genus *Rosa.* The rose is an ornamental shrub with upright or climbing stems, usually prickly, the leaves are alternate, compound and oddly pinnate with stipules adherent to the leaf stalks. Flowers are solitary or in corymbs. Calyx is five lobed, lobes either simple or compound and inserted at the top of a roundish or pear shaped fleshy thalamus, petals and sepals are generally five, but more petals are seen in commercial cultivars due to transformation of stamens.

The commercial importance of flowers has been realized throughout the world. The huge demand for flowers has led to growing market that with the passage of time has turned into an industry. The international floriculture trade is estimated to be 40 billion dollars

(Rs.1,25,000 crores) of which cut flowers account for nearly 60 per cent i.e. 25 billion US dollars (Rs. 80,000 crores) (Prasad *et al.,* 2000). Rose is the most preferred flower in the international market. The demand for roses has been growing at a higher rate compared with other flowers. Roses alone share 51 per cent of European market (Rajgopalan, 2000).

After the ushering in of green revolution, India has witnessed a series of other revolutions linked to farm development. The latest in the list is the Red Revolution or floriculture development (Anonymous, 2000). But there is no authentic data on exact area under floriculture in India. However, it is estimated that about 82,000 hectares are under flower crops in the country, most of which is under traditional flowers. The major flower growing states are Karnataka, Tamil Nadu, Maharahstra, Andhra Pradesh, West Bengal, Rajasthan, Utter Pradesh, Punjab and Haryana. The total area under flower cultivation in Maharashtra is estimated to be 6500 ha out of which only 150 ha are under polyhouse. Maharashtra is the largest contributor to the country's export of flowers. Hi-tech cultivation of flowers is currently covering an area of 500 ha in India, which is dominated by rose cultivation with an investment amounting to more than Rs. 1000 crores (Roy *et al.*, 2000).

Rose is grown throughout the world and is attacked by a number of diseases. The most destructive diseases are Powdery mildew (*Sphaerotheca pannosa* var. *rosae*), Dieback (*Diplodia rosarum*), Black spot (*Diplocarpon rosae*) and Rust (*Phragmidium* sp.).

The powdery mildew is economically important disease causing considerable damage in the crop. The symptoms appear as white powdery patches on the under surface of the leaves and white minute spots on the upper surface of the lower leaves. With the advancement of the disease, leaves get dried leading to defoliation and cause severe yield losses.

Taking into consideration the severity of the disease, it is imperative to find out an effective and economical fungicidal control measures. Therefore, the present investigation "Management of powdery mildew of rose under polyhouse condition", was carried out with following objectives

1. To study the effect of newer fungicides to control powdery mildew of roses.
2. To study the effect of biocontrol agents in management of powdery mildew of roses.
3. To evaluate plant extract (garlic cloves) in managing powdery mildew.
4. To obtain information on the quality of flowers by the application of different fungicides, bio control agents and plant extracts.
5. To note the yield obtained from various treatments.
6. To study the infection pattern in the different treatments of fungicides and bio control agents.
7. To know the most effective and economical management schedule to control powdery mildew of roses.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The first monographic work on the members of *Erysiphaceae* was that of Salmon (1900), while Butler and Bisby (1931) have given distribution of *Erysiphaceae* or white powdery mildew from India. The powdery mildew is economically important disease causing considerable damage in the crops like grapes, peas, green gram, black gram and roses. The literature on powdery mildew of roses was recorded and reported hereunder.

2.1 Occurrence

The powdery mildew of rose is caused by *Sphaerotheca pannosa* var *rosae* (Wall.ex Fr) Lev. The fungus was first described by Wallroth in 1819.

However, the first account of mildew on the rose was that of Theophrastus around 300 B.C (Coyier, 1961) but many centuries passed before this was rightly attributed to a fungal pathogen.

2.2 Taxonomy

Wallroth (1819) first described the fungus as *Alphitomorpha pannosa,* was transferred to the genus *Erysiphe pannosa* by Fries in 1829 and was then placed in the genus *Sphaerotheca* which Leveille described in 1851. It has remained as *S. pannosa* (Wall. Ex Fr) Lev. apart from a recognition by some authorities of the division of this species by Woronichine (1914) into two varieties *rosae* infecting roses & *persicae* infecting peach and almond.

Salmon (1900) in his monograph considered most of the specimens from North America to be *Sphaerotheca humuli* and many mycologists subsequently followed Salmon in thinking that whilst in Europe *S* *pannosa* was the cause of rose powdery mildew, in North America this could be attributed to *S. humuli.*

Coyier (1961) examined herbarium and fresh material together representing collections from 32 states within the USA and from 22 foreign countries cast doubts on the separation of the two fungi *S. pannosa* and *S. humuli* sensu Salmon, and most workers there considered that in the USA all powdery mildews on the rose is caused by *Sphaerotheca pannosa* var. *rosae.*

2.3 Morphology of the fungus

Salmon (1900) described that single ascus is broadly oblong to globose, 88-115 μ (average 100X60.75 μ) and contains eight ascospores, 20-27X12.15 μ. Cleistocarps form somewhat erratically. Generally they appeared to form more frequently on ramblers, climbers and old shrub roses where they were found embedded in the pannose mycelium usually round the thorns, stems and receptacles of the blooms. No Cleistocarps were found on leaves.

Foex (1926) described in detail the development of the conidiophore of *Sphaerotheca pannosa.* The conidiophore was thin walled, septate and variable in length (upto 700 μ) and usually branched. The conidia were formed singly at tip, hyaline and egg shaped.

Coyier (1961) reported that the size of the conidia vary slightly with the cultivar of the host on which they are growing. He also reported that the average length of the conidia varies between 22.9 and 28.6 μ and the width between 13.6 and 15.8 μ.

Sphaerotheca pannosa develops on rose bushes and frequently forms a different mycelium from a thin evanescent type observed in the colorization of young leaves. This "secondary" mycelium consists of rather straight hyphae with much thickened walls and an almost obliterated lumen. It usually persists in patches as a thick felt, the so-called " pannose mycelium" from which the species gets it name. Cleistothecia are globose to pyriform, 85-120 μ in diameter, usually with a few, tortuous, mycelioid appendages which are usually short, pale brown and septate.

Coyier (1961) however, reports the cleistocarps formed on leaves of *Rosa virginiana* both in the greenhouse and in field plots in Wisconsin.

2.4 Conidial germination

Germination of *S. pannosa* on peach leaves improved in the presence of condensation droplets, a finding discussed by Weinhold (1916) in the context of the harmful effect of water films. Water may interfere with the penetration of the host.

The cardinal temperature for germination of conidia as observed by Corner (1935) were 5^0, 18^0 to 20^0 and 27^0C. In experiments carried out at high relative humidity, Longree (1939) found that the minimum temperature for germination on detached leaves of the cultivars Excelsa and Pernet was 3-5^0C, the optimum 21^0C and the maximum 33^0C. At 3-5^0C and 30-31^0C haustoria were occasionally found but there was no evidence of further growth; no formation of haustoria could be detected at 33-34^0C. Mycelial growth was poor in the range of 6-10^0C, good between 11-28^0C and optimal between 18-25^0C.

According to Yarwood (1950), the powdery mildew conidia had high water content and did not require external moisture for germination and hence they possessed ability to germinate in low humidity and that those conidia germinate at low atmospheric humidity in the absence of free water.

Perera and Wheeler (1975) postulated that a fine spray applied to rose leaves soon after inoculation, floated the conidia and prevented contact with leaf surface.

2.5 Varietal screening

Hilal and Kamel (1990) from Egypt tested 23 cultivar of rose. None of them was resistant to powdery mildew.

Chatani *et al* (1996) evaluated resistance of rose cultivars and wild rose to powdery mildew and black spot .In an attempt to produce powdery mildew and black spot disease resistant rose plants (*Rosa hybrida*), an efficient inoculation system for precise evaluation of the resistance or susceptibility of rose cultivars to these diseases was established. Two cultivars, Paul's pink and Magic, were found to be highly resistant to the powdery mildew and the "C line" of wild rose (*R. multiflora)* was highly resistant to both powdery mildew and black spot.

Thammaiah *et al.* (1997) screened rose cultivars against diseases. Observations on 2 year-old plants in Arabhavi, India, made at the end of the rainy season, found that incidence of black spot diseases (Diplocarpon rosae) was highest in rose cultivars Arjun, Golden Times and Superstar, and least in Gladiator. Cultivars Arjun, Montezuma and Superstar were highly resistant to powdery mildew (*Sphaerotheca pannosa* var. *rosae*).

Wojdyla *et al* (1999) screened 146 rose cultivars against *Sphaeratheca pannosa* var. *rosae.* The following cultivars/species were immune-Sky violet (Hybrid tea), Montana, Pussta (Floribunda), Degenhardt (Miniature), Fnihlingsduft, Handel, *Rosa rugosa* Hansa, Heldekonigin, Lichtkonigin Lucia, *R. rugosa* Pink Grootendorst, *R. nitida* and *R. glauca* (park and climbing) of the remaining material, 11 genotypes were highly resistant, 62 resistant, 45 moderately resistant and 16 susceptible. Degree of infection changed during the growth season.

2.6 Fungicidal control of powdery mildew of rose-

Paulus and Nelson (1988) recommended Award (Penconazole), spotless (diniconazole) and Systhane (myclobutani) for the effective control of powdery mildew of rose.

Sahni (1988) in New Delhi, obtained good control of *Sphaerotheca pannosa* by thiophanate methyl, carbendazim and triforine, even under conditions of high inoculums pressure. No phytotoxicity was observed.

Mathur et al (1991) from India obtained the best control of the rose powdery mildew with penconazole and dinocap. The best flower yields were obtained with penconazole.

Nikolov (1992) from Bulgaria, tested fungicides penconazole (as Topaz), diclobutrazol (as Vigil) and fenpropimorph (as Corbel) against powdery mildew pathogen on greenhouse grown roses during the 1985-87. All fungicides tested gave good disease control.

Lam and Lim (1993) from Malaysia, tested efficacy of hexaconazole and its mixture with protectant fungicides to control powdery mildew of roses. Hexaconazole at 50 µg/ml controlled *Sphaerotheca pannosa*. No phytotoxic effects were evident on rose plants treated with hexaconzole.

Venkataramana *et al.* (1993) from New Delhi, tested fungicides for the control of *S. pannosa* var. *rosae* on the susceptible rose variety Neelambari of the 4 products tested, Bavistin (carbendazim), Karathane (dinocap) , sulfex (sulphur) and Topsin M., the best control was given by 0.1% dinocap.

Sivapalan (1994) from Australia, made a study on the effects of submerging inoculated leaves under water on the development of *Erysiphe pisi* and *Sphaerotheca pannosa* on rose. Submerging leaves immediately after inoculation removed 27-40% of conidia from them. Additionally conidia either failed to germinate or germinated abnormally resulting in reduced production of elongating secondary hyphae.

Wojdyla (1994) from Poland, conducted an experiment during 1989-90 on rose cv. Lampion. Fungicides were applied on appearance of the first disease symptoms at concentration 100 ml/m^2 with 7,10 or 14-days intervals. Sandovit was added to each fungicide suspension. The best control was obtained with tetraconazlce (as Eminent), triforine (as saprol) and difencanozole (as score 250 EC).

Dhruj *et al.* (1994) from India tested 7 fungicides including hexaconazole, sulphur, triadimefon, cyproconazole, chlorothalonil, thiophanate-methyl and dinocap in controlling *S. pannosa* var. *rosae* in rose cultivars Dilkhush, Yellow Hybrid Tea and Red Farida in Gujarat, India. All of the fungicides except chlorothalonil significantly reduced infection levels.

In Mexico, Perez and Lozoya (1994), tested hexaconazole at 0, 0.1, 0.25 and 1 ml/litre water against *S. pannosa* var. *rosae* in a 4 month trial with 8, 14 and 28-d application intervals. The best control of the disease was obtained with the highest concentration applied at 8-d intervals.

Reuveni *et al.* (1994) controlled the powdery mildew of rose by application of bupirimate (as Nimrod) at 0.5 ml/lit. The experiment was carried out in Israel.

Costache *et al.* (1995) obtained good control with Carbendazim (as Bavistin 50 WP) against rose powdery mildew.

Sobti *et al.* (1996) studied the effect of powdery mildew on fresh flower yield of rose in Pushkar valley of Rajasthan. Data revealed that there was a significant reduction in Flower yield in disease categories 4-7 (25-56.39%) as compared with healthy check.

In Poland Wojdyla (1998) studied the effectiveness of different spraying methods on the activity of Saprol (20% triforine), Sportak Alpha 380 EC (300 g/lit prochloraz + 80 g/lit carbendazim) and Topas MZ61 WP (1.25% penconazole + 59.75% mancozeb) in the control of *S. pannosa* var. *rosae* on roses (cv. Mercedes) were evaluated in greenhouse experiments in 1995. When both leaf sides were covered with fungicide, the efficacy was significantly increased.

In Poland, Wojdyla (1999) evaluated in greenhouse experiments the effectiveness of 24 fungicides in the control of *Sphaerotheca pannosa* var. *rosae*. The treatments were performed after the first symptoms appeared and were repeated 4 times at 7 days intervals. The best results in the control of powdery mildew were obtained with bupirimate (as Nimrod 250 EC).

In West Bengal, Das *et al.* (2000) evaluated two systemic fungicides and three non systemic fungicides. The following fungicides were applied three times at 10 days intervals: Saprol (0.25%) Blitox (0.25%), Indofil M-45 (0.25%), Bavistin (0.1%), Karathane (0.12%) untreated control. All fungicides significantly reduced the disease intensity compared to the control. Saprol (0.25%) and Karathane (0.1%) were effective in controlling the disease followed by Bavistin (0.1%), Blitox (0.25%) and Indofil M-45 (0.25%) were least effective

In Taiwan, Liu (2001) recommended automatic water sprays for management of rose powdery mildew. Two field experiments and greenhouse experiments were conducted to evaluate the effects of water-sprays everyday for 2 months on the incidence of powdery mildew. The disease incidence of water sprayed area was significantly lower than that of the unsprayed area (99.7 and 100%) indicating that water spraying could effectively control rose powdery mildew.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1 Material

The experimental material used for the present investigation, the cultivars, First red was planted on 19th March, 2002 in the polyhouse of Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune.

3.1.1 Fungicidal control

Powdery mildew appears on leaves causing severe damage to the crop and reduction in the yield and hence economically important. For the management of this economically important disease, chemical control becomes imperative in the field and particularly in Hi-tech floriculture.

In view of achieving the effective control, it is always necessary to evaluate the newer fungicides while comparing the old ones. Therefore, a polyhouse trial was laid out during the year 2002 to evaluate fungicides against powdery mildew of rose (*Sphaerotheca pannosa* var. *rosae*) along with biocontrol agents.

The details of material used and methods followed in the polyhouse trial have been described below.

3.2 Methods

3.2.1 Experimental details

The experiment was conducted under protected condition in the polyhouse of Hi- tech Floriculture and Vegetable Project, College of Agriculture, Pune-5.

Design	: Randomized Block Design
Replications	: Three
Spacing	: 50 X 20 cm 0.5 X 0.2 m

Variety : First red

Treatments : 13

Number of plants/ treatment : 10

Fertilizer dose of 150 : 50 : 150 ppm NPK was given per plant per day.

3.2.2 Treatment details

T_1 : Wettable Sulphur (0.07%)

T_2: : Wettable Sulphur (0.1%)

T_3 : *Trichoderma viride* (0.2%)

T_4 : *Trichoderma harzanium* (0.2%)

T_5 : T_3 + T_4 (0.2%), 0.1% each

T_6 : Difencanozole (0.05%)

T_7 : Penconazole (0.05%)

T_8 : Carbendazim (0.05%)

T_9 : Hexaconazole (0.05%)

T_{10} : Nimrod (0.05%)

T_{11} : Plant extract (Garlic cloves 6%)

T_{12} : Water spray

T_{13} : Absolute control

Date of planting : 19/ 03/ 2002

Fungicides and doses used

The fungicides tried under polyhouse condition for the chemical control of powdery mildew were selected on the basis of their availability in the market and their broad spectrum action along with other newer chemicals.

The details of the fungicides are given in Table 1.

Plate 1. Planting of rose for management of powdery mildew

Table 1. Details of treatments used in the experiment.

Sr. No.	Common name	Chemical name	Active Ingredient	Concentration used	Name of the firm
1	Sulwet	Micronised Sulphur	80% wettable powder	0.07% 0.1%	Sparkala Chemical Industries, Ltd., Vapi-396196.
2	Difencanozole Score-250 EC	1-(2-[4-(chlorophenoxy)-2- chlorophenyl) – (4-methyl-1,3-dioxolan-2-yl)-methyl])-1H-1,2,4- triazole	25% EC	0.05%	Syngenta India Ltd., Mumbai-400025.
3	Penconazole	1-[2-(2,4-dicholorophenyl)-pentyl]- 1H-1,2,4-triazol	25% EC	0.05%	Sparkala Chemical Industries, Ltd., Vapi-396196
4	Carbendazim	2(Methoxy-carbamoyl)Benzimidazole	50% wettable powder	0.05%	BASF, India, Ltd., Mumbai- 400011.
5	Hexaconazole	(RS)-2-(2,4-Dichlorophenyl)-1-(1-H-1,2,4-Trizole-1-YL)-Hexan-2-OL	5% EC	0.05%	RALLIS INDIA Ltd., Mumbai 400001.
6	Nimrod	Bupirimate	25% EC	0.05%	RALLIS INDIA Ltd., Mumbai 400001.

Table contd..

7	Bioderma	*Trichoderma viride*	-	0.2% and 0.1%	Biotech International Ltd., New Delhi-110048.
8	Phule Trichokill	*Trichoderma harzanium*	-	0.2% and 0.1%	Plant Pathology and Agricultural Microbiology Department, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar.
9	Plant extract Garlic Cloves	*Allium sativum*	-	6%	-

3.2.3 Spraying/ dusting

The experimental plot was visited regularly and observed for the incidence of powdery mildew. The first incidence was noted on 5th August 2002 and immediately treatments of sprays were administered followed by repeated sprayings in the interval of eight days.

Dates of spraying/ dusting :

First spraying	: 6 August 2002
Second spraying	: 13 August 2002
Third spraying	: 20 August 2002.

3.2.4 Observations

The observations were recorded on incidence of disease to find out the per cent intensity of powdery mildew. The first observation was recorded on the same day of the appearance of the disease in the field and subsequent three observations were recorded eight days after each spraying/dusting.

For recording observations, five plants from each plot were randomly selected before appearance of the disease. Five leaves below the bud of each selected plant were tagged for observations along with bud neck. The intensity of disease was recorded separately for each treatment.

On the basis of four ratings, percentage of disease intensity was worked out. The intensity was recorded as per cent development of powdery mildew on bud neck and leaves, considering the area of whole leaf and bud neck. The scorecard was prepared by measuring total leaf area and bud neck affected and graded according to following categories.

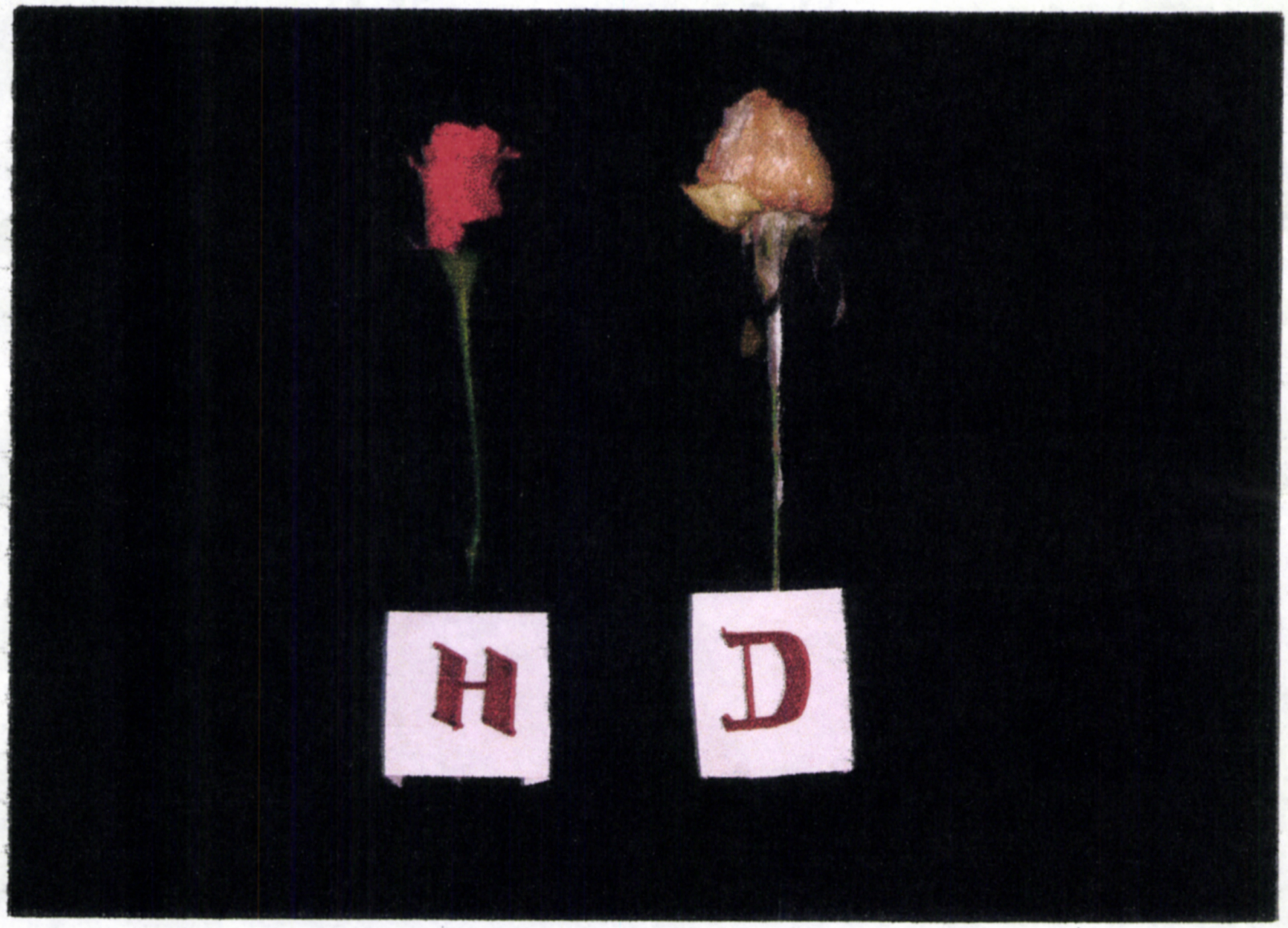

Plate 2. Healthy and diseased flowers.

Plate 3. Infection of powdery mildew on bud neck and leaves of rose.

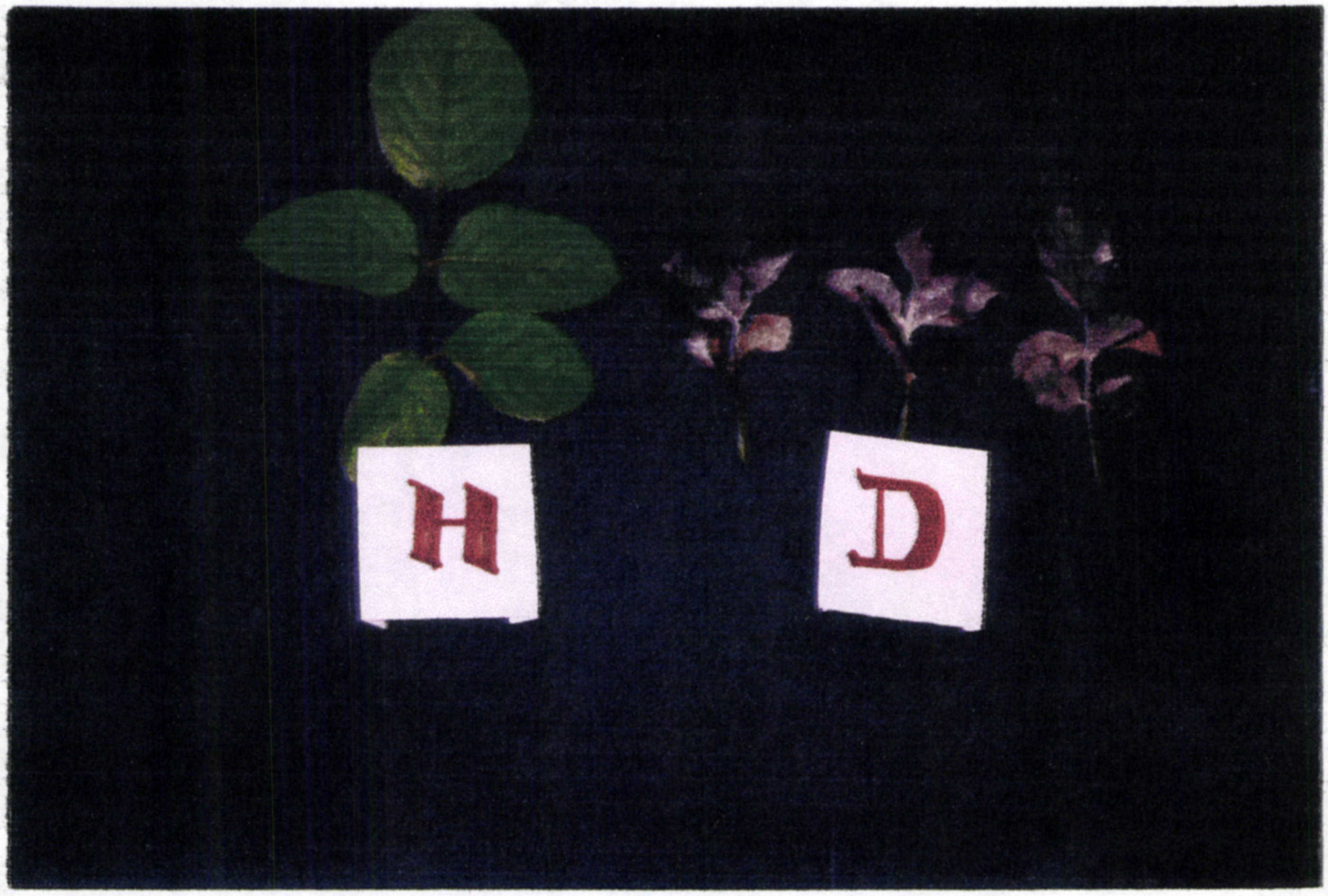

Plate 4. Healthy and diseased leaves.

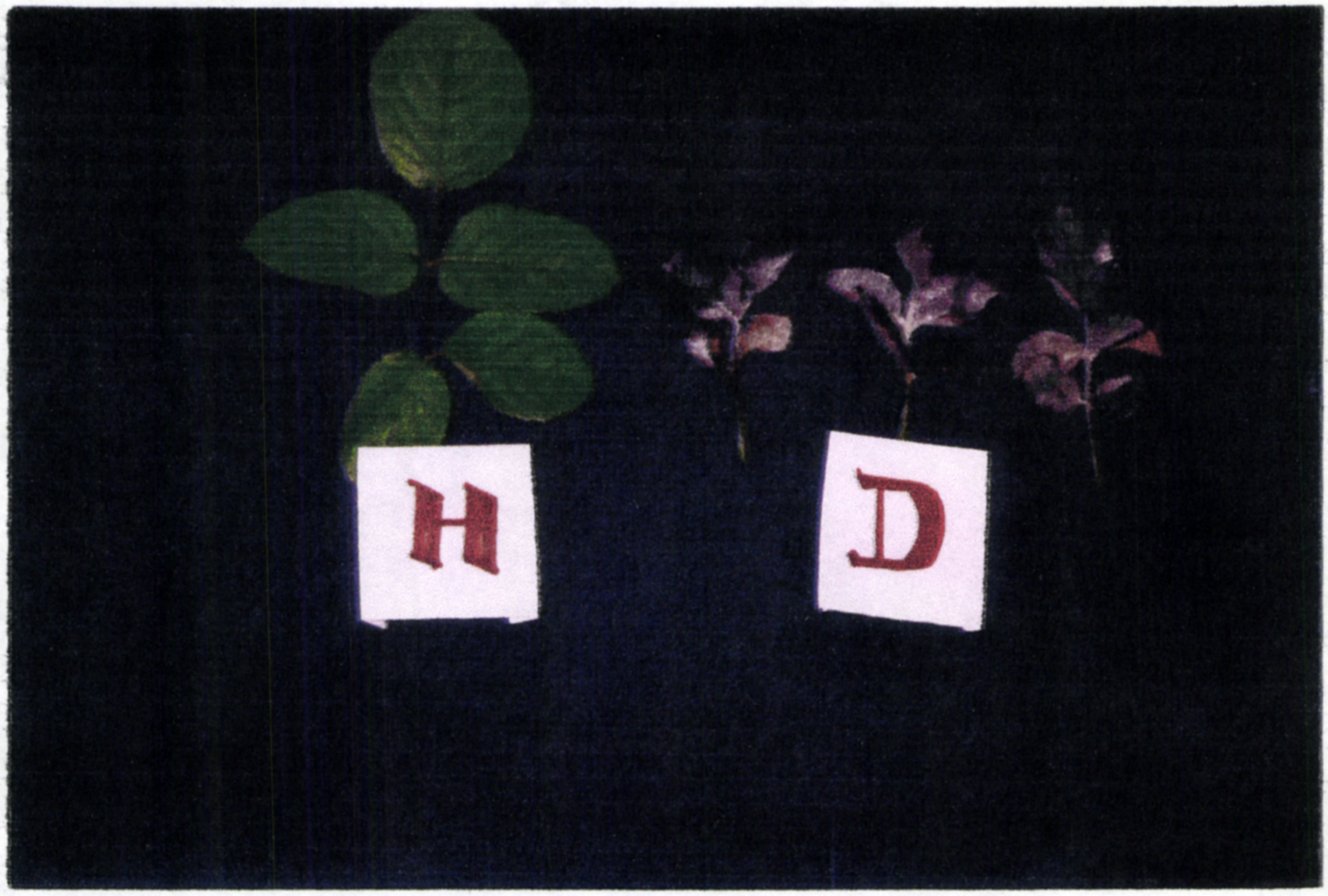

Plate 4. Healthy and diseased leaves.

Rating		Percentage disease intensity
0	:	Healthy (free from powdery mildew)
1	:	1-10% (infection in traces on lower leaves)
2	:	11-25% (slight infection, white patches on leaves covering 25% of leaf area)
3	:	26-50% (moderate infection, white powdery growth covering 50% of area)
4	:	51% and above (heavy infection, covering above 51% area, powdery growth on bud neck and defoliation)

Percentage disease intensity (P.D.I.) was calculated on the basis of method adopted by Horsfall and Barratt (1945).

$$\text{P.D.I} = \frac{\text{Total numerical ratings}}{\text{Number of leaves examined}} \times \frac{100}{\text{Maximum rating}}$$

Percentage disease control (P. D. C.) was worked out by using formula

$$\text{P.D.C.} = \frac{\text{P.D.I. in control} - \text{P. D. I. in treatment}}{\text{P. D. I. in control}} \times 100$$

Dates of observations :

First (pre- treatment)	: 5 August 2002
Second	: 12 August 2002
Third	: 19 August 2002

3.2.4.1 Yield

3.2.4.1.1 Total yield of flowers per plant

Total yield of flowers per plant from first flower harvest to last flower harvest during the period of investigation was recorded.

3.2.4.1.2 Yield of flowers per square meter

Total yield of flowers per plant was recorded, average was worked out and from this average value of yield of flowers per square meter was calculated.

3.2.4.2 Quality

3.2.4.2.1 Length of the shoot (cm)

Length of each flower shoot harvested was recorded.

3.2.4.2.2 Diameter of flower bud (cm)

Diameter of flower bud from each harvested flower shoot was recorded with the help of vernier caliper.

3.2.5 Harvesting

For recording yield data, the rose flower stalks were harvested at an interval of 7 to 8 days. The flower stalks harvested from different plots were kept separately and graded according to quality of flowers.

3.2.6 Economics of the treatments

To find out effective and economical fungicides and net additional returns, the economics for each treatment was worked out.

3.2.7 Statistical analysis

On the basis of observations recorded, the per cent intensity of disease was worked out for each plot. The recorded values of intensity were transformed into arcsin values and used for statistical analysis. For comparing two treatment means, critical difference (C. D.) at 5% level of significance was worked out.

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

4.1 Fungicidal and biological control of powdery mildew of rose

4.1.1 Percentage disease intensity

Soon after the appearance of powdery mildew three sprayings/dustings were carried out and the data have been presented in Table 2-a, 2-b and 2-c respectively.

4.1.1.1 First spraying

It was seen from Table 2-a that all the fungicidal treatments significantly reduced disease intensity as compared to check. Treatments; Difencanozole (0.05%), Carbendazim (0.05%), Nimrod (0.05%) and Wettable Sulphur (0.1% and 0.07%) were statistically superior over rest of the fungicides and they were on the par with each other.

Maximum percentage disease control (35.73%) was observed in the plot treated with Difencanozole (0.05%) while it was minimum (02.12%) in case of spraying with garlic cloves extract (6%). Percentage disease control by other treatments was within the range of 12.33 to 34.99 per cent.

4.1.1.2 Second spraying

It was seen from Table 2-b that Difencanozole was significantly superior to Penconazole, Carbendazim and Hexaconazole, which were on par among themselves. Penconazole, Hexaconazole and Carbendazim were significantly superior to Wettable Sulphur and Nimrod. *Trichoderma viride* and *T. harzanium* were statistically on par.

The maximum percentage disease control was observed (88.37%) in case of Difencanozole and it was minimum (31.27%) as in case of garlic cloves extract.

Table 2a Percentage disease intensity after first spraying

Treatments	Replications			Total	Mean	Percentage disease control
	R-I	R-II	RIII			
T_1 Wettable Sulphur (0.07%)	18.90 (25.769)	20.5 (26.922)	22.75 (28.448)	62.15 (81.178)	20.71 (27.0599)	28.35
T_2 Wettable Sulphur (0.1%)	21.15 (27.380)	18.27 (23.305)	22.8 (28.522)	62.22 (81.207)	20.74 (27.069)	28.27
T_3 *T. viride* (0.2%)	24.89 (29.927)	21.85 (27.868)	22.65 (28.419)	69.39 (86.215)	23.13 (28.738)	20.012
T_4 *T. harzanium* (0.2%)	20.00 (26.565)	23.60 (29.065)	21.50 (27.665)	65.10 (83.255)	21.70 (27.752)	24.95
T_5 T_3 +T_4 (0.2%) 0.1% each	22.05 (28.007)	22.97 (28.638)	19.15 (25.951)	64.17 (62.596)	21.39 (27.532)	26.02
T_6 Difencanozole (0.05%)	17.7 (24.880)	16.70 (24.120)	21.35 (27.520)	55.75 (76.520)	18.58 (25.507)	35.73
T_7 Penconazole (0.05%)	19.30 (26.060)	18.55 (25.512)	21.37 (27.534)	59.22 (79.106)	19.74 (26.369)	31.73
T_8 Carbendazim (0.05%)	18.65 (25.583)	21.00 (27.275)	16.74 (24.151)	56.39 (77.011)	18.79 (25.670)	34.99
T_9 Hexaconazole (0.05%)	18.30 (25.327)	20.5 (26.922)	22.45 (28.282)	61.25 (80.531)	20.41 (26.844)	29.39
T_{10} Nimrod (0.05%)	18.45 (25.438)	21.36 (27.527)	22.55 (28.351)	62.36 (81.316)	20.78 (27.105)	28.11
T_{11} Garlic cloves (6%)	26.65 (31.080)	27.76 (31.795)	30.50 (33.523)	84.91 (96.398)	28.30 (32.133)	02.12
T_{12} Water spray	25.30 (30.198)	22.60 (28.385)	28.15 (32.044)	76.05 (90.627)	25.35 (30.209)	12.33
T_{13} Absolute control	27.5 (31.628)	30.25 (33.367)	29.00 (32.583)	86.75 (97.578)	28.91 (32.526)	-
S. E. (±)	0.7719					
C. D. at 5%	2.2532					

Table 2b Percentage diseases intensity after second spraying

Treatments	Replications			Total	Mean	Percentage disease control
	R-I	R-II	RIII			
T_1 Wettable Sulphur (0.07%)	11.20 (19.552)	9.65 (18.098)	10.22 (18.644)	31.07 (56.294)	10.35 (18.765)	75.76
T_2 Wettable Sulphur (0.1%)	13.45 (21.515)	16.35 (23.851)	15.00 (22.787)	44.8 (68.152)	14.93 (22.717)	65.05
T_3 *T. viride* (0.2%)	19.45 (26.169)	21.10 (27.345)	15.5 (23.185)	56.05 (76.699)	18.68 (25.566)	56.27
T_4 *T. harzanium* (0.2%)	20.44 (26.879)	27.345 (15.55)	23.185 (17.60)	53.59 (74.908)	24.969 (17.43)	58.19
T_5 T_3 +T_4 (0.2%) 0.1% each	18.25 (25.290)	17.20 (24.502)	16.85 (24.235)	52.30 (74.028)	17.43 (24.676)	59.20
T_6 Difencanozole (0.05%)	4.25 (11.897)	5.65 (13.751)	5.00 (12.921)	14.9 (38.569)	4.96 (12.856)	88.37
T_7 Penconazole (0.05%)	8.65 (17.014)	10.4 (18.814)	9.00 (17.458)	28.05 (53.375)	9.35 (17.792)	78.11
T_8 Carbendazim (0.05%)	7.55 (15.948)	9.40 (17.854)	8.46 (16.910)	25.41 (50.712)	8.47 (16.904)	80.17
T_9 Hexaconazole (0.05%)	9.55 (18.001)	18.578 (16.30)	17.952 (17.34)	54.531 (49.34)	18.177 (16.44)	61.50
T_{10} Nimrod (0.05%)	23.343 (27.60)	23.812 (29.0)	24.608 (31.50)	71.763 (88.1)	23.921 (29.36)	31.27
T_{11} Garlic cloves (6%)	27.60 (31.692)	29.0 (32.583)	31.50 (34.142)	88.1 (98.417)	29.36 (32.806)	31.27
T_{12} Water spray	26.80 31.177()	29.65 (32.992)	28.09 (32.005)	84.54 (96.175)	28.18 (32.058)	34.05
T_{13} Absolute control	43.50 (41.265)	40.15 (39.319)	44.54 (41.865)	128.19 (122.450)	42.73 (40817)	-
S. E. (±)	0.7719					
C. D. at 5%	2.2532					

4.1.1.3 Third Sprayings

It was evident from Table 2-c that Difencanozole continued to be significantly superior to all other treatments followed by Carbendazim, Penconazole and Hexaconazole in reducing the disease intensity. Carbendazim, Penconazole and Hexaconazole were on par but significantly superior to Wettable Sulphur (0.1% and 0.07%). Similarly, Wettable Sulphur (0.1%) and (0.07%) were on par but significantly superior to Nimrod, *Trichoderma viride* and *Trichoderma harzanium*. The combination of *Trichoderma viride* and *Trichoderma harzanium* was significantly superior tc garlic cloves extract and water spray.

Noticeable percentage disease control was observed in case of Difecanozole (96.13%) followed by Carbendazim (95.22%), Penconazole (94.44%) and Hexaconazole (93.16%), Wettable Sulphur 0.07% (89.34%) and Wettable Sulphur 0.1% (86.62%). Percentage disease control in the remaining fungicidal treatment was within the range of 51.66 to 76.58 per cent.

4.1.1.4 Effect of number of sprays

The result of the percentage disease control after each spraying have been summarized in Table 3 and final effect of different treatments on percentage disease control in relation to percentage disease intensity represented graphically in fig 1.

It was seen from the data presented in Table 3 that after first spraying, percentage disease control was within range of 02.12 to 35.73 per cent. After first and third spraying, it has been observed that percentage disease control was increased as compared to first spraying. After final spraying maximum percentage disease control was 96.13%. The fungicide like Difencanozole, Carbendazim, Penconazole. Hexaconazole and Wettable Sulphur showed effective control right from first spray till final spray.

Table 2c Percentage disease intensity after third spraying

Treatments	Replications			Total	Mean	Percentage disease control
	R-I	R-II	RIII			
T_1 Wettable Sulphur (0.07%)	5.55 (13.626)	6.45 (14.712)	6.40 (14.654)	18.4 (42.993)	6.13 (14.331)	89.34
T_2 Wettable Sulphur (0.1%)	7.15 (15.509)	9.20 (17.657)	6.76 (15.070)	23.11 (48.236)	7.70 (16.079)	86.62
T_3 *T. viride* (0.2%)	15.30 (23.026)	17.35 (24.616)	18.7 (25.622)	51.35 (73.264)	17.116 (24.421)	70.27
T_4 *T. harzanium* (0.2%)	13.60 (21.641)	20.13 (26.658)	15.85 (23.066)	49.58 (71.365)	16.52 (23.788)	71.58
T_5 T_3 +T_4 (0.2%) 0.1% each	12.95 (21.092)	13.10 (21.219)	15.54 (23.217)	41.59 (65.528)	13.86 (21.843)	75.92
T_6 Difencanozole (0.05%)	2.40 (8.912)	1.95 (8.027)	2.33 (8.780)	6.68 (25.719)	2.22 (8.573)	96.13
T_7 Penconazole (0.05%)	3.65 (11.014)	2.70 (9.458)	3.25 (10.386)	9.6 (30.858)	3.2 (10.286)	94.44
T_8 Carbendazim (0.05%)	2.95 (9.890)	1.80 (7.710)	3.50 (10.783)	8.25 (28.383)	2.75 (9.461)	95.22
T_9 Hexaconazole (0.05%)	5.15 (13.117)	3.75 (11.166)	2.90 (9.805)	11.8 (34.088)	3.93 (11.363)	93.16
T_{10} Nimrod (0.05%)	11.40 (19.733)	13.85 (21.849)	15.20 (22.947)	40.45 (64.528)	13.48 (21.509)	76.58
T_{11} Garlic cloves (6%)	28.3 (32.139)	29.8 (33.086)	25.4 (30.264)	83.5 (95.489)	21.509 (27.8)	51.66
T_{12} Water spray	30.45 (33.492)	25.95 (30.625)	20.00 (26.565)	76.4 (90.681)	25.46 (30.227)	55.77
T_{13} Absolute control	55.25 (48.014)	58.60 (49.952)	58.90 (50.127)	172.75 (148.092)	57.58 (49.364)	-
S. E. (±)	0.9952					
C. D. at 5%	2.9051					

Table 3 Percentage disease control after each spraying

Treatments	Percentage control after each spray		
	I	II	III
T_1 Wettable Sulphur (0.07%)	28.35	75.76	89.34
T_2 Wettable Sulphur (0.1%)	28.27	65.05	86.62
T_3 *T. viride* (0.2%)	20.01	56.27	70.27
T_4 *T. harzanium* (0.2%)	24.95	58.19	71.58
T_5 T_3 +T_4 (0.2%) 0.1% each	26.02	59.20	75.92
T_6 Difencanozole (0.05%)	35.73	88.37	96.13
T_7 Penconazole (0.05%)	31.73	78.11	94.44
T_8 Carbendazim (0.05%)	34.99	80.17	95.22
T_9 Hexaconazole (0.05%)	29.39	77.22	93.16
T_{10} Nimrod (0.05%)	28.11	61.50	76.58
T_{11} Garlic cloves (6%)	02.12	31.27	51.66
T_{12} Water spray	12.33	34.05	55.77

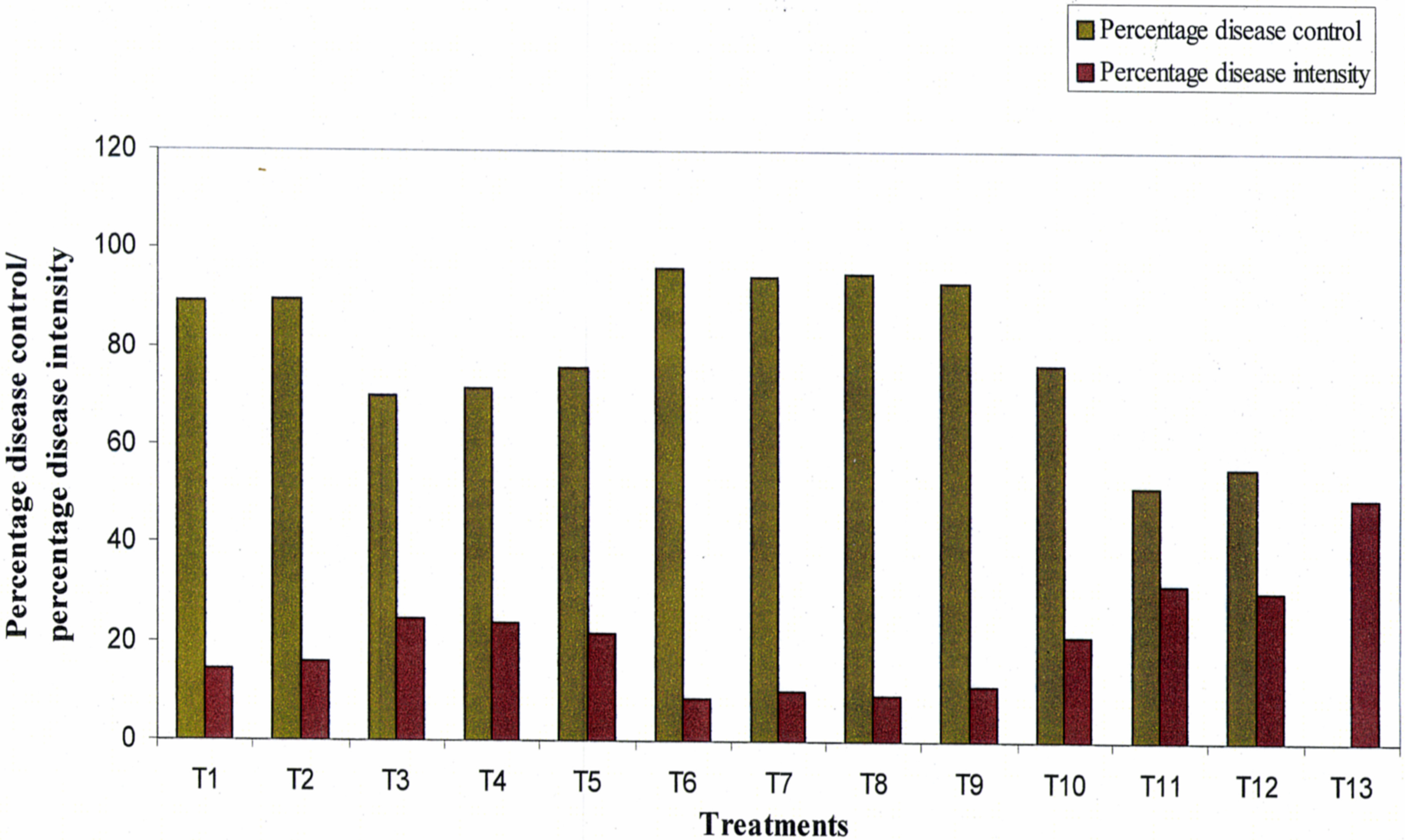

Fig. 1 Final effect of different treatments on percentage disease control in relation to percentage disease intensity

It is seen from the Table 3 that for better control minimum three sprays are essential.

4.2 Yield data

The yield data presented in Table 4 and graphically represented in Fig. 2, 3 and 4. It showed that the plots treated with fungicides gave significantly higher yield as compared to the control. The mean yield in plot treated with Carbendazim was found to be statistically superior to all the treatment and resulted in the maximum yield of 224.05 flowers/m^2. The next fungicides in which the increased yield was observed were Difencanozole (217.53 flowers/m^2), Wettable Sulphur 0.07% (211.00 flowers/m^2) Penconazole(210.03 flowers/m^2) and Hexaconazole (201.81 flowers/m^2) and they were on par among themselves. Wettable Sulphur (0.1%) was found to be significantly superior to Nimrod and *Trichoderma viride* and *Trichoderma harzanium.*

The garlic cloves spray and water spray were on par among themselves and significantly superior to control. The control treatment resulted in lowest yield of 113.59 flowers/m^2/year.

4.3 Effect of treatments in relation to powdery mildew control on quality of rose flowers

The data in respect to length of shoot (cm) and diameter of flower bud (cm) are presented in Tables 5 and 6 and represented graphically in figure 5 and 6.

4.3.1 Length of Shoot

The data in respect of the length of shoot are presented in Table 5 and represented graphically in Figure 5. The observations revealed that all the treatments were significantly superior over control in respect of increasing the length of stalk of flower. The treatment T_6 (70.35 cm) had significantly highest shoot length among the treatments. It was followed by treatment T_9 (67.47 cm), T_8 (67.33 cm) and T_7 (66.57 cm).

Table 4 Yield of flower stalks per meter square

	Replications			Total	Mean	Percentage increase over control
	R-I	R-II	RIII			
T_1 Wettable Sulphur (0.07%)	150.4	229.4	253.2	633.00	211.00	85.75
T_2 Wettable Sulphur (0.1%)	175.77	219.84	153.99	549.6	183.20	61.28
T_3 *T. viride* (0.2%)	194.616	139.84	152.75	486.54	162.18	42.77
T_4 *T. harzanium* (0.2%)	183.3	156.37	118.58	458.25	152.75	34.47
T_5 T_3 +T_4 (0.2%) 0.1% each	187.64	119.286	162.18	469.11	156.37	37.66
T_6 Difencanozole (0.05%)	261.03	178.83	212.72	652.59	217.53	91.50
T_7 Penconazole (0.05%)	252.04	192.27	185.78	630.09	210.03	84.90
T_8 Carbendazim (0.05%)	207.08	258.86	206.21	672.15	224.05	97.24
T_9 Hexaconazole (0.05%)	186.28	176.97	242.17	605.43	201.81	77.66
T_{10} Nimrod (0.05%)	174.08	215.78	148.99	539.46	179.82	58.30
T_{11} Garlic cloves (6%)	145.61	117.33	151.08	414.03	138.01	21.49
T_{12} Water spray	143.70	140.83	142.54	427.08	142.36	25.32
T_{13} Absolute control	126.30	94.47	119.9	340.77	113.59	-
S. E. (±)	19.3676					
C. D.	53.6842					

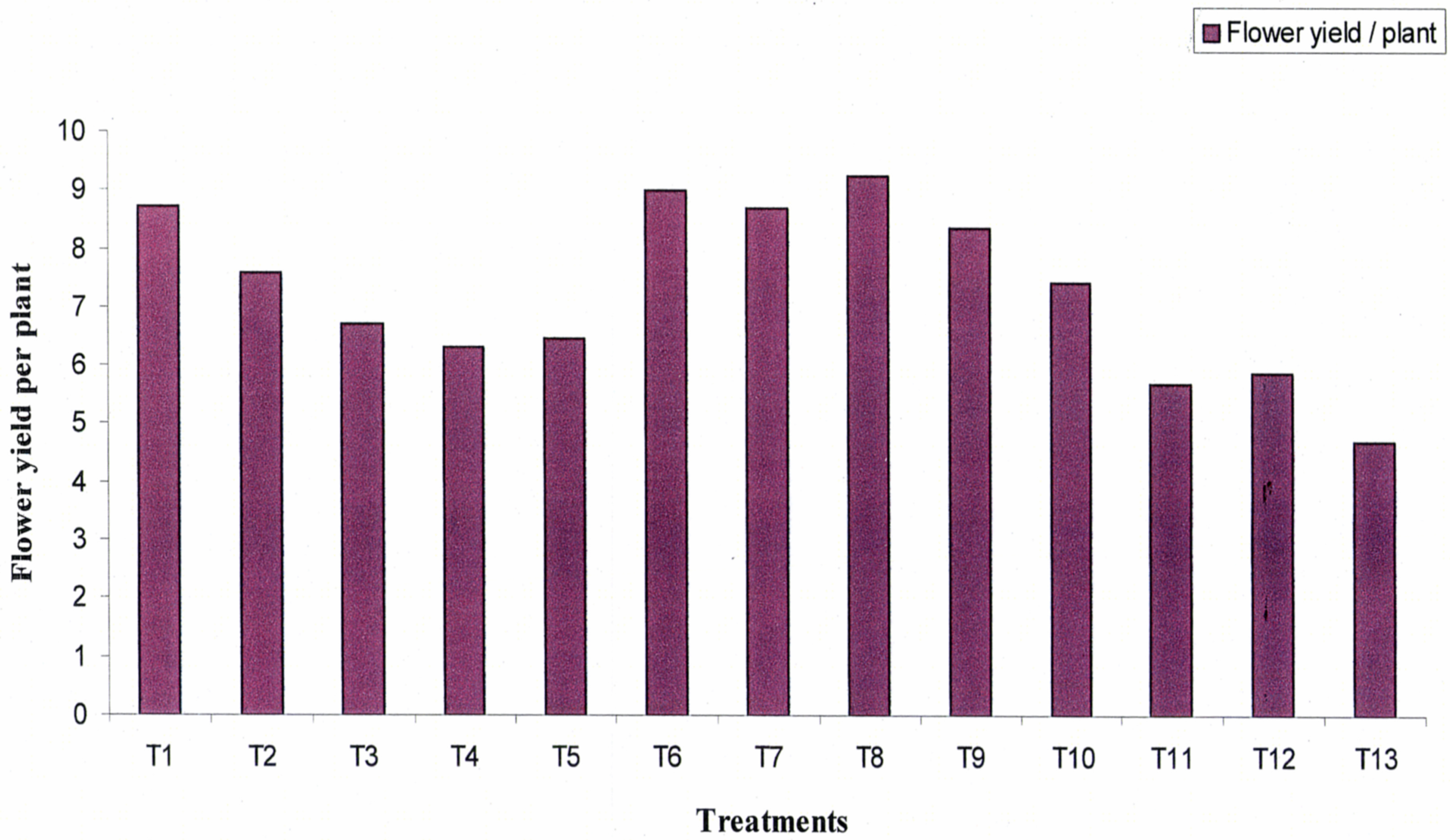

Fig. 2. Yield of flowers per plant as influenced by different treatments

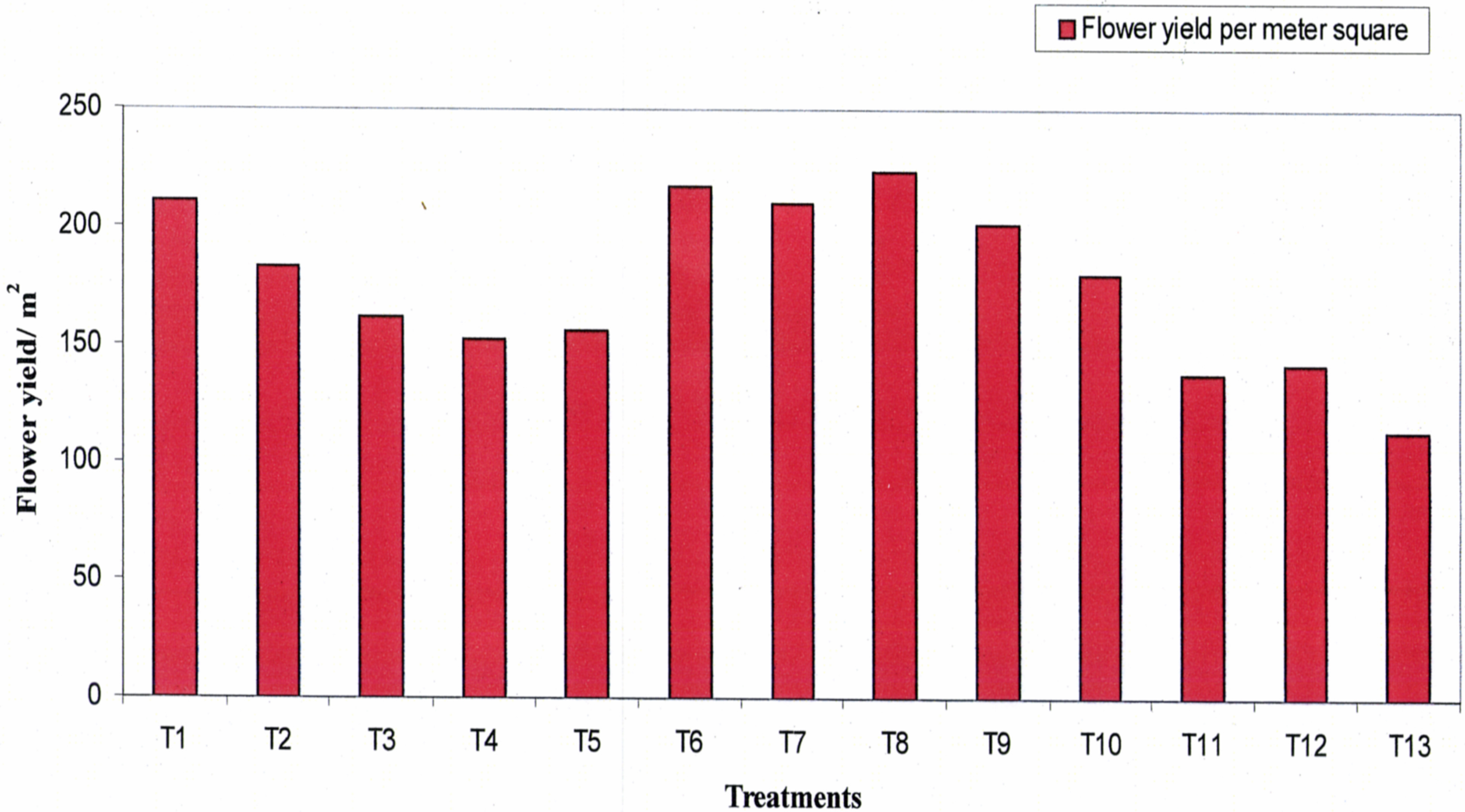

Fig. 3 Yield of flowers per square meter as influenced by different treatments

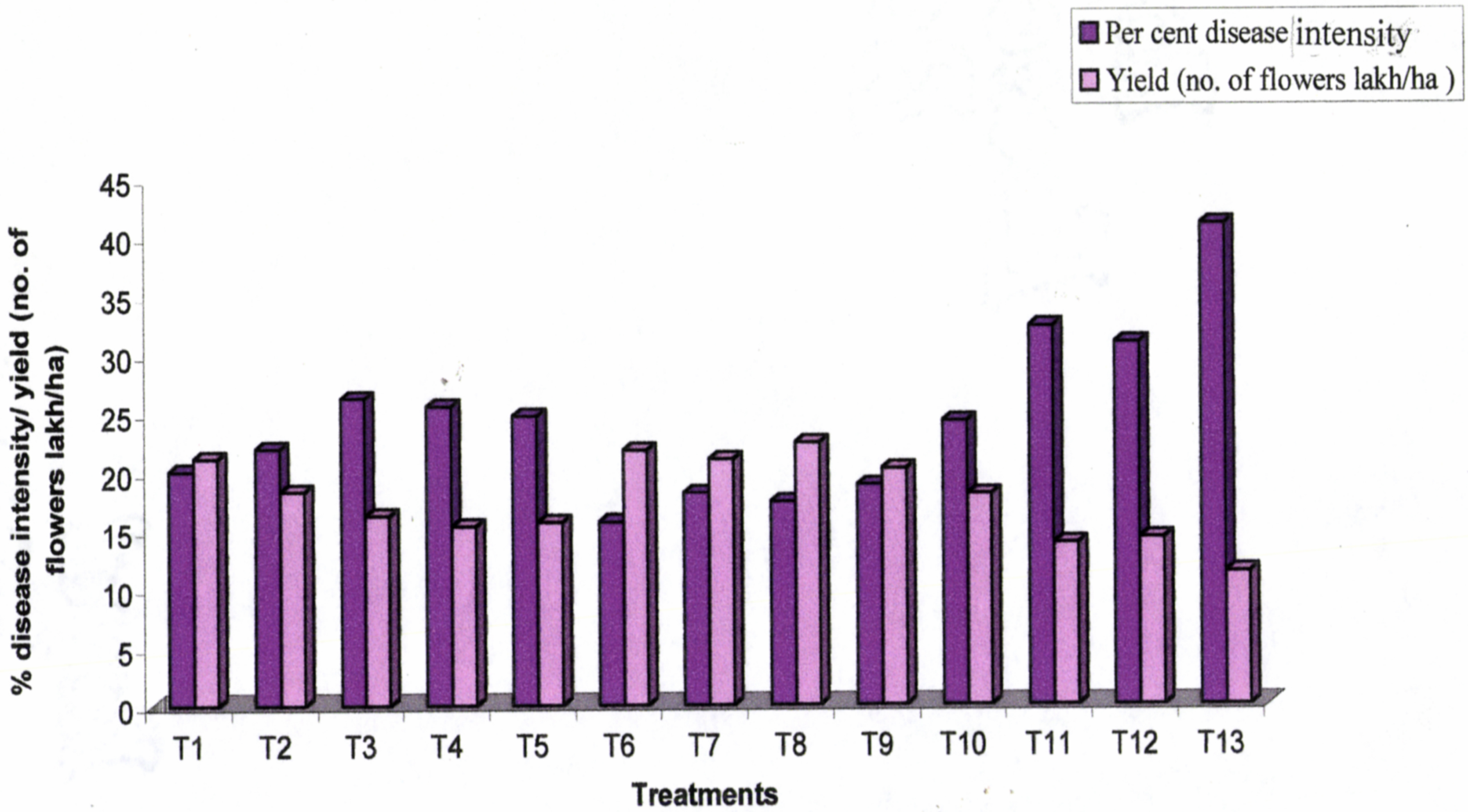

Fig.4 The intensity of powderymildew and yield as influenced by various treatments

Table 5 Length of shoot as influenced by different treatments

Sr. No.	Treatments	Treatments	Length of shoot (cm)
1	T_1	Wettable Sulphur (0.07%)	63.42
2	T_2	Wettable Sulphur (0.1%)	61.64
3	T_3	*T. viride* (0.2%)	56.52
4	T_4	*T. harzanium* (0.2%)	58.00
5	T_5	T_3 +T_4 (0.2%) 0.1% each	59.32
6	T_6	Difencanozole (0.05%)	70.35
7	T_7	Penconazole (0.05%)	66.57
8	T_8	Carbendazim (0.05%)	67.33
9	T_9	Hexaconazole (0.05%)	67.47
10	T_{10}	Nimrod (0.05%)	60.68
11	T_{11}	Garlic cloves (6%)	53.31
12	T_{12}	Water spray	54.67
13	T_{13}	Absolute control	52.00
S. E. (±)			0.142
C. D.			0.396

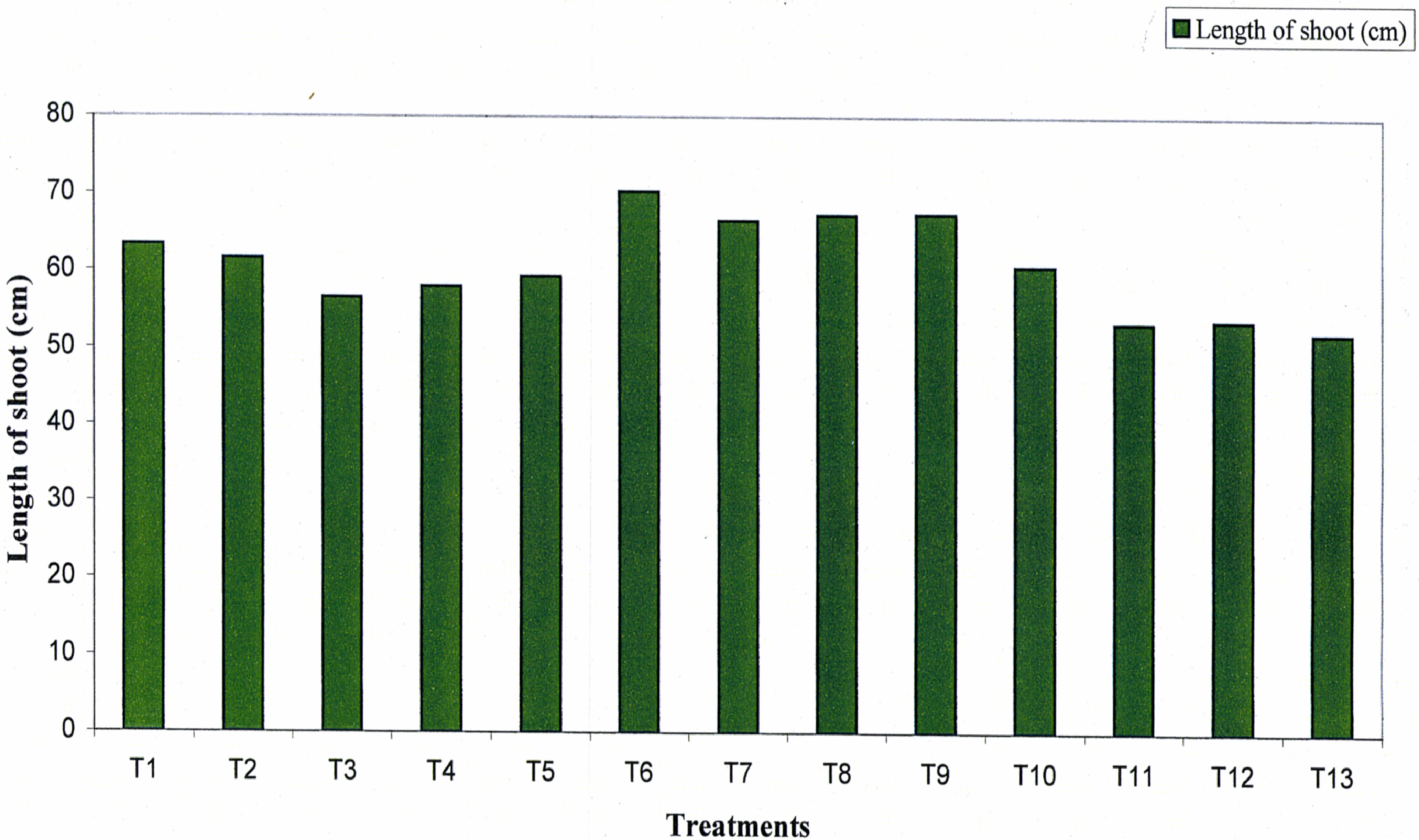

Fig. 5 Length of shoot (cm) as influenced by different treatments

Table 6 Diameter of flower bud as influenced by different treatments

Sr. No.	Treatments	Treatments	Diameter of flower bud (cm)
1	T_1	Wettable Sulphur (0.07%)	2.13
2	T_2	Wettable Sulphur (0.1%)	2.12
3	T_3	*T. viride* (0.2%)	2.08
4	T_4	*T.harzanium* (0.2%)	2.08
5	T_5	T_3 +T_4 (0.2%) 0.1% each	2.00
6	T_6	Difencanozole (0.05%)	2.22
7	T_7	Penconazole (0.05%)	2.17
8	T_8	Carbendazim (0.05%)	2.16
9	T_9	Hexaconazole (0.05%)	2.07
10	T_{10}	Nimrod (0.05%)	2.03
11	T_{11}	Garlic cloves (6%)	1.99
12	T_{12}	Water spray	2.00
13	T_{13}	Absolute control	1.98
	S. E. (±)		3.340
	C. D.		9.258

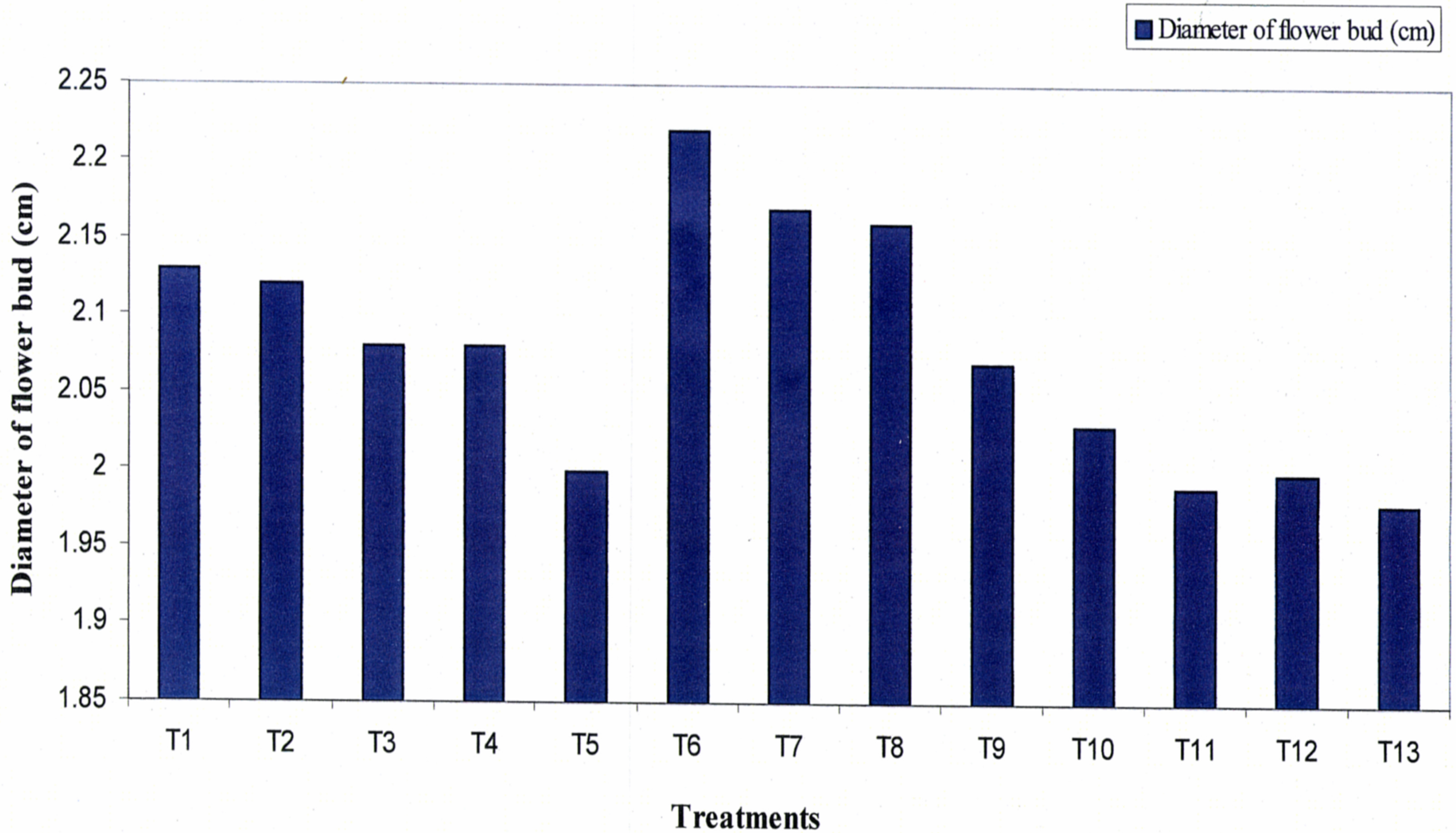

Fig. 6 Diameter of flower bud (cm) as influenced by different treatments

4.3.2 Diameter of flower bud

The data on diameter of flower bud are presented in the Table 6 and represented graphically in Figure 6. The data showed that there were significant differences in the diameter of flower bud due to different treatments. Significantly highest (2.22 cm) and the lowest (1.983 cm) diameter of flower bud was produced by T_6 and T_{13} respectively.

All the fungicidal treatments gave significantly increase in diameter of flower bud than the control (T_{13}). These observations indicate that the fungicidal and biocontrol sprays could improve the quality of flowers.

4.4 Economics of control measures

Detailed information regarding cost of fungicides, labour charges for spraying, yield/ha, gross income/ha. net additional monetary returns/ha, percent monetary returns obtained by different treatments is given in Table 7and represented graphically in fig. 7.

It was observed that all the treatments tried for the control of disease incidence have given more or less net additional profit ranging from Rs. 4.47 lakh/ha. to Rs. 20.23 lakh/ha. The highest net profit was obtained from the treatment Carbendazim. This was followed by Wettable Sulphur (19.61 lakh/ha), Difencanozole (Rs. 19.03 lakh/ha). Penconazole (Rs. 17.66 lakh/ha), Hexaconazole (Rs. 16.15 lakh/ha) and the lowest net profit of Rs. 4.47 lakh/ha was obtained from the treatment of garlic cloves extract.

The percent monetary returns from different treatments showed that the range of monetary returns was from 21.48 to 97.18 per cent. The highest monetary returns of 97.18 per cent were obtained from the treatment of Carbendazim and the lowest monetary returns of 21.48 per cent from the treatment garlic cloves extract.

Table 7 Economics of different treatments for the control of powdery mildew of rose

	Treatments	P.D.I	Yield No. of fl/ha	Gross income (Rs/ha)	Total cost of fungicide Rs/ha	Spraying charges Rs100/spray + harvesting charges	Net Income (Rs/ha)	Additional monetary return over control (Rs/ha)	% monetary Return over control	Cost benefit ratio
T1	Wettable Sulphur (0.07%)	6.13 (14.33)	21,10,041	42,20,082	302.40	176136.75	4043642.9	19,61,459.6	94.20	1:11.14
T2	Wettable Sulphur (0.1%)	7.70 (16.07)	18,32,086	36,64,172	432	305647.67	3358092.3	12,75,909	61.27	1:4.17
T3	*T. viride* (0.2%)	17.116 (24.42)	16,21,807	32,43,614	1764	270601.17	2971248.8	8,89,065.5	42.69	1:3.28
T4	*T. harzanium* (0.2%)	16.52 (23.78)	15,27,544	30,55,088	1764	254890.67	2798433.3	7,16,250	34.40	1:2.8
T5	T_3 +T_4 (0.2%) 0.1% each	13.86 (21.84)	15,63,799	31,27,598	1764	260933.17	2864900.8	7,82,717.5	37.59	1:2.99
T6	Difencanozole (0.05%)	2.22 (8.57)	21,75,300	43,50,600	1885	362850	3985865	19,03,681.7	91.43	1:5.246
T7	Penconazole (0.05%)	3.2 (10.286)	21,00,373	42,00,746	1778	350362.17	3848605.8	17,66,422.5	84.83	1:5.041
T8	Carbendazim (0.05%)	2.75 (9.46)	22,40,559	44,81,118	1732.50	373726.5	4105659	20,23,475.7	97.18	1:5.041
T9	Hexaconazole (0.05%)	3.93 (11.36)	20,18,195	40,36,390	2205	336665.83	3697519.2	16,15,335.9	77.58	1:4.798
T10	Nimrod (0.05%)	13.48 (21.50)	17,98,248	35,96,496	630	300008	3295858	12,13,674.7	58.29	1:4.045
T11	Garlic cloves (6%)	27.8 (31.83)	13,80,107	27,60,214	360	230317.83	2529536.2	4,47,352.9	21.48	1:1.942
T12	Water spray	25.46 (30.22)	14,23,613	28,47,226	-	237568.83	2609657.2	5,27,473.9	25.33	1:2.22
T13	Absolute control	57.58 (49.36)	11,35,900	22,71,800	-	189616.67	2082183.3	-	-	-

1. Total quantity of Wettable Sulphur (0.07%) required for three sprays- 3.15 kg /ha @ Rs. 96/kg.
2. Total quantity of Wettable Sulphur (0.1%) required for three sprays- 4.5 kg /ha @ Rs. 96/kg.
3. Total quantity of *Trichoderma viride* (0.2%) required for three sprays- 9.0 kg /ha @ Rs. 196/kg
4. Total quantity of *Trichoderma harzanium* (0.2%) required for three sprays- 9.0 kg /ha @ Rs. 196/kg
5. Total quantity of $T_3 + T_4$ (0.2%) required for three sprays- 9.0 kg /ha @ Rs. 196/kg
6. Total quantity of Difencanozole (0.05%) required for three sprays- 2.25 lit/ha @ Rs. 837/lit
7. Total quantity of Carbendazim (0.05%) required for three sprays- 2.25 kg/ha @ Rs. 770/kg
8. Total quantity of Penconazole (0.05%) required for three sprays- 2.25 lit/ha @ Rs. 790/lit
9. Total quantity of Hexaconazole (0.05%) required for three sprays- 2.25 lit/ha @ Rs. 980/lit
10. Total quantity of Nimrod (0.05%) required for three sprays- 2.25 lit/ha @ Rs. 280/lit
11. Total quantity of Garlic Cloves extract required for three sprays- 9 kg/ha @ Rs. 40/lit
12. Total labour charges required for three sprays- Rs. 100/spray
13. Selling price Rs. 2/ flower stalk

Considering, the economics i.e. net additional returns and percent monetary returns, the fungicides Carbendazim (0.05%), Wettable Sulphur (0.07%), Difencanozole (0.05%), Penconazole (0.05%) and Hexaconazole (0.05%) were found to be more economical (as represented in fig. 7) .

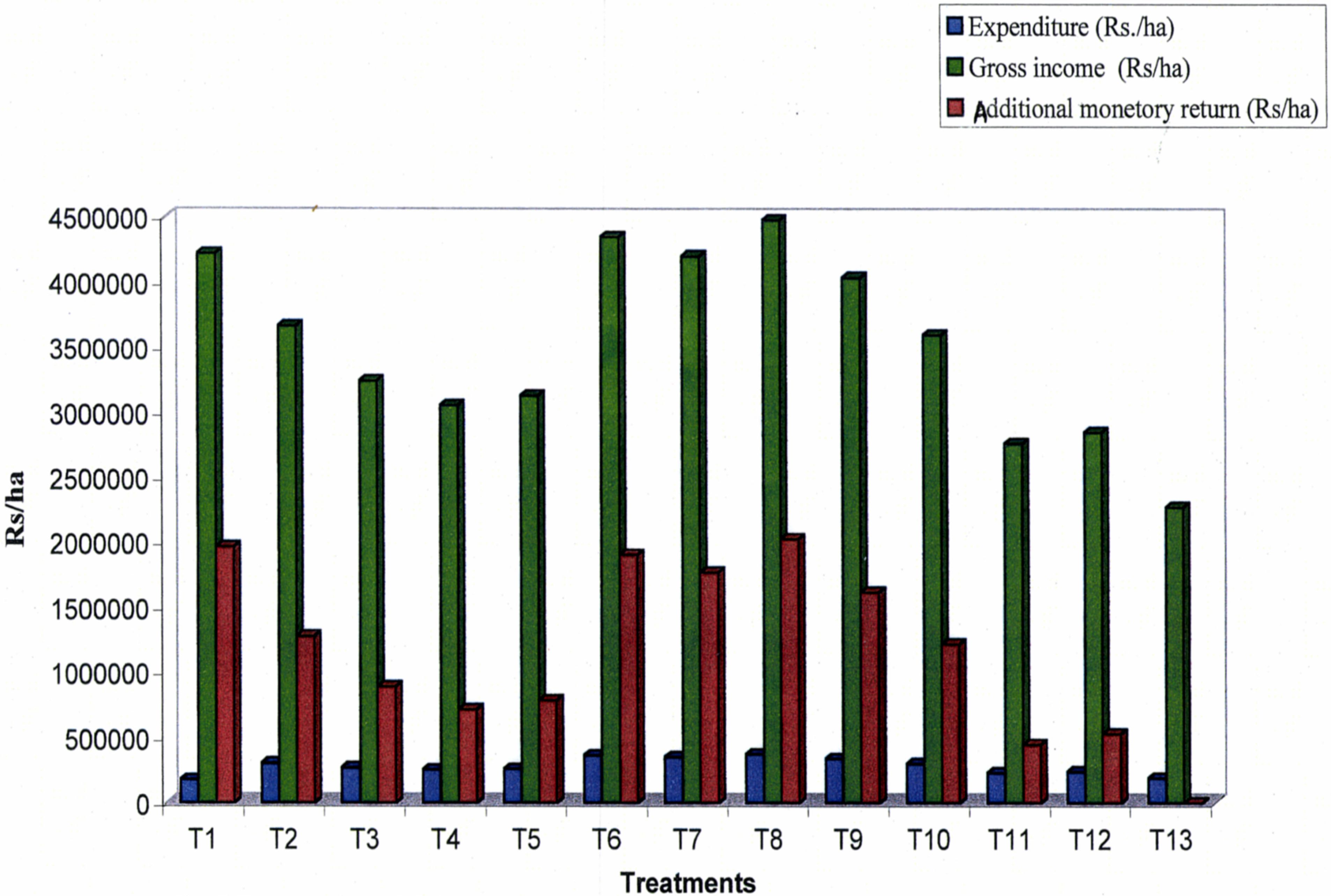

Fig.7 Economics of differnt treatments employed for the control of powdery mildew of rose

Chapter Opener Page

DISCUSSION

5. DISCUSSION

The experimental results obtained in respect of effect of fungicides, and biocontrol agents on rose powdery mildew has been discussed by reviewing available literature.

5.1 Fungicidal control of powdery mildew of rose

The evaluation of fungicides in polyhouse indicated that the fungicides under test were found effective in controlling the powdery mildew in varying degree.

The treatment Difencanozole (0.05%) gave maximum (96.13%) disease control followed by Carbendazim (95.22%), Penconazole (94.44%), Hexaconazole (93.16%) and Wettable Sulphur (89.34%).

Wojdyla (1994) observed Difencanozole to be the most effective while Costache *et al.* (1995) obtained good control with Carbendazim against rose powdery mildew. Similar results were obtained by Sahni(1988) with Carbendazim, even under high inoculum pressure. No phytotoxicity was observed.

Venkataramana *et al.* (1993) also obtained good control of powdery mildew of rose with Sulphur.

Paulus and Nelson (1988) carried out an experiment for control of powdery mildew of rose and recommended Penconazole for the effective control of powdery mildew of rose. Similarly Mathur *et al* (1991) and Nikolov (1992) also observed the similar results with Penconazole.

According to Wojdyla (1999) Nimrod was very effective against rose powdery mildew. The treatments were performed after the appearance of the first symptoms and repeated at seven days interval.

Lam and Lim (1993) obtained good control of rose powdery mildew with Hexaconazole. No phytotoxic symptoms were evident on rose plants and also a quality of flowers was improved. Similarly, Dhruj et al (1994) and Perez and Lozoya (1994) observed that Hexaconazole significantly reduced the infection level.

5.2 Evaluation of biocontrol agent in management of powdery mildew of rose

Trichoderma viride, Trichoderma harzanium and mixture of both *T. viride* and *T. harzanium* were tested against powdery mildew of rose. These biocontrol agents were found effective in controlling the powdery mildew of rose. The treatment with the mixture of *T. viride* and *T.harzanium* gave good control (75.92%) follwd by *T.harzanium* (71.58%) and *T. viride* (70.27%).

Deshmukh *et al.* (1994) have reported that *Trichoderma harzanium* Rifai and *Trichoderma viride* Pers. to be the most efficient mycoparasites on wide range of seed and soil borne fungi.

&, solano

Martinez (1995) studied the antagonism of *Trichoderma* sp. to *Alternaria solani* and obtained the good results.

Babu *et al.* (2000) studied the efficacy of fungal antagonists against leaf blight of tomato. *Trichoderma viride* and *Trichoderma harzanium* were significantly effective in inhibiting the mycelial growth of *A. solani.*

Li Mei Yun *et al.* (2001) selected for *Trichoderma* isolates applicable in biocontrol of major fungal diseases of tobacco. All the isolates retarded, to different degrees, the growth of *Glomerella cingulata, Pythium* sp., *Alternaria alternata, Phytopthora parasitica* var. *nicotianae* and *Rhizoctonia solani*, through competition, antibiosis and hyparparasitism.

5.3 Antifungal properties of plant extract (Garlic Cloves) on the pathogen

The antifungal properties of plant extract (Garlic Cloves) were studied by recording observations on per cent disease control by the foliar sprays.

Tynecka (1973) and Amonkar (1979) have reported inhibitory action of garlic (*Allium sativum*) on growth and respiration of some plant pathogenic fungi.

Agarwal and Pushpa (1978) have also observed that clove extract of garlic suppressed the growth of *Fusarium monoliforme* and *Fusarium humicola*.

Yadav (1986) while working with clove extract of garlic observed complete inhibition of spore germination and mycelial growth of *Fusarium oxysporum* f. sp. *ciceri.*

Tariq *et al.* (1990) studied effect of volatiles from garlic bulb extract on *Fusarium oxysporum* f. sp. *lycopersici* and observed suppression of growth of the fungal pathogen.

Shivpuri *et al.* (1997) studied fungitoxic properties of plant extracts including garlic cloves against pathogenic fungi and obtain satisfactory control of the fungal pathogen.

5.4 Flower yield of roses as influenced by management practices

The fungicides tested against powdery mildew of rose had significant influence on the yield of flowers per plant and yield of flowers per square meter.

The yield of flowers per plant increased as the disease intensity decreased. The yield of flowers per square meter depends on the yield of flowers per plant, it has an additive effect per unit area. The highest yield of flowers per plant was observed in the plots treated with Carbendazim

(224.05 flowers/m^2) and the lowest yield was recorded in control (113.59 flowers/m^2).

Sobti *et al.* (1996) conducted studies in the commercial rose production areas in the Pushkar valley of Rajasthan, to determine effect of powdery mildew on fresh flower yield of rose. They have reported that there was a significant reduction in flower yield in disease categories 4-7 (25-56.39 % yield loss) as compared with healthy check.

5.5 Economics of the control measures of powdery mildew of rose under polyhouse conditon

For working out the economics of different treatments the cost of fungicides and biocontrol agents, labour charges required for spraying and harvesting were considered for calculating the net additional monetary returns. The data revealed that the percentage monetary returns were highest from Carbendazim (97.18%) followed by Wettable Sulphur (94.20%), Difencanozole (91.43%) and Penconazole (84.83%).

In view of these observations, the fungicides Carbendazim (0.05%), Wettable Sulphur (0.07%), Difencanozole (0.05%) and Penconazole (0.05%) can be recommended for spray to control powdery mildew of the roses.

5.6 The quality of rose flowers as influenced by different treatments

Flower quality parameters like length of the flowering shoot and diameter of flower bud were significantly affected by different treatments.

The length of flowering shoot was maximum in treatment of Difencanozole (70.35 cm) followed by Hexaconazole (67.47 cm). Carbendazim (67.33 cm) and Penconazole (66.57 cm).

The observations on quality parameters revealed that diameter of flower bud significantly influenced due to treatments indicating beneficial effect of fungicidal treatments in improving quality of flowers. The highest trend of the diameter of flower bud was observed due to Difencanozole (2.22 cm) while lowest was recorded in control (1.98 cm).

SUMMARY

6. SUMMARY

The maximum yield realization with exportable flower production can be very well achieved with Hi-tech floricultures. This has been shown by many growers of India and particularly of Maharahstra. Suitable varieties of the flower crops like roses are now available for this purpose, which are either introduced or locally bred.

Rose (*Rosa indica*) is one of the important commercial flower crops which also grown under protected cultivation. However, this crop suffer from many biotic stresses like plant diseases *viz.,* powdery mildew (*Sphaerotheca pannosa* var. *rosae*), dieback (*Diplodia rosarum*), black spot (*Diplocarpon rosae*) and rust (*Phragmidium* sp.).

Amongst these diseases, powdery mildew caused by (*Sphaerotheca pannosa* var. *rosae*) is always taking a big toll in the field as well as polyhouses and therefore, management of this important malady is important. Therefore, experiment to evaluate efficiency of different fungicides and biocontrol agents in managing the powdery mildew was conducted at Department of Plant Pathology and Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune-5 during August, 2002 to March, 2003.

The variety First red which was planted on 19th March, 2002 was used for experimentation. The fertilizer dose of 150 : 50 : 150 ppm N, P and K was given per plant per day. The study revealed that Difencanozole (0.05%) to be most effective followed by Carbendazim (0.05%), Penconazol (0.05%), Hexaconazole (0.05%) and Wettable Sulphur (0.07%).

The quality parameters and yield parameters were significantly influenced by different treatments. Highest yield was obtained from Carbendazim followed by Difencanozole, Penconazole and

Hexaconazole. The biocontrol agents, *Trichoderma viride* and *Trichoderma harzanium* were also observed to control the disease upto the extent 70.27 per cent and 71.58 per cent, respectively. The fungicides in the order of Carbendazim (0.05) Difencanozole (0.05%), Penconazole (0.05%) and Hexaconazole (0.05%) were found to be effective and economical in managing powdery mildew of roses.

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*** Originals not seen**

APPENDIX

8. APPENDIX

Meteorological data during the period of investigation Weekly averages of meteorological parameters during the experimental period in the polyhouse

m. w.	Meteorological Month & Date	Temperature ^0C		Relative humidity %	
		T_{max}	T_{min}	Morning RH-I	Evening RH-II
10	5-3-02 to 11-3-02	36.70	16.59	69.41	15.21
11	12-3-02 to 18-3-02	38.89	22.65	65.79	28.12
12	19-3-02 to 25-3-02	37.30	16.79	69.00	15.00
13	26-3-02 to 2-4-02	37.43	17.22	65.69	22.12
14	3-4-02 to 9-4-02	38.00	21.00	60.11	18.10
15	10-4-02 to 16-4-02	37.86	21.29	61.27	17.89
16	17-4-02 to 23-4-02	39.25	20.65	56.40	23.81
17	24-4-02 to 30-4-02	38.81	21.27	59.40	28.11
18	1-5-02 to 7-5-02	39.30	23.70	62.45	18.22
19	8-5-02 to 14-5-02	40.00	25.75	62.00	22.00
20	15-5-02 to 21-5-02	37.79	21.49	71.21	30.59
21	22-5-02 to 28-5-02	36.33	24.60	74.11	39.21
22	29-5-02 to 4-6-02	36.00	23.10	72.00	40.00
23	5-6-02 to 11-6-02	33.30	21.00	83.00	35.40

24	12-6-02 to 18-6-02	33.40	23.00	80.00	36.49
25	19-6-02 to 25-6-02	31.52	20.00	86.69	47.00
26	26-6-02 to 2-7-02	29.39	16.59	87.00	50.69
27	3-7-02 to 9-7-02	27.15	17.58	87.65	67.39
28	10-7-02 to 16-7-02	28.45	20.60	85.79	68.00
29	17-7-02 to 23-7-02	29.00	22.80	75.00	68.00
30	24-7-02 to 30-7-02	29.41	23.89	87.00	51.62
31	31-07-02 to 6-08-02	26.3	17.8	66.00	71.62
32	7-08-02 to 13-08-02	25.7	16.3	62.00	69.00
33	14-08-02 to 20-08-02	26.9	17.00	65.00	72.00
34	21-08-02 to 27-08-02	25.8	16.2	67.00	72.00
35	28-08-02 to 4-09-02	26.2	17.9	63.00	74.00
36	5-09-02 to 11-09-02	25.0	25.75	65.00	68.00
37	12-09-02 to 18-09-02	25.7	17.2	67.00	76.00
38	19-09-02 to 26-09-02	26.4	18.00	64.00	72.00
39	27-09-02 to 03-10-02	27.6	16.9	63.00	70.00
40	04-10-02 to 10-10-02	27.9	17.5	69.00	74.00
41	11-10-02 to 16-10-02	27.9	23.10	64.00	76.00
42	17-10-02 to 23-10-02	26.0	16.59	63.00	72.00
43	24-10-02 to 29-10-02	25.5	17.58	65.00	69.00
44	5-11-02 to 11-11-02	26.8	16.3	63.00	71.00

45	12-11-02 to 18-11-02	25.9	17.0	60.00	68.00
46	19-11-02 to 25-11-02	25.0	16.2	63.00	71.00
47	26-11-02 o 02-12-02	26.8	16.7	59.00	74.00
48	3-12-02 to 09-12-02	25.9	15.6	59.00	69.00
49	10-12-02 o16-12-02	26.0	14.2	61.00	68.00
50	13-12-02 to 23-12-02	26.3	12.5	64.00	72.00
51	17-12-02 to 23-12-02	26.9	11.9	64.00	74.00
52	24-12-02 to 31-12-02	27.1	13.5	60.00	69.00
1	1-1-03 to 7-1-03	28.32	10.11	89.25	34.00
2	8-1-02 to 14-1-03	27.57	12.24	90.20	38.10
3	15-1-03 to 21-1-03	28.10	10.90	88.11	33.69
4	22-1-03 to 28-1-03	28.61	10.40	89.20	35.90
5	29-1-03 to 4-2-03	29.70	13.40	87.35	33.88
6	5-2-03 to 11-2-03	32.10	15.90	81.00	31.29
7	12-2-03 to 18-2-03	33.52	14.21	80.72	30.72
8	19-2-03 to 25-2-03	33.00	15.00	79.70	28.23
9	26-2-03 to 4-3-03	34.73	15.29	79.00	26.10

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VITA

9.VITA

MS. UDAWANT SHILPA NANDKISHOR

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

PLANT PATHOLOGY

2003

TITLE OF THESIS	:	Management of powdery mildew of rose under polyhouse condition
MAJOR FIELD	:	Plant Pathology
BIOGRAPHICAL INFORMATION		
PERSONAL	:	Born at Pune, Dist. Pune, on 10^{th} October, 1979. Daughter of Sou. Sandhya and Shri. Nandkishor Ramchandra Udawant.
EDUCATIONAL	:	Completed secondary education from Kanya Vidya Mandir High School, Ahemednagar with distinction in 1995 and Higher Secondary education from Residential Jr. College, Ahmednagar with distinction in 1997. Received B.Sc. (Agri.) degree from College of Agriculture, Pune, of Mahatma Phule Krishi Vidyapeeth, Rahuri, with distinction in 2001: