

**DEVELOPMENT AND PERFORMANCE
EVALUATION OF POWER TILLER
OPERATED BOOM SPRAYER
FOR GRAPE VINEYARD**

By

Shantaram Balasaheb Gite

B. Tech. (Agril. Engg.)

A Thesis Submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413722, DIST - AHMEDNAGAR
Maharashtra State (India)**

in partial fulfilment of the requirements for the degree

of

MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING)

in

FARM MACHINERY AND POWER

**DEPARTMENT OF FARM MACHINERY AND POWER
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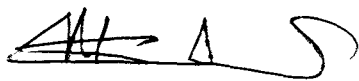
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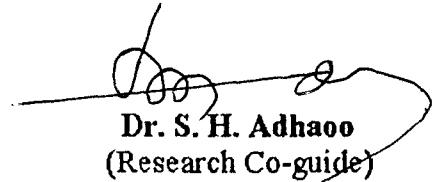
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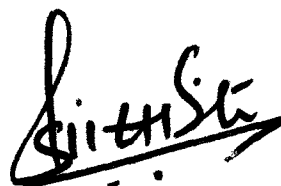
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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
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by me or other person to
any other University
or Institute for
a Degree or
Diploma.

Place : MPKV, Rahuri.

Dated : 30 / 12 / 1998



(SHANTARAM B. GITE)


CERTIFICATE

This is to certify that the thesis entitled, "DEVELOPMENT AND PERFORMANCE EVALUATION OF POWER TILLER OPERATED BOOM SPRAYER FOR GRAPE VINEYARD" submitted to the Faculty of Agricultural Engineering, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra State) in partial fulfillment of the requirements for the award of the degree of MASTER OF TECHNOLOGY (AGRICULTURAL ENGINEERING) in FARM MACHINERY AND POWER, embodies the results of the *bona fide* research work carried out by SHRI S.B. GITE, under my guidance and supervision and that no part of the thesis has been submitted to any other University or Institute for any Degree or Diploma.

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

Place : M.P.K.V., Rahuri

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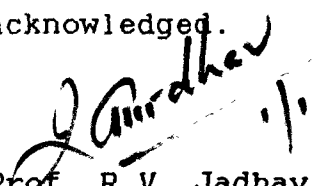
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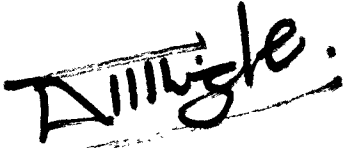
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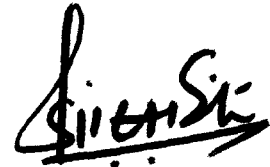
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(SHANTARAM B. GITE)

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LIST OF ABBREVIATIONS

ABBREVIATIONS	DESCRIPTION
a.c.	Alternating current
A.D.	Ano Domini
Agril.	Agricultural
Av.	Average
cc/min	Cubic centimetre per minute
C.D.	Critical Difference
cm	Centimetre
Contd.	Continued
Dist.	District
DPD	Droplet density
et al.	And others
etc.	Etcetra
Fig.	Figure
gm/l	gramme/litre
G.I.	Galvanised iron
ha	Hectare
HP	Horse power
hr	Hour(s)
HTP	Horizontal triplex piston
i.e.	That is
kg	Kilogramme
kg/sq.cm	Kilogramme per square centimetre
kmph	Kilometre per hour
l/ha	Litres per hectare
l/min	Litres per minute

Contd...

List of abbreviations contd...

ABBREVIATIONS	DESCRIPTION
m	metre
mm	millimetre
μm	Micrometre
ml/min	Millilitre per minute
M.P.K.V.	Mahatma Phule Krishi Vidyapeeth
m.s.	mild steel
N	travel speed
NMD	Number median diameter
No/sq.cm	Numbers per square centimetre
NS	Non significant
P	System Pressure
rpm	Revolutions per minute
S.E.	Standard error
UC	Uniformity coefficient
V	Volts
VMD	Volume median diameter

ABSTRACT**DEVELOPMENT AND PERFORMANCE EVALUATION OF POWER TILLER
OPERATED BOOM SPRAYER FOR GRAPE VINEYARD**

By

SHANTARAM B. GITE

A candidate for the degree of

MASTER OF TECHNOLOGY (AGRIL.ENGG.)**FACULTY OF AGRICULTURAL ENGINEERING,
MAHATMA PHULE KRISHI VIDYAPEETH,
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1998

Research Guide : Dr. S.B. Ghadge
Department : Farm Machinery and Power

Grape (*Vitis vinifera* L.) is a worldwide popular fruit due to its taste and fruit of juicy nature. This grape crop is more susceptible to pests and diseases as such normally needs 25 to 38 applications of insecticides or pesticides in a year.

The conventional methods of spraying in grape vineyard are labour intensive and time consuming. Also, proper penetration and spray volume deposition are not obtained. Average farmer can not afford larger tractor for spraying. To overcome these drawbacks, the present studies were undertaken to develop and evaluate the performance of power tiller operated sprayer to meet the requirements. The power tiller operated sprayer, for bower system, was designed, fabricated

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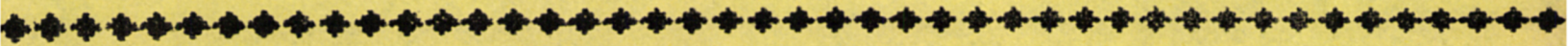
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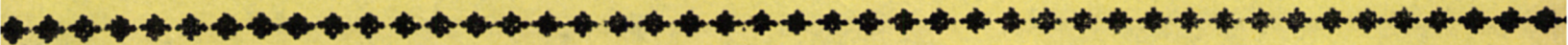
and tested in laboratory for cone angle, discharge and spray distribution. The sprayer was also tested in the field for droplet density, spraying uniformity and droplet size distribution. The sprayer gave uniform deposition at low speed. Optimum droplet density (31 droplets per sq.cm) was obtained at bottom locations at treatment combination of travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm. Only treatment combination of N_1P_3 i.e. travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm is suitable for spraying in grape vineyards as it gave optimum droplet densities for effective pest control.

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Chapter Opener Page



Introduction



1 . INTRODUCTION

Fruits has been grown in India for thousands of years, and occupy today a position of considerable importance. Indians, from the very beginning have been lovers of fruits and flowers. Planting of orchards in the earlier times was mainly confined to affluent class and was considered to be a status symbol. The scenario has changed and fruit trees are grown on commercial basis for nutritional purpose. This art has now gradually developed into one of the most civilized, skillful and intensive forms of land utilization. This is one of the fascinating avocations of farming profession which influences the agricultural economy of the country in a very large measure.

Importance of fruit in human diet is universally recognized. They are the chief source of vitamins, without which the human body can not maintain proper health and resistance to diseases. They also contain certain mineral salts, the deficiency of which can lead to disturbances of metabolism resulting in ill health. India occupies the pride of place in respect of wide range of fruits grown.

The Grape (*Vitis vinifera* L.) is one of the most important remunerative horticultural crops. It is one of the most delicious, refreshing and nourishing fruits rich in minerals, sugars and vitamins. It's juice is stimulating drink for kidneys and is a laxative. In India, 80 per cent of grape production is used for table purpose, 10 per cent for raisins and 10 per cent for wine preparation (Kelkar et al., 1994).

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The area under grape in India is about 60,000 hectare, with more than 1.25 million tonnes of production. This involves marketing turnover of Rs.300 crores in which Maharashtra states share is almost one third . The other major grape growing states in India are Andhra Pradesh, Tamil Nadu, Karnataka, Haryana, Punjab, Uttar Pradesh and Rajasthan.

Grape cultivation in Maharashtra is increasing day by day. This increase was slow till 1950, but rapid between 1950-1960 and got a real spurt after 1960. Government of Maharashtra is also granting loans for this purpose. This sustained interest of agriculturists and the Government is bound to encourage the growth of the area under grapes. Maharashtra claims nearly 30 per cent of total area and leadership in viticulture. In Maharashtra, area under grapes is 18,000 hectares with more than 0.3 million tonnes of production (Kelkar et al., 1994). The important grape growing districts in Maharashtra are Nasik, Sangali, Ahmednagar, Solapur, Pune, Osmanabad and Beed.

Spraying is one of the most important operations in plant and crop protection from the point of view of pests and diseases control. Some of the country's food production is lost due to pests and diseases because they are predominant factors responsible for the reduction in fruit and crop yields. Thus to use the pesticides and insecticides through improved plant protection techniques is only solution to save the food production.

Grape is one of the most susceptible crop to pests and diseases. Generally, 25 to 38 sprayings per year are

required to control the pests and diseases (Vevai et al., 1964). Being time consuming, labour intensive and non-uniform, the conventional method of spraying is not suitable to control the pests and diseases on the grape vines. An accurate amount of pesticide should be applied at right time and at right place. Chemical control is the only effective method of controlling most of insects, pests, weeds and diseases (Smith, 1970). Chemical pesticides played and continue to play major role in increasing agricultural production. Sprayers and dusters are prominent pesticide application equipments.

A sprayer must meet the following requirements

- a. Uniform spraying job,
- b. Desired droplet size and
- c. Minimizing the application rate of formulations to control insects, pests and diseases.

Several types of sprayers for orchards have been developed for the use, but boomless nozzles showed an uneven application and poor control of pests. If the application is low, poor or little, little control will result and over application may result in quick burning of plant canopy. A boom sprayer is the best to produce uniform spray pattern (Jacob, 1990). Therefore, research work on boom sprayer was undertaken to fulfill above requirements.

Now a days, two wheel tractors are available and are being used by the farmers. It is generally used for light agricultural operations like tilling the land, puddling the rice fields and haulage etc. It was, therefore, felt necessary to find out how small tractor could be increasingly used for

various agricultural operations to make it more versatile. Therefore, it was proposed to develop a sprayer which could be used with the power tiller for spraying in orchards.

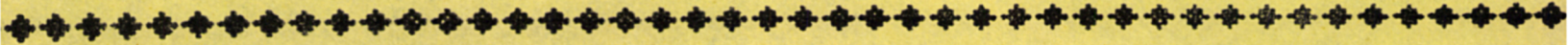
In a country like India, two wheel tractor is most suitable which unlike large tractors would replace animal labour but not human labour and would be consistent with country's objectives of promoting economic development, employment and better income distribution (Hamid, 1973).

Drudgery and physical exertion are much in agriculture. It scares men of intelligence and reduces affinity towards agriculture. An operator with knapsack sprayer has to walk 5 to 10 kms for spraying one hectare of grape vineyard. Carrying the sprayer on back leads to exertion. This drudgery can be eliminated with the help of power tiller operated orchard sprayer.

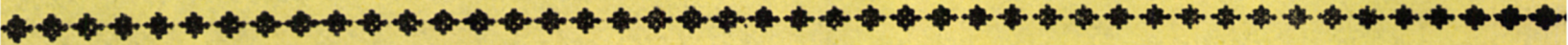
In the light of above background, the study was undertaken with the following objectives,

1. To develop a hydraulic sprayer to install on a power tiller suitable for bower type grape vineyard.
2. To test the developed hydraulic sprayer in the laboratory.
3. To evaluate the field performance of developed hydraulic sprayer.

Chapter Opener Page



Review of Literature



2 . REVIEW OF LITERATURE

This chapter deals with the research work done in the past by various investigators on the topic under study.

The first section deals with the information regarding grape crop, it's cultivation and the various pests and diseases attacking it. Second section deals with the need to control pests, spray classification, general spray programme and techniques and equipments used for pest control. Thirdly the new developments on boom spraying are taken into account. Lastly, study of power tiller, power tiller operated sprayer and pumps are discussed.

2.1 Grape crop (*Vitis vinifera* L.)

Grape (*Vitis vinifera* L.) is a favourite fruit of semi-arid and subtropical countries. Vevai et al. (1964) revealed that grape crop was originated in Armenia near Caspian sea. From this region, it spread to Mediterranean region, eastern part of Afghanistan and India. It was introduced into India during 1300 A.D. by invaders from Iran and Afghanistan. Muslim rulers brought the grapes from North to South India.

In Maharashtra, commercial cultivation started in 1930 in Nasik district.

Bose (1986) quoted the following information regarding grape crop.

2.1.1 Climate

Grape requires dry summers and cool winters with moderate rainfall. Dry cloudless weather during flowering and

fruit setting and development is must for successful cultivation. Optimum temperature range is 28°c to 32°c. Very high temperature causes scorching of leaves. Very low temperature results in hardening of berries and of new growth after October pruning.

2.1.2 Soil

Grape can be grown on wide range of soil types. Well drained, fertile, one m deep soil is good for grape cultivation. Medium, alluvial or loamy soils are the best choice. PH range for it's cultivation is 6.0 to 8.5. Soil should be free from harmful salts like Na and Ca. Very heavy and ill drained soils are rejected.

2.1.3 Varieties of grapes

Grape varieties are classified broadly on the basis of use and presence or absence of seeds. There are about 10,000 varieties of grape in the world. In India, seeded varieties are Champa, Bhokri, Anabe-shahi, Champion, Chemashebi, Gold, Bangalore purple, Early muscat, Gulabi, Kalisahebi, Pandharisahebi etc. Seedless varieties are Thompson seedless, Beaty seedless, Pusa seedless, Perlette, Kishmish beli, Sharad seedless, Cordinal, Kishmish Chorni, Maru seedless, Arkavati, Nilmani, etc.

2.1.4 Planting distance

Plant to plant and row to row spacings for grape vines depends mainly upon variety. Vigorous varieties (Anabe-shahi) need more spacing than less vigorous ones (Gulabi). In heavy soils, spacing is more than light soils. It changes

according to training system, region etc. Some preferred spacings are 2.4 m x 1.2 m, 2.4 m x 1.8 m, 3 m x 2.4 m and 3 m x 1.5 m.

2.1.5 Propagation

There are only two methods of propagation of grape vines. They are sexual and asexual. The sexual method is employed chiefly for evolving new varieties through hybridization. In asexual method, vines are multiplied by vegetative parts such as branches, buds, canes, etc. Among these, propagation by hard wood cutting, budding, grafting, layering and tissue culture are commonly done. Cuttings from matured canes from October pruning with 3 to 5 buds are preferred for propagation by hard wood cuttings.

2.1.6 Planting season

October-January is common period of planting. In Tasgaon method, planting is done in April-June. In-situ planting is done in October or April or rooted cuttings are planted in January-June.

2.1.7 Planting method

Land is leveled, green manured to add enough organic matter. Planting should be done in north-south direction to enjoy full sunshine.

Methods of planting are

1. Trench method :

Mostly adopted where planting distance is less. In heavy soils, trenches are dug and soil is replaced with light

loamy soils. Trench of size 60-70 cm deep and 60-90 cm wide is opened, filled with organic matter, well drained loamy soil and compost.

2. Pit method :

Pit size of 60 cm x 60 cm x 60 cm are dug at desired distance and filled with good soil, compost and green manure.

2.1.8 Training

It primarily concerns the form and framework of the vine to obtain maximum benefits. Scientifically, training is nothing but judicious removal of any plant part to give a proper shape, it facilitates different operations like pruning, plant protection, interculture, harvesting etc.

Different training systems are

1. Head system
2. Bower/ Pergola/ pendal system
3. Cordon system
4. Kniffen system
5. Overhead trellies system
6. Y - system
7. Expanded Y system

Kelkar et al. (1994) revealed that Bower or Pergola system is the best training system which is commercially followed in Maharashtra.

2.1.9 Pruning

Pruning is nothing but an art and science of removing scientifically certain parts of plant with a view to divert sap flow towards fruiting area to induce vegetative and fruitful growth.

Time of pruning in Maharashtra is given bellow

A) April pruning

Purpose : For vegetative growth

Time : Middle of March to middle of April

B) October pruning

Purpose : For fruit growth

Time : Middle of September to middle of October

2.1.10 Important insects and diseases of grape

2.1.10.1 Insects

There are different 50 pests found attacking grape vine and it's fruit in different grape growing regions of the world. Insects constitute the major population of pest.

Jotwa et al. (1980) listed following major pests of grape crop.

1. Grapevine flea beetle (*scelodonta stigicollis*)
2. Thrips (*scirtothrips dorsalis*)
3. Rose chafer (*Adoretus* sp.)
4. Scales (*Lecanium* sp.)
5. Red spider mites (*Tetranychus* sp.)
6. Cane girdler (*Sthenias grisator*)
7. Bark borer (*Batocera* sp.)
8. Termites (*Cyclotermes* sp.)

2.1.10.2 Diseases

Grapes are susceptible to a number of diseases mostly caused by fungus. Diseases which commonly occur in India are

1. Downy mildew (Kevdya)
2. Anthracnose or Bird's eye spot (Karpa)
3. Dead arm (Fandi mar) ^{विलंब रोग}
4. Powdery mildew (Bhuri Rog)
5. Cracking of the grape berries (Fal futane Rog)

^{बक} ^{यु. रोग}

2.2 Need to Control Pests

Matthews (1979) pointed out that pests were man's chief competitors on the earth. They fed on his crop and some of his possessions. They transmitted diseases to him and his domesticated animals. Organisms that had become pests often included insects, fungi, bacteria, viruses, weeds, nematodes, rodents and birds. About one third of the potential agricultural production in the world was annually lost to the pest.

Patel (1963) estimated that, percentage contribution of damage due to weeds, diseases, insects, rodents, birds and others as 33, 26, 20, 6-8, 1-2 and 1-3 respectively.

2.2.1 Control of pests

The control of pests or diseases can generally be achieved by natural control and control practices applied by man.

Matthews (1984) reported following methods to control the pests.

These methods includes physical, cultural, genetic, electrical, biological, plant resistance, integrated and chemical control.

1. Physical control :

Physical removal of barriers, traps and environmental manipulation.

2. Cultural control :

Crop rotation, cropping system, crop spacing, trap crop, tillage etc.

3. Plant resistance :

Immunity, resistance, tolerance etc.

4. Biological control :

Parasites, predators, viruses, bacteria, fungi, protozoa, nematodes etc.

5. Genetic control :

Male sterile technique, hybrid sterility, chromosomal translocations etc.

6. Chemical control :

Pesticides, insect hormones and pheromones etc.

7. Electrical control :

Electrical circuits for pest repelition and irradiation.

8. Integrated control :

Any combination of either of the above methodologies.

Chemical control of plant diseases and pests is the most popular technique because it gives quick results.

2.2.2 Chemical control

Chemical control is highly complex subject. The application of chemicals to seed, soil and growing crops depends upon the epidemiology of disease and the characteristics of the pesticide to be used.

It is applied for the pathogens on the aerial parts of plant which spread rapidly. Apart from choosing the correct pesticide, problems relating to the placement and timing are particularly critical in chemical control of diseases.

2.2.3 Classification of spray

The spray can be classified based on droplet size and volume application rate (Matthews, 1979) as follows :

Table 2.1. Spray classification based on droplet size

Sr. No.	Description	Range of VMD, μm	Use
1.	Aerosol spray	50	Drift spray against flying insects
2.	Mist spray	50-100	Spray for foliage with very low volume and ULV application
3.	Fine spray	100-200	Spray comprising reduced drift and good coverage
4.	Medium spray	200-400	Spray crop with residual sprays against pest and diseases
5.	Course spray	400	Spray with minimum drift

Table 2.2. Spray classification based on volume application rate

Sr. No.	Description	Application rate, l/ha	
		Field crops	Bushes and trees
1.	Ultra-low volume(ULV)	5	20
2.	Very-low volume(VLV)	5-20	20-50
3.	Low volume (LV)	20-100	50-300
4.	Medium volume (MV)	100-600	300-1000
5.	High volume (HV)	600	1000

Vevai et al. (1964) gives general spray programme for control of grape diseases and pests.

Table 2.3. General spray programme for control of grape diseases and pests (After October pruning)

Appl No.	Month	Stage	Days after October pruning	Diseases or Pests	Control measures
1.	October	beginning	Immediately after pruning	Flea beetle	Guesarol 550 + Blitox 50 + Sulkol
2.	-do-	sprouting bud	5	Flea beetle	Guesarol 550 + Blitox 50
3.	-do-	-do-	15	Anthracoese and Downy mildew	Blitox 50 or Dithane Z-78
4.	-do-	Foliage	20	-do-	-do-
5.	-do-	-do-	25	-do-	-do-
6.	-do-	-do-	30	-do-	-do-
7.	November	Flowering	35	Antracnose, Downy mildew and thrips	Blitox 50 or Dithane Z-78 + Geigy 1250
8.	-do-	-do-	40	-do- + Aphids	Blitox 50 or

Table 2.3. Contd...

Appl No.	Month	Stage	Days after October pruning	Diseases or Pests	Control measures
9.	-do-	-do-	45	Thrips and Downy mildew	Geigy 1250 + Blitox 50
10.	-do-	Young berries	50	Downy mildew	-do-
11.	-do-	-do-	55	-do-	-do-
12.	-do-	-do-	60	Antracnose, Downy mildew and Powdery mildew	Blitox 50 + Sulkol
13.	December	-do-	65	Downy mildew and Podery mildew	-do-
14.	-do-	-do-	70	-do-	-do-
15.	-do-	-do-	75	-do-	-do-
16.	-do-	-do-	80	-do-	-do-
17.	-do-	-do-	85	Mealy bugs	Basudin 20 E or Rogar
18.	-do-	-do-	90	Powdery mildew	Sulkol
19.	January	-do-	95	-do-	-do-
20.	-do-	-do-	100	-do-	-do-
21.	-do-	-do-	110	-do-	-do-
22.	February	Ripe-Grapes	120	-do-	-do-

**Table 2.4 General spray programme for control of grape diseases and pests
(After April pruning)**

Appl. No.	Month	Stage	Days after April pruning	Diseases or Pests	Control measures
1.	April	Sprouting buds	Immediately after pruning	Flea beetle and Downy mildew	Blitox 50 or Dithane Z-78 + Guesarol 550
2.	-do-	-do-	5	Flea beetle	Guesarol 550
3.	-do-	Foliage	15	Anthraco nose or Downy mildew	Blitox 50 or Dithane Z-78
4.	-do-	-do-	25	-do-	-do-
5.	May	-do-	35	Anthraco nose	-do-
6.	-do-	-do-	40	-do-	-do-
7.	-do-	-do-	45	Red spider mites	Rogar 40
8.	-do-	-do-	60	-do-	-do-
9.	June	-do-	70	Anthraco nose Downy mildew and Powdery mildew	Blitox 50 or Dithane Z-78 + Sulkol
10.	-do-	-do-	80	Red spider mites	Akar 338 or Rogar
11.	July	-do-	90	Red spider mites, Jassids and Downy mildew	Blitox 50 + Rogar
12.	-do-	-do-	110	-do-	-do-
13.	August	-do-	125	Anthraco nose, Downy mildew Powdery mildew	Dithane 50 + Sulcol
14.	-do-	-do-	130	-do-	-do-
15.	-do-	-do-	140	-do-	-do-
16.	September	-do-	150	Anthraco nose and Red spider mites	-do-

2.2.4 Techniques and equipments used for pest control

It is observed that proper technique needs to be adopted for the dispersal of chemical and proper equipment is to be selected for applying the various types of chemicals with a view to achieve the required coverage.

Sastry (1985) listed the following spraying techniques with corresponding equipment used.

Table 2.5. Different spraying techniques

Sr. No.	Spraying technique	Name of equipment
1.	High volume spraying	Knapsack hand compression sprayer
2.	Low volume spraying	Knapsack motorised mist blower
3.	Ultra low volume spraying	Fog air mist blower with restrictors.
4.	Fogging	Swing fog machines
5.	Electrodyne spraying	Electrodynamic sprayer
6.	Herbicide spraying	Knapsack sprayer with flat fan nozzle
7.	Dusting	Hand rotary or power duster
8.	Granule application	Granule spreader or granule applicator
9.	Wet dusting	Sprayer cum duster

2.3 Various Developments On Boom Sprayer

Bindra and Singh (1971) developed bullock drawn pneumatic traction sprayer at Indian Institute Of Sugarcane Research, Lucknow. It consisted of a tank, where liquid was

kept under pressure and there was one flexible hose which connected the liquid from tank to boom. The boom was fixed on the frame having 6 nozzles spaced 40 cm apart.

Deshpande (1973) developed a machine for spraying insecticides, fungicides and soluble fertilizers. The equipment was mounted on the back of a draft animal which was readily available to the farmer.

Cannon (1979) designed, developed and tested a wide boom ground sprayer for its effectiveness, field capacity and reliability. The machine was wide enough to cover 24 rows, spaced 1.106 m apart. The actual field capacity of the sprayer was 23.8 ha/hr at ground speed of 16 km/hr.

Ahuja (1979) developed a tractor mounted high clearance sprayer with swath width of 20 m. The field performance of the sprayer was satisfactory except time loss in tank filling and limited height adjustments.

Hofman (1984) developed a 7.3 m spray boom mounted on the bumper of the vehicle for spraying pesticides and herbicides to crop by the side of the road. The inner 3.65 m section was capable of tilting down 20° from the horizontal to follow the slope of the ditch.

2.4 Power Tiller

Hamid (1973) suggested that for a country like India, two wheel tractor was most suitable which unlike large tractors would replace animals but not people and would be consistent with country's objectives of promoting economic development, employment and better income distribution.

Mathur et al. (1985) revealed that, the population of animals being stagnant in coming decade and four wheel tractor could not offer solution to small and medium size farms, due to high initial investment , operational cost and could not be operated in hilly regions. Power tiller offered the major option to achieve desired level of mechanization in that area. Production of power tiller was started in 1963 in India. Till 1982 only 22,700 power tillers could be produced against annual requirement of about 80,000 power tiller.

Verma et al. (1988) found that power tiller with it's matching equipment for different operations was an appropriate and economical source of power. Power tiller with it's matching equipment could be used in raising of orchards and energy plantation like nursery raising, seed bed preparation, field layout, pit digging ,interculturing etc.

2.4.1 Power tiller operated Sprayers

Kaithwal et al. (1988) developed a boom sprayer operated by power tiller. He also developed a tall tree operated a tall tree sprayer operated with the help of power tiller. It was best suited for spraying in tall orchard trees.

Verma et al. (1988) studied the requirement of plant protection measures and according to them, there was a great need of plant protection measures. They carried out experiment at different research centres of power tiller with ASPEE HTP sprayer and found that it's operation was 30-40 per cent cheaper than manual spraying.

Annon (1988) revealed that the time required per hectare for spraying by power tiller was less (1 hr) than manually operated rocking sprayers (7.76 hrs). The cost of spraying per hectare by power tiller was less (Rs.32.76) than that of manually operated rocking sprayer (Rs. 101.00). The height of reach of spray was 600 cm in power tiller sprayer against 400 cm in rocking sprayer.

Kokane et al. (1988) reported that the power tiller operated sprayer was found suitable over manually operated rocking sprayer in view of effectiveness and ease of spraying operation in grape orchards.

Annon (1991) revealed that the developed power sprayer was suitable for pomegranate and citrus crops. Ease in operation, easy adaptation to power tillers, savings of time, labour and chemical, less operating cost were desirable characteristics of power tiller sprayer. By using power tiller orchard sprayer, about 240 pomegranate trees were covered comparative to only 90 trees in case of marut sprayer.

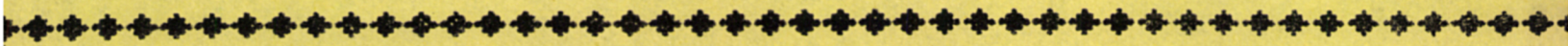
Shinde (1995) designed, developed and evaluated power tiller operated boom sprayer for pomegranate orchard. The hollow cone nozzles (BCN 90750, BAN 75450) were tested in laboratory for discharge and cone angle under various pressures. He concluded that droplet density increases with increase in system pressure, also in travel speed decreases the droplet density. Effect of both, travel speed and system pressures on spray deposition at all locations was found to be significant.

2.4.2 Pumps operated by power tiller


Annon (1991) used Aspee HTP pump as a pressure generating unit. The pump was mounted on handle of power tiller and then driven by a v-belt from flywheel pulley. The pump develops pressure nearly 35 kg/sq.cm.

Matthews (1992) used rotor pump working on power tiller. It developed a discharge of 30 l/min at 950 rpm. The pump consisted of an eccentrically mounted eight slotted rotor running in a housing. On these slots, plastic rollets were kept.

Chapter Opener Page



Material and Methods



3. MATERIAL AND METHODS

This chapter deals with a brief description of the various components of the sprayer, experimental set up and the procedure followed during the experimentation.

3.1 Major components of the sprayer

3.1.1 Trailed type unit

Trailed type unit is a major part of sprayer. It consists of chassis for hitching (Fig. 3.4) and tank carrier on which plastic tank was fitted (Fig. 3.3).

3.1.1.1 Tank carrier

The tank carrier (Fig. 3.3) for mounting the pesticide tank was fabricated in the laboratory. Angle iron of size 40 mm x 40 mm x 4 mm was used to fabricate the frame of the tank carrier. Two load wheels were fixed on underside of the tank carrier with 25 mm shafting.

3.1.1.2 Chassis for hitching

A 2 m long channel of size 76.2 mm x 6.35 mm was used for hitching the tank carrier to the power tiller. The one end of long channel was attached to the power tiller hitch point as shown in Fig. 3.4. Necessary arrangement was made on the channel for hitching it to the power tiller.

3.1.2 Pump

Pump is necessary for increasing the pressure energy of the spray fluid. The required discharge and the pressure were developed with help of Horizontal Triplex Piston

- 1- Boom assembly
- 2- Tank carrier
- 3- Operator seat
- 4- Tank

- 5- Control panel assembly
- 6- HTP pump
- 7- Chasis
- 8- Power tiller

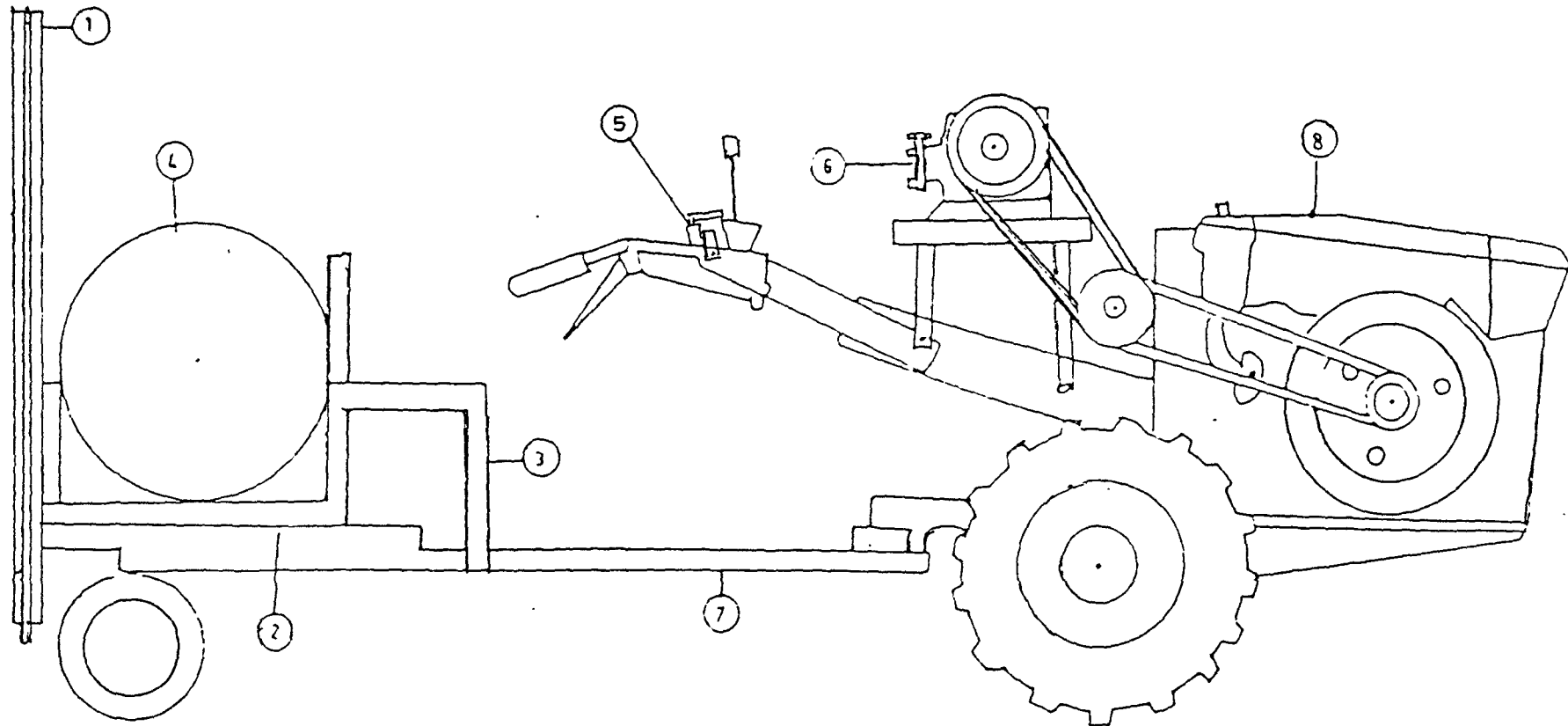


Fig 3.1 Power tiller operated sprayer

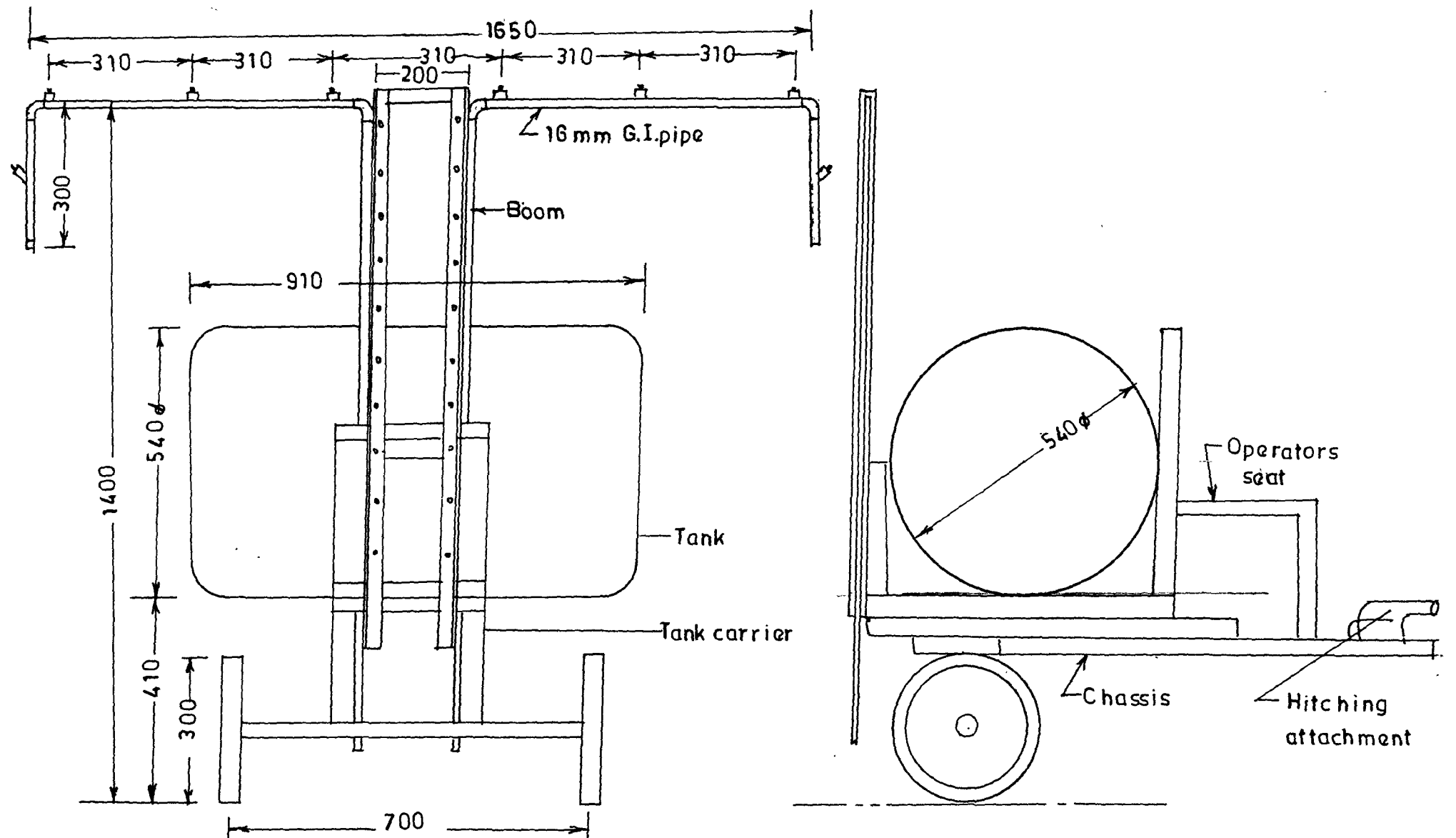
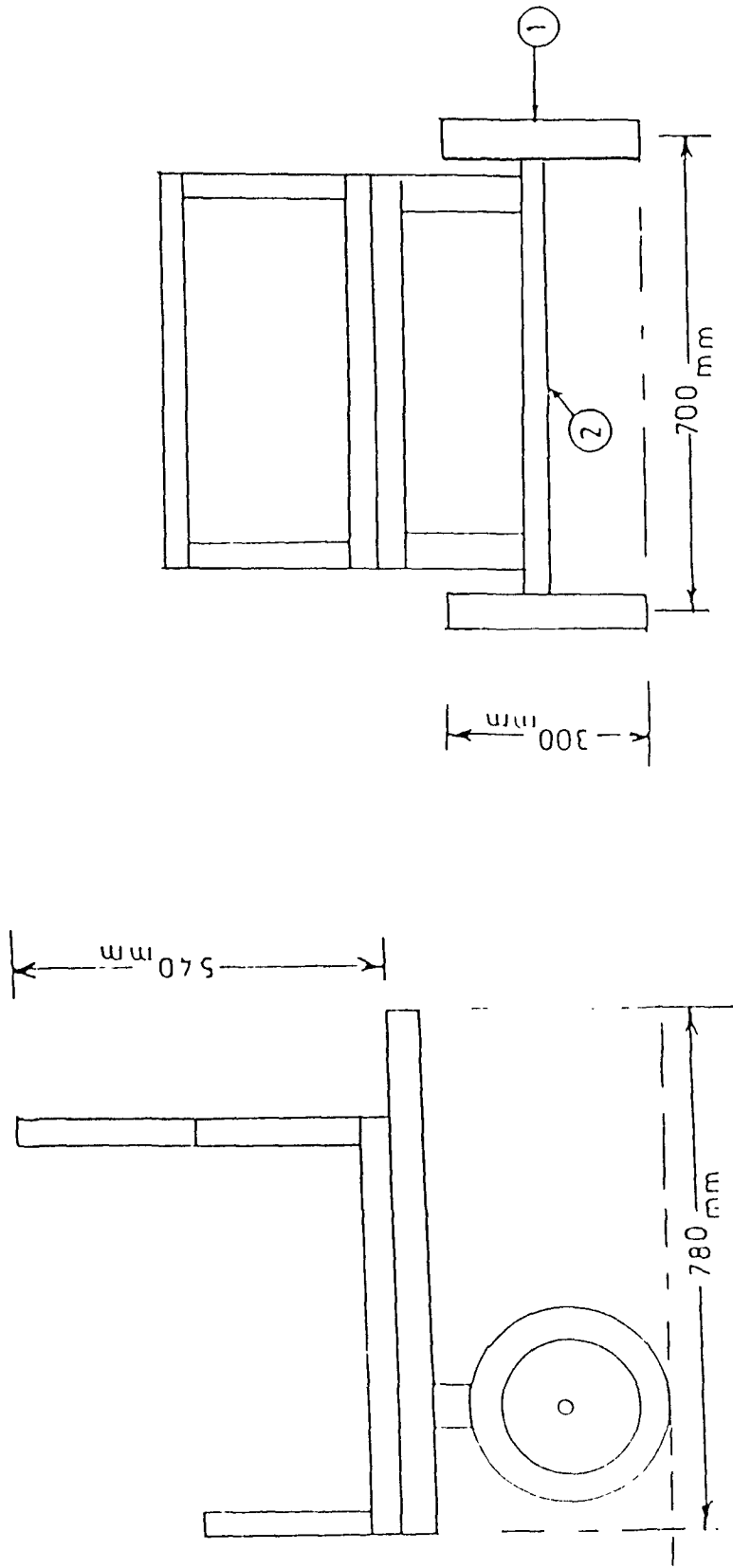
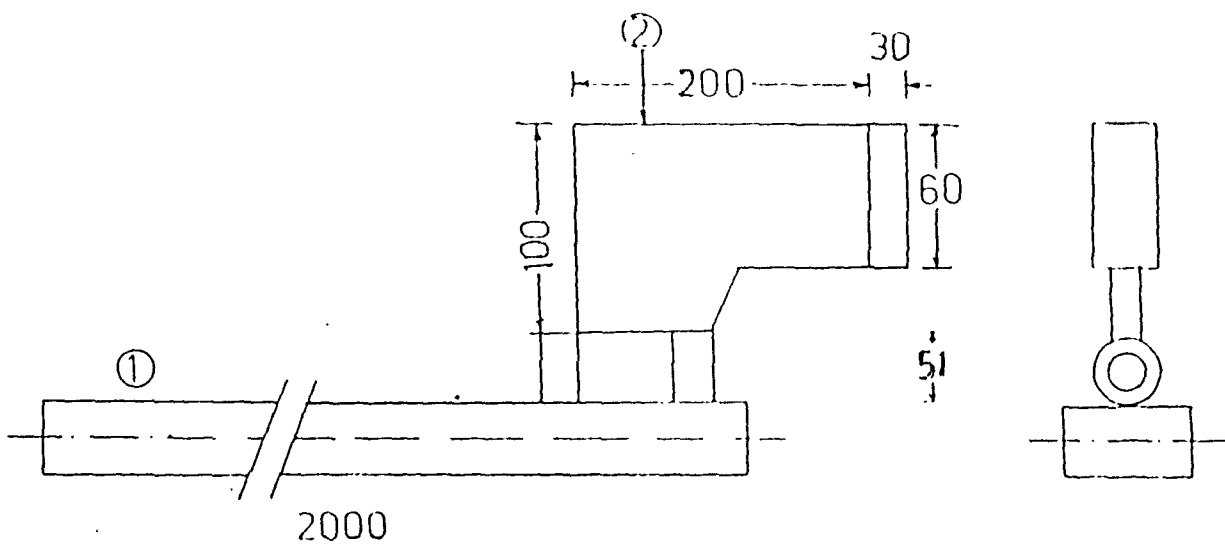


Fig. 3.2 Trailed type unit with boom and tank.



① Load wheel ② Axle

Fig.3.3 Tank carrier



2000

Side view

Front view

1 - Chasis

2 - Hitching adjustment

(All dimensions are in mm)

FIG-3.4 CHASIS FOR HITCHING

(HTP) pump. It developed a discharge of 36 l/min at 950 rpm. Three HP power was required to drive the HTP pump and it developed a pressure of 20 kg/sq.cm. The power to the pump was transmitted from the flywheel pulley to the pump pulley by means of belt and pulley arrangement as shown in Plate 3.6.

3.1.3 Power source

The power to the sprayer was taken from a Mitsubishi shakti C.T. 85/v.w.h.120 water cooled power tiller of 10 HP at 2400 rpm. The power to the pump was taken from the flywheel pulley with V-belt. The specifications of the power tiller are given in Appendix C.

3.1.4 Chemical storage tank

The tank acts as a reservoir for the spray fluid to be sprayed. Hence a plastic tank of 200 l capacity was used as shown in Fig. 3.6. The tank carrier frame for mounting the tank was fabricated in workshop.

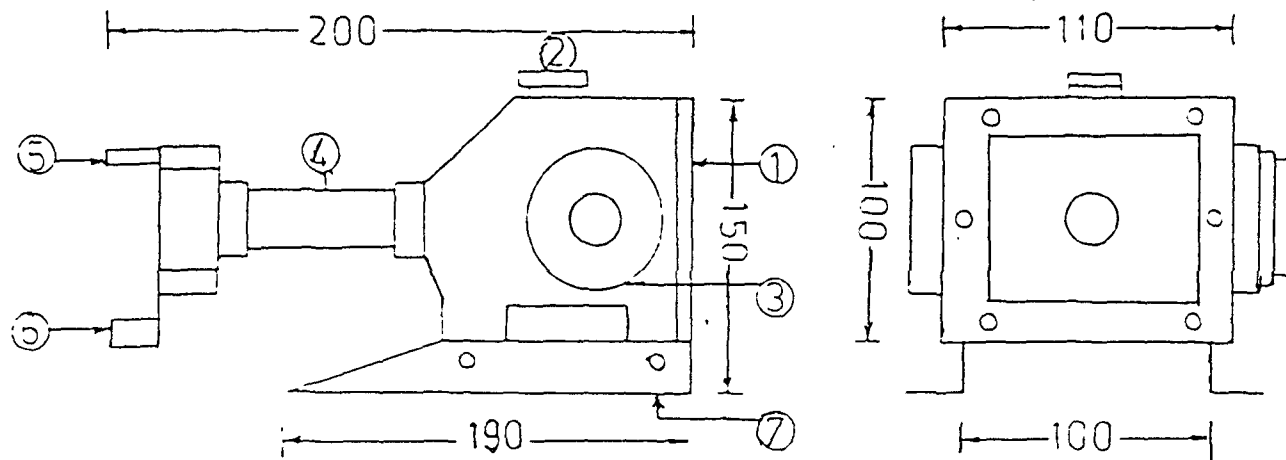
3.1.5 Agitator

A hydraulic agitation was provided with the help of return flow of the excess of spray liquid from the main line. This bypass line was kept at the bottom of the tank for adequate agitation of the pesticide in the tank

3.1.6 Boom

Considering the shape of the grape vineyard layout pattern, the boom for bower (pendal) type was fabricated in workshop. The plant canopy of grape vineyard was of pendal shape. Some of the grape vines are in hanging position along

(All dimensions are in mm)

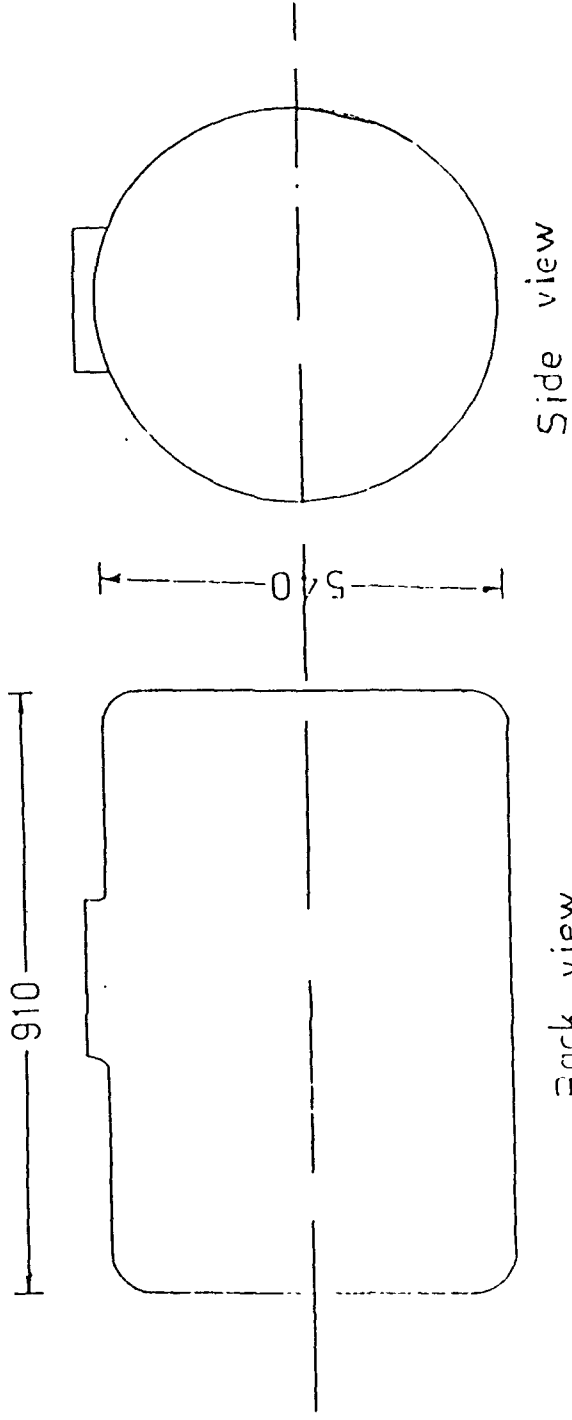


Side view

Back view

1 - Casing , 2 - Cap , 3 - Pully , 4 - Piston ,
5 - Delivery opening , 6 - Suction opening , 7 - Base

FIG- 3.5 HORIZONTAL TRIPLEX PISTON PUMP (HTP)

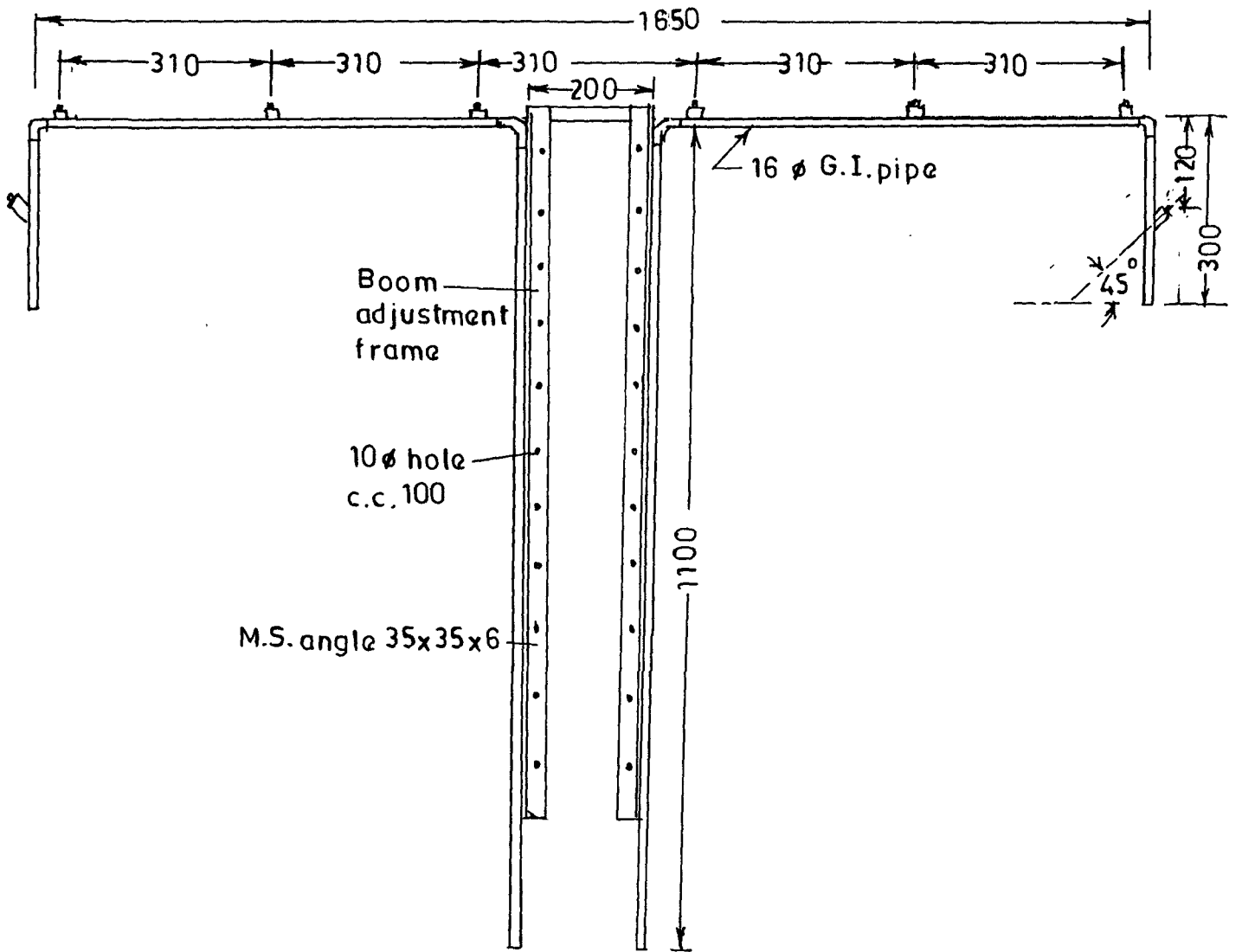


Back view

Side view

(All dimensions are in mm)

FIG-3.6 PESTICIDE TANK



All dimensions in mm

Fig. 3.7 Boom with frame

the length of main stem. The horizontal straight boom was not sufficient to spray that vertical portion of canopy. Therefore, for complete and uniform spraying, two booms of "inverted L" shape were used as shown in Fig. 3.7. There were eight nozzles, four on each boom. Booms were made from 16 mm GI pipe. These booms were supported on m.s. frame. The frame was fixed on back side of the trailed type unit on which the booms were fixed by making collar arrangement. Considering cone angle, distance of nozzle tip from target and overlap of the spray pattern, the spacing between the two nozzles was designed and according to that, the nozzles on the boom were spaced at a spacing of 31 cm. Necessary provision was made for adjustment of height of booms and row spacing.

3.1.7 Nozzles

Nozzle is the heart of a sprayer. It atomizes the liquid into different sizes of droplets at a controlled rate of flow in a given direction. In the Indian market, different designs of nozzles are available. The proper choice and use of nozzles have a direct effect on application efficiency. Hydraulic nozzles have been used for many years and have provided acceptable performance, with better penetration of spray droplets into plant foliage (Matthews, 1973). Therefore, hollow cone nozzles of type NMD/S 60450 for finer droplets, reduced drift and uniform coverage, were used for the pesticide spraying. For spraying canopy portion, six NMD/S 60450 nozzles were used, which were fixed on two horizontal booms, three on each boom. For spraying hanging portion of grape canopy along the length of main stem, two adjustable

NMD/S 60450 nozzles were used which were fixed on two vertical booms on both sides, fitted to horizontal booms in "inverted L" shape.

3.1.7.1 Hollow cone nozzles

Hollow cone nozzles are used primarily where penetration of spray into plant foliage is essential for effective insect and disease control, and where drift is not a major consideration. In a hollow cone nozzle, liquid is forced through a swirl plate having one or more tangential or helical passages, into a swirl chamber. NMD/S 60450 nozzle was swirl plate type hollow cone nozzle. Its body and cap were made up of brass, swirl plate and orifice plate were of stainless steel and seal and spacer i.e. gasket was of rubber.

3.1.8 Control panel

The control panel was fitted on the arrangement made on power tiller handle as shown in Plate 3.5. The control panel was used to control the discharge to the boom and to regulate the pressure.

3.2 Laboratory Testing of Sprayer

3.2.1 Details of laboratory test rig

The laboratory set up consisted of the following accessories.

3.2.1.1 Prime mover

The equipment was an adoption of horizontal triplex piston pump (Fig. 3.2) to a three phase a.c. induction motor. The specifications of the motor were as follows :

Type	Three phase induction motor
Speed	1440 rpm
Voltage	440 V
Horse power	3 HP

3.2.1.2 Power transmission assembly

Power was transmitted from motor shaft pulley to HTP pump pulley by means of belt and pulley arrangement. This power transmission assembly was first used to the nozzle on patternator and then to sprayer unit to find discharge through boom.

3.2.1.3 Patternator

Patternator was used to study the spray intensity distribution of the spray liquid for a nozzle. It was also used to measure discharge and cone angle of nozzle (Plate 3.1). The distance between nozzle tip and patternator channel surface was maintained through adjustable frame. There were 66 channels, each with centre to centre distance of 3.17 cm. The channel surface was inclined at 5.5° to the horizontal. From each channel, the spray liquid fell into the corresponding vertical glass tube of 2.1 cm inner diameter. The bottom ends of which were connected to a common outlet chamber through spring loaded valves.

The patternator was equipped with the pressure gauge, flowmeter and pressure control valve in the pressure line. Pressure was controlled by pressure control valve and by observing flowmeter, discharge was found out. Cone angle was measured with the help of special protractor on patternator (Plate 3.2).

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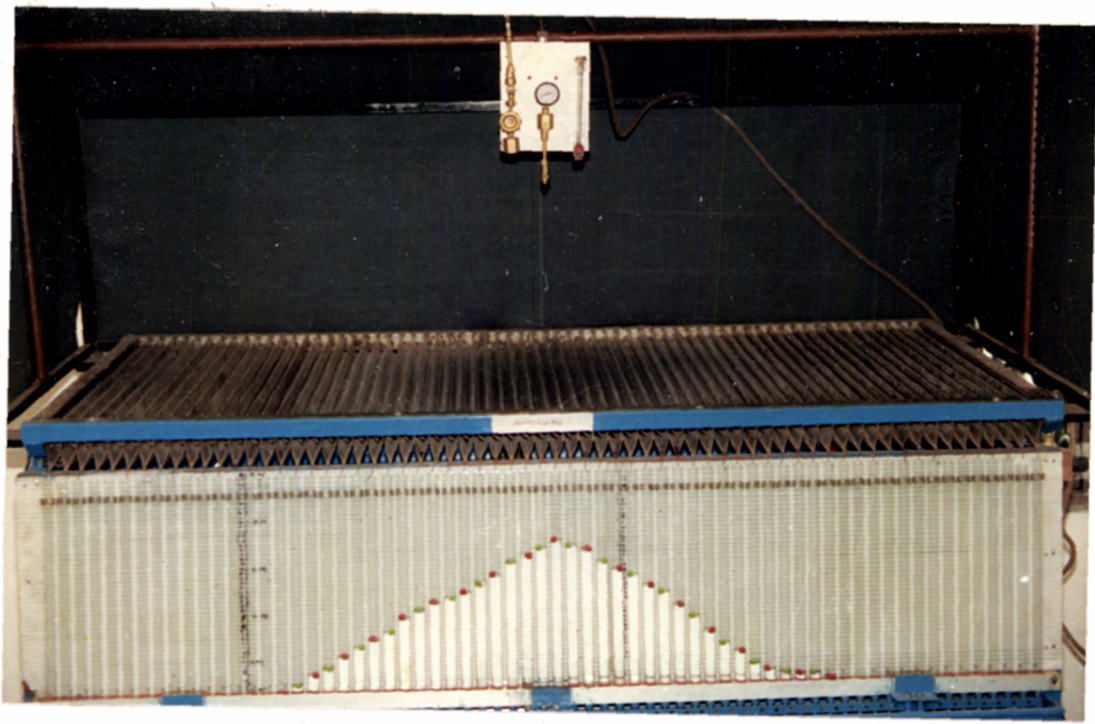


Plate 3.1 Patternator for spray distribution of nozzle

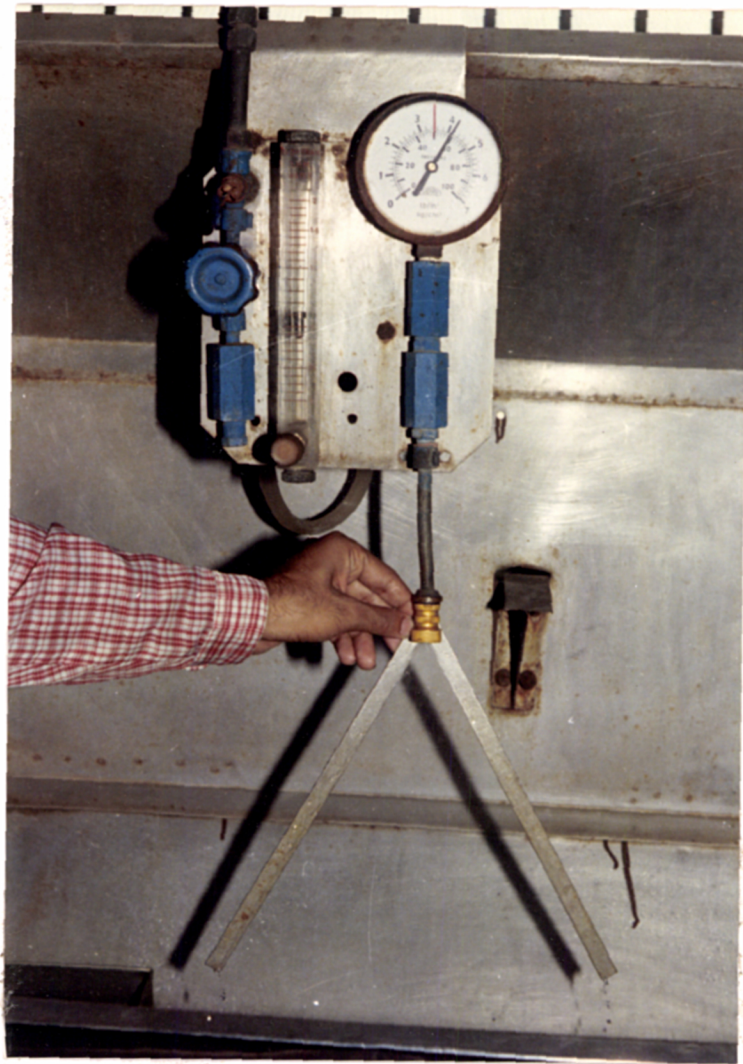


Plate 3.2 Measurement of nozzle cone angle

3.2.1.4 Stop watch

Stop watch was used to measure time period while testing. Time required to fill the one litre capacity measuring jar was noted and from that, nozzle discharge in l/min was calculated.

3.2.1.5 Measuring jar

Measuring cylinder of one litre capacity was used to measure discharge through nozzle at different pressures.

3.2.2 Laboratory testing procedure

3.2.2.1 Measurement of nozzle cone angle

Cone angles of hollow cone nozzle (NMD/S 60450) at the pressure of 2, 3, 4 and 5 kg/sq.cm were noted with the help of angle measuring instrument (Plate 3.2). The measuring aid consisted of two flat metal strips hinged at one end. The outer sides of strips were folded at right angle along their length. This measuring aid was placed near the tip of the nozzle and it's angle is adjusted, so that the spray from the edges of the nozzle just trickled down along the edges of the two arms uniformly drop by drop. This angle was then measured with protractor as recorded in Table A1.

3.2.2.2 Measurement of nozzle discharge

Discharge of hollow cone nozzle (NMD/S 60450) at varying pressure of 2, 3, 4 and 5 kg/sq.cm were noted for a period of 60 seconds with the help of measuring jar (Plate 3.3). Discharge volumes of the individual nozzles on the boom were also noted for same pressures and recorded in Table A2.

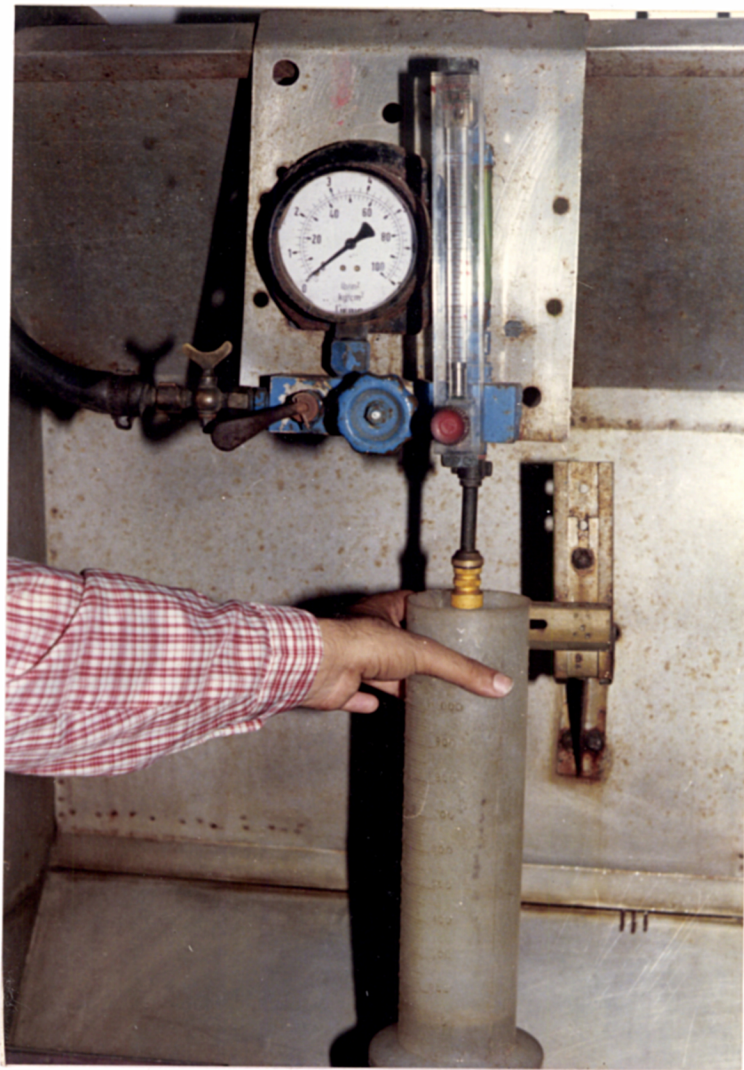


Plate 3.3 Measurement of nozzle discharge



Plate 3.4 Power tiller operated boom sprayer

3.2.2.3 Study of spray distribution

The spray distribution of nozzle with respect to its tip was studied with the help of patternator (Test code IS : 10064-1982). The nozzle was kept at a fixed distance from channel and it was worked for one minute. During operation, tubes were closed for one minute and the spray liquid in each tube corresponding to each channel of the patternator would get collected. The height of liquid collected in each tube would give the intensity of spray distribution. The data is recorded in Table A3 through A6.

3.3 Field testing of sprayer

The methodology followed in planning, conducting and analyzing the field results is discussed in this section.

The field testing of sprayer was conducted in the first week of April, 1997 at Central campus, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar. The main aim of field testing was to know the performance of power tiller operated sprayer in relation to proper coverage and ideal application of pesticide on grape vineyard and then to recommend best N-P (speed-pressure) combination and proper approach to increase practical utility of sprayer in grape vineyard. The data is recorded in Table B1 through B9.

3.3.1 Biological observations

1. Crop _____ Grape
2. Variety _____ Thompson seedless
3. Plot location _____ Central campus,
M.P.K.V., Rahuri.

4. Plant to plant spacing ___ 1.5 m
5. Row to row spacing _____ 3 m
6. Number of vines/hectare _ 2222
7. Height of plant _____ 1.8 m

3.3.2 Experimental design of field testing

3.3.2.1 Statistical design of field trials

Field trials were carried out for the evaluation of droplet size distribution, uniformity of spraying and droplet density for power tiller operated hydraulic sprayer system. Split plot design with nine treatments each with three replications were made to conduct the field trials with minimum experimental error and maximum precision.

3.3.2.2 Independent variables

1. Number of sprayers : 1 (Power tiller operated boom sprayer)
2. Power tiller speeds : 1.0 , 1.5 and 2.0 kmph
3. System pressures : 3, 6 and 9 kg/sq.cm
4. Flow rate : 450 ml/min per nozzle

3.3.2.3 Dependent variables

1. Droplet size distribution
2. Uniformity of spraying
3. Droplet density

3.3.3 Method of assessing the spray deposition

Droplets deposited on the leaves are difficult to analyse as no marks are left on the leaves, if sprayed with pesticide. Glossy paper retains shape and size of droplet, if

R I		
N ₁	N ₂	N ₃
P ₁	P ₃	P ₂
P ₂	P ₁	P ₃
P ₃	P ₂	P ₁

R II		
N ₂	N ₁	N ₃
P ₂	P ₃	P ₁
P ₁	P ₂	P ₃
P ₃	P ₁	P ₂

R III		
N ₃	N ₁	N ₂
P ₁	P ₂	P ₃
P ₃	P ₁	P ₂
P ₂	P ₃	P ₁

N₁-1.0 Km ph

N₂-1.5 Km ph

N₃-2.0 km ph

P₁-3.0 Kg/sq.cm

P₂-6.0 Kg/sq.cm

P₃-9.0 Kg/sq.cm

FIG -3.8 SPLIT PLOT DESIGN

sprayed with coloured water. So, white coloured glossy paper was preferred to ensure easy detection in the plant and also for determination of droplet deposition on the card surface. The methyl violet colour dye was used as tracer at the rate of 5 gm/l of water. The papers were fixed to the leaf by using the stapler pins. The papers were located on upper and lower surface of the leaf as shown in Plate 3.7.

Nine locations were selected for glossy paper in each replication as shown in Fig. 3.8. The cards were marked to identify the test treatments, replication number, row number and orientation of the leaf to which it was attached.

3.3.4 Spray liquid application rate and discharge

Liquid discharge rate varies as the square root of system pressure. In each nozzle, liquid discharge was varied by changing system pressure. Liquid discharge through booms at pressure of 3, 6, 9 and 12 kg/sq.cm was 3.62, 4.32, 5.76 and 7.24 l/min and on one side it was half of above mentioned at the given pressure. Application rate, l/ha, depends upon the discharge rate, spacing between vines and number of vines in a hectare.

3.3.5 Applying treatments

There were nine treatments with three replications each. Instead of actual pesticides, clear water was used to spray on grape vineyard. Prior to applying the treatments, driver was given intensive training to maintain proper power tiller speed and liquid pressure. All the nine treatments were applied as per design.

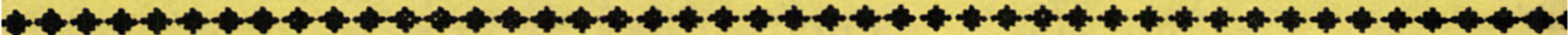
Plate 3.7 Glossy paper fixed on grape leaf

Plate 3.8 Computerised particle size image analyser

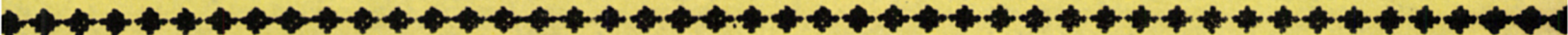
3.4 Determination of droplet size

After applying all treatments, water sensitive papers fixed on grape vines were removed for droplet size analysis. There are numerous techniques such as high speed photography, laser photography and sophisticated scanning technique. Computerised particle size image analyser was used to determine the size and droplet density. Volume mean diameter (VMD) and number mean diameter (NMD) were computed.

Chapter Opener Page



Results and Discussion



4. RESULTS AND DISCUSSION

The main aim of research work was to achieve objectives of the project. So, the sprayer operated on power tiller was developed and tested in laboratory and in the field.

In this chapter, results obtained from the laboratory and field testing of power tiller operated boom sprayer are discussed.

4.1 Laboratory performance of sprayer

The power tiller operated sprayer was developed as per the design and was tested in laboratory of ASPEE Research Institute, Bhiwadi. In laboratory, the nozzle (NMD/S 60450) was tested for cone angle, discharge and spray distribution on patternator at various pressures. The booms of sprayer were also tested at varying pressure for discharge as shown in Table A7.

4.1.1 Nozzle testing

NMD/S 60450 nozzle was tested and the results are as tabulated in Table A1 through Table A6.

4.1.1.1 Spray cone angle

Spray cone angle is the angle subtended at the orifice by the edge of the spray pattern. Nozzle NMD/S 60450 was tested for its cone angle at various pressures. The results obtained are given in Table A1. The cone angle variation was plotted against pressure as shown in Fig. 4.1. From the figure, it is clear that the relationship is of straight line nature.

4.1.1.2 Discharge rate

The hollow cone nozzle NMD/S 60450 was tested in the laboratory for discharge rate at different pressures and results are as shown in Table A2. The discharge variation is plotted against pressure as shown in Fig. 4.2. Behaviour of this graph also shows straight line nature. Also from table A7, total boom discharge increases with increases in working pressure.

4.1.1.3 Spray distribution

The nozzle spray distribution was observed for four values of pressures on the patternator. The results are given in Table A3 through A6. The observed distribution was as shown in Fig. 4.3. As the pressure increases, more uniform distribution occurs on the central portion of the patternator. At centre, intensity of spraying is more and as we go away from centre, the intensity goes on decreasing. Thus, there is more uniform distribution on the central portion of the patternator for higher pressures. From the figure, it is evident that the desirable pressure is more than 5 kg/sq.cm. At these pressures, the overlap to be provided is to the extent of 50 per cent.

4.1.2 Testing of spray boom

Both the right and left side booms were tested in laboratory at varying pressures. The discharge through each nozzle for one minute was measured with measuring cylinder. The observed data is as presented in Table A7. The relationship between pressure and total boom discharge is

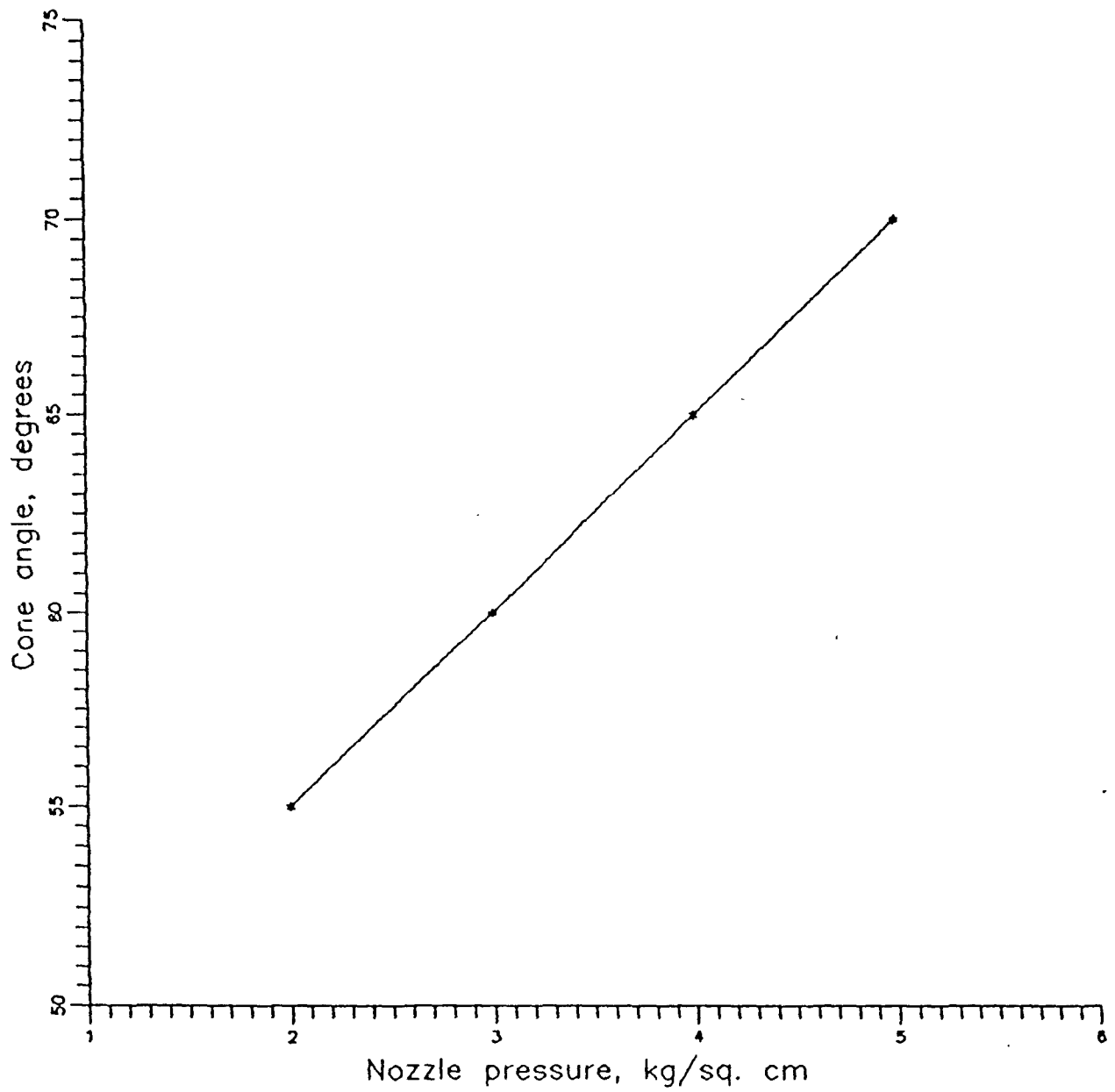


Fig. 4.1: Relationship between pressure and nozzle cone angle

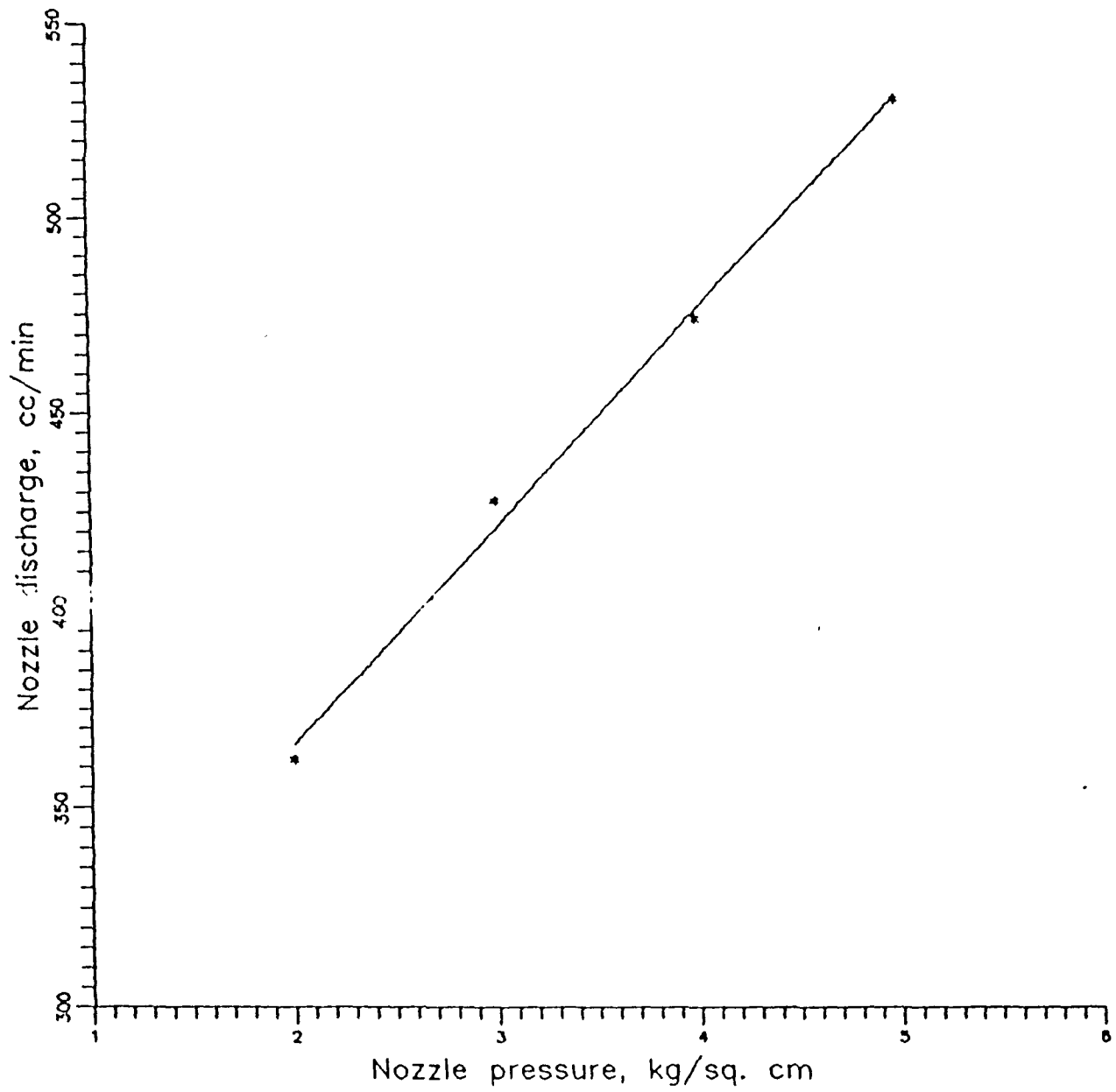


Fig 4.2: Relationship between pressure and discharge of nozzle

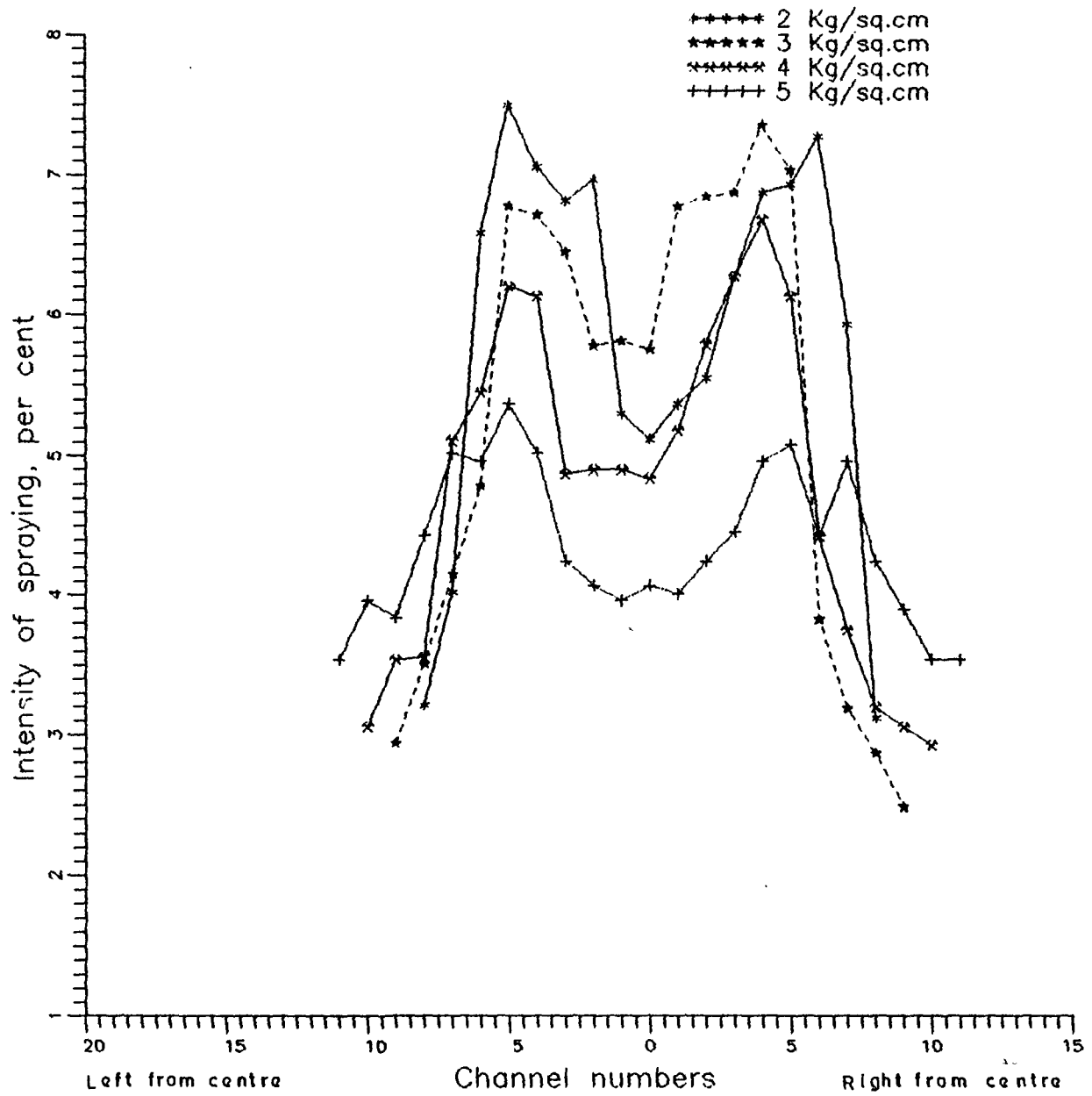


Fig. 4.3 : Spray distribution of nozzle at different pressures

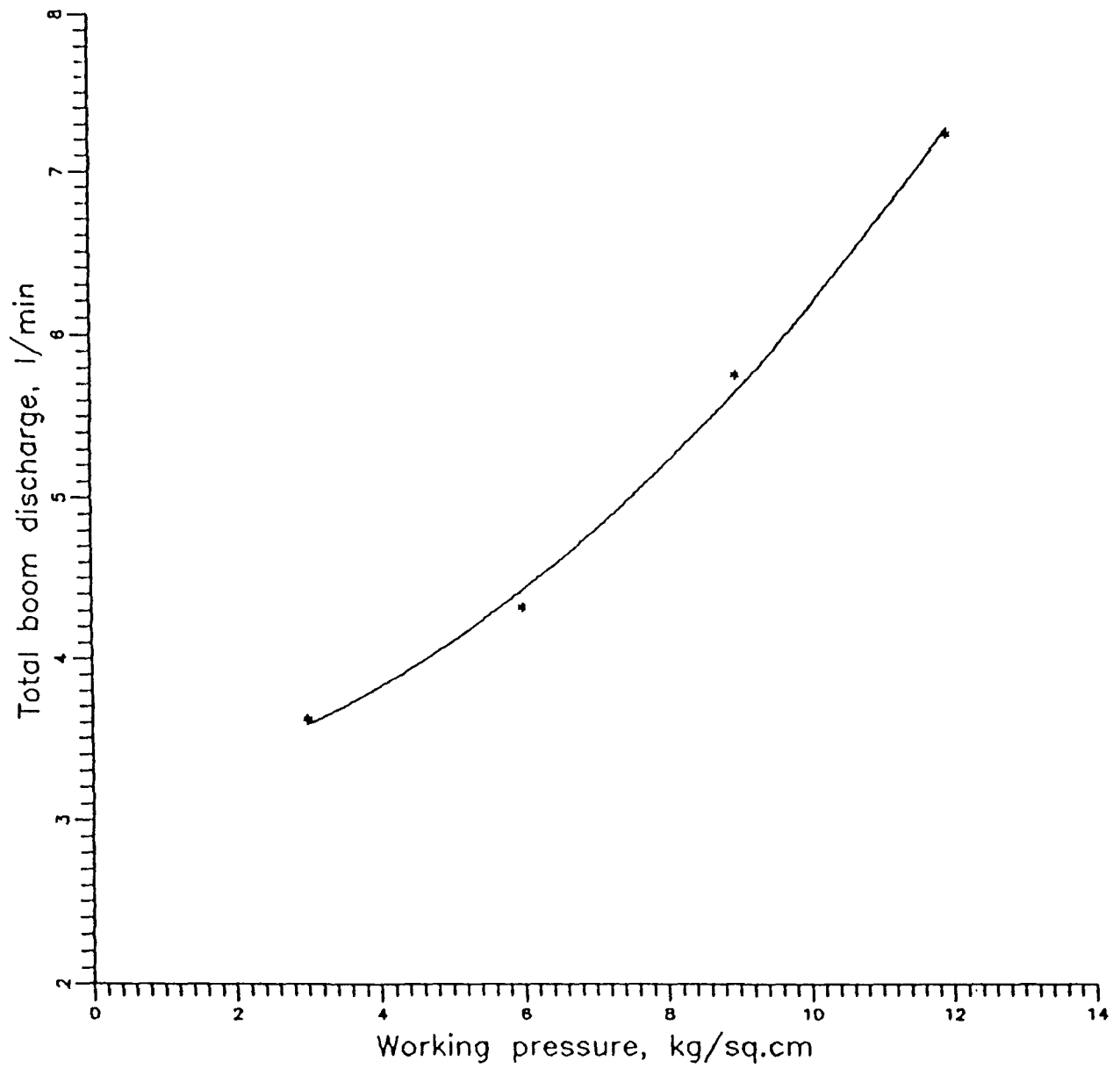


Fig. 4.4: Relationship between nozzle pressure and total boom discharge

shown in Fig. 4.4. The figure shows the parabolic relation. The boom discharge increases with increase in pressure. To increase discharge twice, the pressure is to be increased by four times (Table A7). It shows that discharge was directly proportional to the square root of the pressure.

4.2 Field Performance of Sprayer

Power tiller operated boom sprayer was tested in grape field at various travel speeds and system pressures following the split plot statistical design as shown in Fig. 4.8. There were overall nine treatments, including three travel speeds ($N_1 = 1.0$ kmph, $N_2 = 1.5$ kmph, $N_3 = 2.0$ kmph) and three system pressures ($P_1 = 3$ kg/sq.cm, $P_2 = 6$ kg/sq.cm, $P_3 = 9$ kg/sq.cm). Each treatment was replicated thrice. Average droplet density of three replications from Table B1 through B9 with the mean of front and back of leaf is presented in Table B10 (Appendix B) and this data was considered for statistical analysis following split plot design. The field performance of the sprayer in terms of droplet density at different combinations of the travel speed and the system pressure and at various portions of grape pedal is discussed as under.

4.2.1 Droplet density at left bottom portion of pedal

Table 4.1 indicates that, the droplet density at left bottom portion of the pedal was not significantly affected by the travel speeds, but it was significantly affected by the system pressures. The mean droplet density of 26 droplets/sq.cm obtained at system pressure of P_3 was significantly superior to the droplet densities obtained at

pressure levels P_1 and P_2 . Moreover, the mean droplet density of pressure level P_3 was found to be greater than the optimum droplet density of 20 droplets/sq.cm (ASPEE information bulletin No. 1) for control of insects, pests with most insecticides and systemic fungicides. However, the mean droplet densities at pressure levels of P_1 and P_2 were found to be less than the optimum droplet density. Hence, the pressure level P_3 i.e. 9 kg/sq.cm was found to be suitable for control of most insecticides and systemic fungicides. Droplet density at the treatment combination N_1P_3 was found to be the highest i.e. 30 droplets/sq.cm which was significantly higher than the droplet densities of remaining all treatment combinations. So, besides spraying operation carried out at the system pressure P_3 , it can be said that the spraying operation carried out at the treatment combination of N_1P_3 is more desirable considering the effective control of insects and pests on the grape vines.

Table 4.1. Droplet density at left bottom portion of pendal

Travel speed	Pressure levels			Mean
	P_1	P_2	P_3	
N_1	20	23	30	25
N_2	14	19	29	21
N_3	13	15	19	16
Mean	16	19	26	21

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	2.102	NS	--
Between levels of P	1.343	4.138	8.742
Between levels of N at the same levels of P	2.325	NS	--
Between levels of P at the same levels of N	2.833	NS	--

4.2.2 Droplet density at left top portion of pendal

Data on droplet density at left top portion of pendal was significantly affected by the travel speed as well as system pressure levels as seen in Table 4.2. The mean droplet density of 20 droplets/sq.cm obtained at travel speed of N_1 was significantly superior to the droplet densities obtained at speed levels of N_2 and N_3 . The mean droplet density of 21 droplets/sq.cm obtained at system pressure of P_3 was significantly superior to the droplet densities obtained at pressure levels of P_1 and P_2 . Droplet density at the treatment combination of N_1P_3 was found to be the highest i.e. 27 droplets/sq.cm which was significantly higher than the droplet densities at remaining all treatment combinations. So, it can be said that, the spraying operation carried out at treatment combination of N_1P_3 is more desirable considering the effective control of most insects and pests on the grape vines.

Table 4.2. Droplet density at left top portion of pendal

Travel speed	Pressure levels			Mean
	P ₁	P ₂	P ₃	
N ₁	15	17	27	20
N ₂	11	16	19	16
N ₃	10	10	15	12
Mean	12	15	21	16

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	0.868	3.008	--
Between levels of P	1.703	5.050	--
Between levels of N at the same levels of P	2.950	NS	--
Between levels of P at the same levels of N	2.560	NS	--

4.2.3 Droplet density at centre bottom portion of pendal

Table 4.3 indicates that the droplet density at centre bottom portion was significantly affected by travel speed and system pressure levels. The maximum mean droplet density of 27 droplets/sq.cm obtained under travel speed level N₁ was significantly superior to speed levels of N₂ and N₃. Similarly, maximum mean droplet density (27 droplets/sq.cm) at pressure level P₃ was significantly higher than the pressure levels of P₁ and P₂. The droplet density at the treatment combination of N₁P₃ was found to be the highest (31 droplets/sq.cm) which was higher than the droplet densities at remaining all treatment combinations.

Table 4.3. Droplet density at centre bottom portion of pendal

Travel speed	Pressure levels			Mean
	P ₁	P ₂	P ₃	
N ₁	21	28	31	27
N ₂	15	19	30	22
N ₃	12	12	20	15
Mean	16	20	27	21

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	0.962	3.779	2.966
Between levels of P	1.194	3.689	7.776
Between levels of N at the same levels of P	2.068	NS	--
Between levels of P at the same levels of N	1.944	NS	--

4.2.4 Droplet density at centre top portion of pendal

The droplet density at centre top portion of pendal was not significantly affected by travel speeds but significantly affected by system pressures (Table 4.4). The mean droplet density of 21 droplets/sq.cm obtained at pressure level of P₃ was significantly higher than the droplet densities at the pressure levels P₁ and P₂. Droplet density at treatment combination of N₁P₃ was found to be the highest and moreover, it was significantly higher than the droplet densities at all other treatment combinations. Secondly, it was effective for control of pests as it was higher than the optimum droplet

density. Minimum droplet density (8 droplets/ sq.cm) was found at this portion at treatment combination of N₃P₁.

Table 4.4. Droplet density at centre top portion of pendal

Travel speed	Pressure levels			Mean
	P ₁	P ₂	P ₃	
N ₁	14	19	24	19
N ₂	12	13	21	16
N ₃	8	10	16	12
Mean	12	14	21	16

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	1.956	NS	--
Between levels of P	1.436	4.426	9.350
Between levels of N at the same levels of P	2.487	NS	--
Between levels of P at the same levels of N	2.820	NS	--

4.2.5 Droplet density at right bottom portion of pendal

Table 4.5 indicates that, the droplet density at right bottom portion was significantly affected by both, travel speed and system pressure. The maximum droplet density was observed at N₁ (25 droplets/sq.cm) followed by N₂ and N₃. Travel speeds 1.0 kmph and 1.5 kmph were at par but significantly superior to travel speed of 2 kmph. Similarly, the highest droplet density was observed at the pressure level of

P₃ (26 droplets/sq.cm) followed by P₂ and P₁. System pressure level P₃ i.e. 9 kg/sq.cm was significantly superior to pressure levels P₂ and P₁. Droplet density at treatment combination N₁P₃ was found to be the highest (30 droplets/sq.cm). Moreover, it was higher than the optimum droplet density.

Table 4.5. Droplet density at right bottom portion of pendal

Travel speed	Pressure levels			Mean
	P ₁	P ₂	P ₃	
N ₁	20	23	30	25
N ₂	15	21	29	22
N ₃	11	15	18	15
Mean	16	20	26	21

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	1.207	4.540	--
Between levels of P	1.714	5.283	11.162
Between levels of N at the same levels of P	2.969	NS	--
Between levels of P at the same levels of N	2.708	NS	--

4.2.6 Droplet density at right top portion of pendal

Data on droplet density at right top portion of pendal was not significantly affected by travel speeds but significantly affected by system pressures (Table 4.6). The mean droplet density (19 droplets/sq.cm) obtained at pressure level P₃ was at par with pressure level P₂ but significantly

superior to pressure level P_1 . Droplet density at treatment combination N_1P_3 was found to be the highest (21 droplets/sq.cm). Moreover, it was just above the optimum droplet density level of 20 droplets/sq.cm.

Table 4.6. Droplet density at right top portion of pendal

Travel speed	Pressure levels			Mean
	P_1	P_2	P_3	
N_1	16	20	21	19
N_2	12	15	19	16
N_3	9	12	16	13
Mean	13	16	19	16

Source	S.E.	C.D. (0.05)	C.D. (0.01)
Between levels of N	1.727	NS	--
Between levels of P	1.459	4.498	--
Between levels of N at the same levels of P	2.528	NS	--
Between levels of P at the same levels of N	2.691	NS	--

4.2.7 Effect of system pressure on droplet density at various travel speeds

Fig. 4.5, 4.6 and 4.7 shows the effect of system pressure on droplet density at travel speed of 1.0, 1.5 and 2.0 kmph respectively. It was found that droplet density was increased with increase in system pressure. Also, droplet deposition was higher at system pressure of 9 kg/sq.cm than

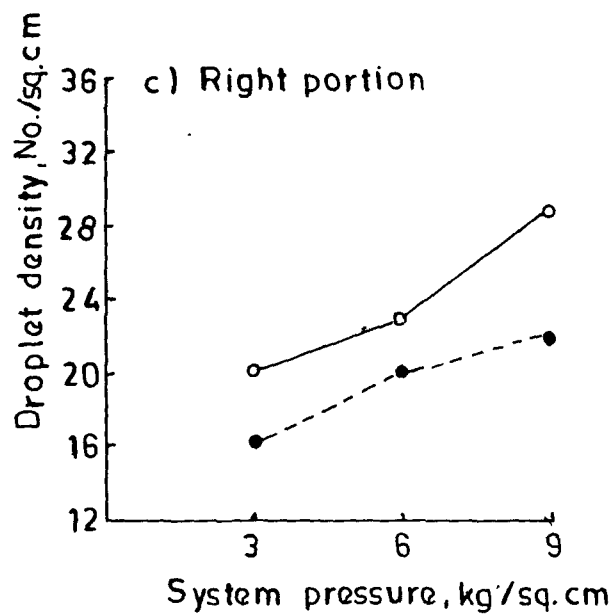
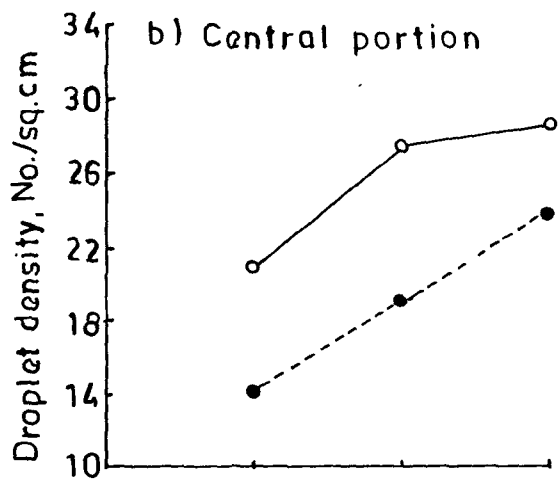
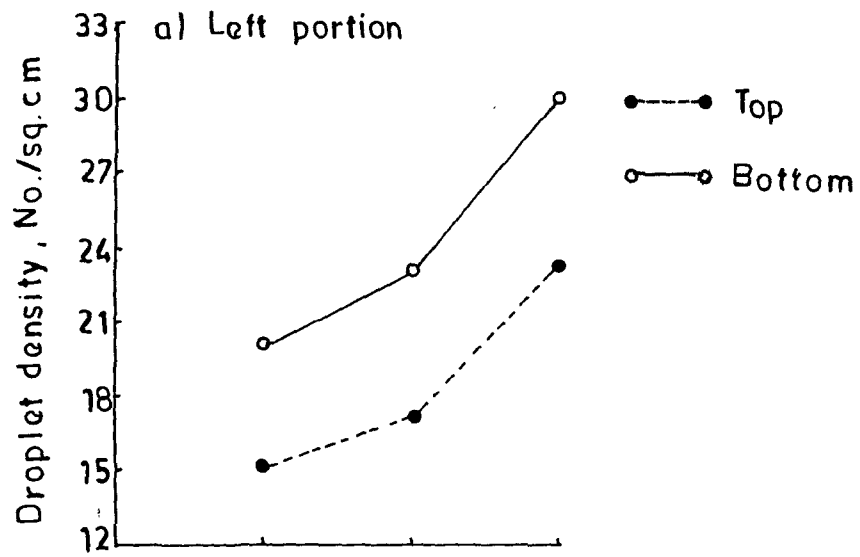


Fig. 4.5 Effect of system pressure on droplet density at 1.0 kmph.

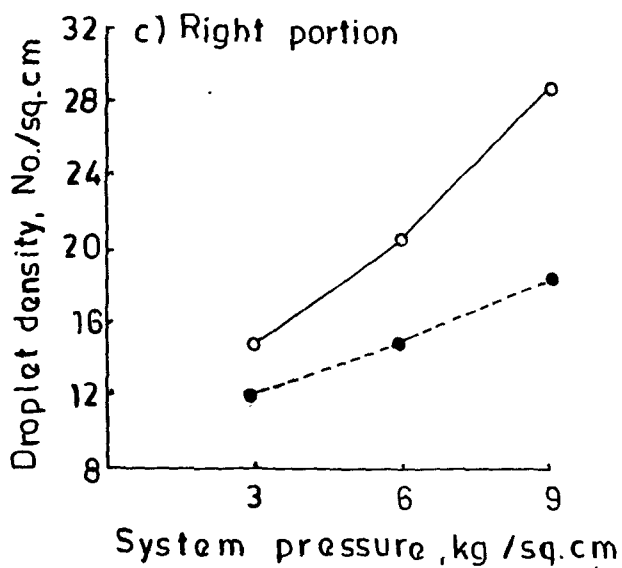
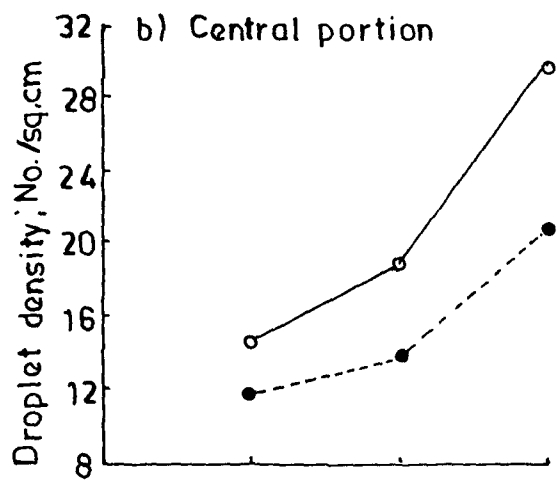
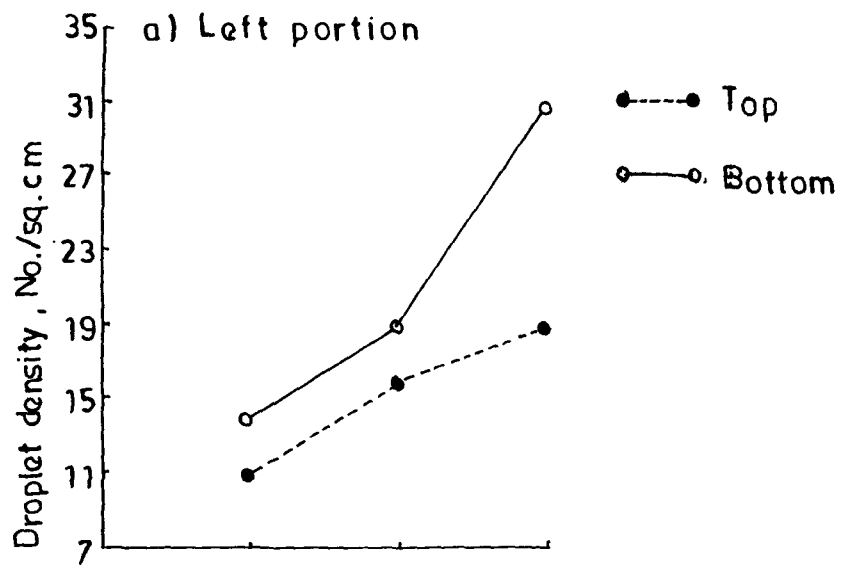


Fig. 4.6 Effect of system pressure on droplet density at 1.5 kmph.

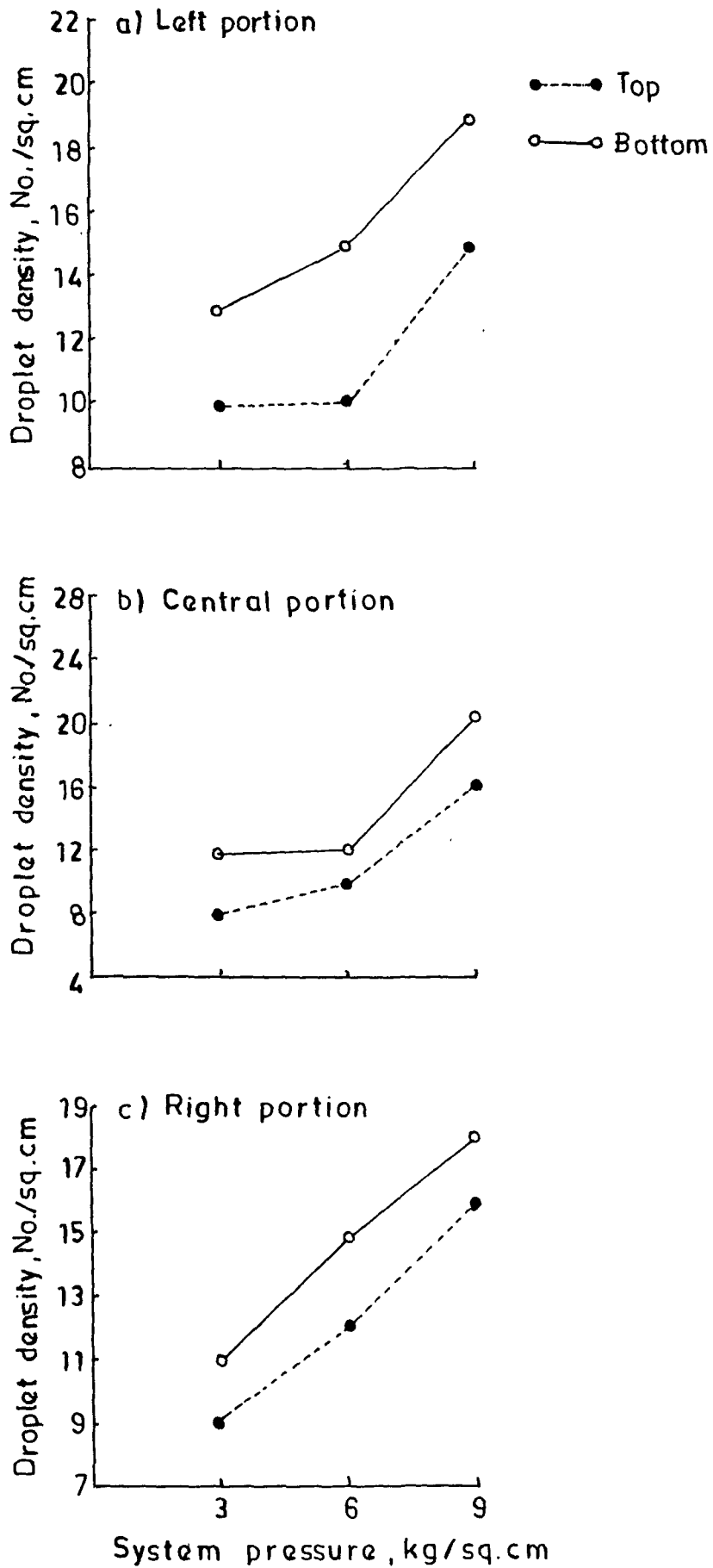


Fig. 4.7 Effect of system pressure on droplet density at 2.0 kmph.

at pressure of 3 and 6 kg/sq.cm. It was also found that droplet density at travel speed of 2.0 kmph was higher than that of 1.0 and 1.5 kmph. Thus, droplet density decreases with increase in travel speed. The spray deposition at the location also depends upon the time spent for spraying on that location. Time spent for spraying a particular location decreases as speed increases. Travel speed should not be too low and too high. Too low speed may cause overspraying and too high speed may cause underspraying.

4.2.8 Uniformity of droplet size

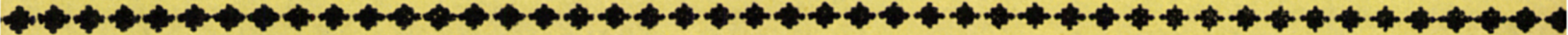
Average VMD, NMD and UC at different treatment combinations of travel speed and system pressure are presented in Table 4.8. The value of UC was found to be 1.96 at treatment combination of N₁P₃ i.e. at travel speed of 1.0 kmph and system pressure of 9.0 kg/sq.cm. This value was the lowest indicating more uniform size of droplets as the value of UC is nearer to 1.0 for more uniform size of droplets (Matthews, 1984).

Table 4.7. Average VMD, NMD and UC at different treatment combinations

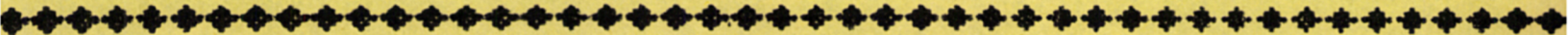
Travel speed, kmph	System pressure, kg/sq.cm	VMD, μm	NMD, μm	UC
1.0	3.0	246.09	91.08	2.70
1.0	6.0	237.89	90.04	2.64
1.0	9.0	184.78	94.30	1.96✓
1.5	3.0	300.41	126.74	2.37
1.5	6.0	245.07	120.37	2.45
1.5	9.0	269.95	101.84	2.65
2.0	3.0	313.15	143.22	2.19
2.0	6.0	291.72	142.44	2.05
2.0	9.0	280.73	120.67	2.33

From the above discussion, it can be said that, the only treatment combination of N_1P_3 i.e. travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm is suitable for spraying in grape vineyards using power tiller operated boom sprayer as it meets the requirement of 20 droplets/sq.cm from the bottom portion to the top portion of the grape pedicel. For reduced drift and good coverage, range of VMD should be 100 to 200 μ m which gives fine droplets. From Table B1 to B9, it was clear that, maximum number of droplets were found in above range. But still it is necessary to get more droplets in this range for reduced drift and good coverage. The droplet density decreases from the bottom portion to top portion of grape canopy. The droplet density obtained at treatment combination of N_1P_3 just meets the requirement but it is calculated considering the average values of droplet densities on the front and the back side of leaf. From the data, it is clear that the droplet density on the back side of the leaf is considerably lower than that of the front side of leaf. Interestingly, the incidence of insects and pests is always on the back side of leaf. So, the insects and pests could not be effectively controlled using power tiller operated hydraulic energy boom sprayer. With air assisted sprayer, there is sufficient leaf movement so that uniform spraying can be achieved on both sides of leaf as well as on top portion of pedicel which is necessary for effective pest control of grape vines.

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Summary and Conclusions



5 . SUMMARY AND CONCLUSIONS

This chapter deals with the summary of the workdone, results of the laboratory and the field testing of the sprayer and the conclusions drawn from the obtained results.

The grape (*Vitis vinifera* L.) is one of the most important remunerative horticultural crops. The area under grape in India is about 24,000 hectares with more than 0.5 million tonnes of production. In Maharashtra, the area occupied by grape crop is about 36 per cent of the total area under grape in India.

Therefore, there is a need to have an effective technique to control the pest and diseases of grape vines.

In our country, by and large spraying operation is carried out with knapsack sprayer, but they are time consuming and less efficient. Now a days, in many parts of india, the orchard and vineyard spraying is carried by hydraulic sprayers. Boomless nozzles showed poor control of pests and an uneven application of spray liquid. A boom sprayer is best to produce uniform spray pattern and uniform application of spray fluid. It also reduces the operational time by increasing the area of coverage.

Now a days, two wheel tractors i. e. power tillers are gaining popularity among the marginal and medium farmers. Similarly, power tillers are most suitable on Indian fields. Power tiller is a middle path between big tractor and animals. Keeping in view all these points, the present research work

was, therefore, undertaken to develop power tiller operated boom sprayer and to study the performance of the sprayer in the laboratory as well as in the grape field with following objectives :

1. To develop a hydraulic sprayer to install on a power tiller suitable for bower type grape vineyard.
2. To test the developed hydraulic sprayer in the laboratory.
3. To evaluate the field performance of developed hydraulic sprayer.

Keeping in view all these objectives, a power tiller operated boom sprayer was designed, developed and fabricated at ASPEE Research Institute, Bhiwali.

Power tiller operated boom sprayer consists of two "Inverted L" shaped booms, control panel, horizontal triplex piston pump, trailed type unit and tank. Pump delivers spray liquid through boom to nozzles. Nozzles atomizes liquid and spray it to target. Control system regulates liquid discharge and system pressure. A newly developed power tiller operated boom sprayer was tested in laboratory. The laboratory testing was done at A. R. I., Bhiwali. In laboratory testing, the pump was driven by three phase induction motor. NMD/S 60450 nozzle was tested on patternator at four different pressures (2, 3, 4 and 5 kg/sq.cm) for cone angle, nozzle discharge variation and spray distribution. The spray boom was also tested for same four pressures for the discharge through each nozzle and total boom discharge.

Power tiller operated boom sprayer was then tested in grape field. The field trials were taken at Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri. The main aim of field testing was to judge the proper combination of system pressure and travel speed for effective spraying in the grape vineyard. The field trials were carried out at three different system pressures (3, 6 and 9 kg/sq.cm) and at three travel speed levels (1.0, 1.5 and 2.0 kmph). The split plot statistical design was used in the field. Glosy (water sensitive) papers were used to collect the spray droplets. These papers were attached at three horizontal locations i. e. left, middle and right of the grape pendal. Optimum droplet density was achieved at travel speed of 1.0 kmph and system pressure of 9.0 kg/sq.cm.

Following conclusions were drawn from the results of laboratory and field testing of power tiller operated boom sprayer for grape vineyard.

Laboratory Performance :

1. The spray cone angle of the nozzle increases with increase in system pressure.
2. Discharge rate is directly proportional to square root of system pressure. This is shown by the straight line behaviour of graph of discharge against pressure.
3. As the pressure of spraying increases, the distribution of spray becomes uniform.
4. Total liquid collected in all tubes of the patternator is less than the actual nozzle discharge.

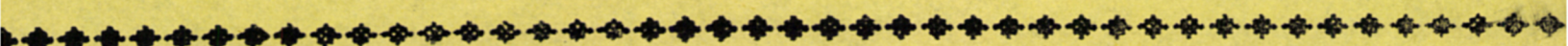
5. Discharge through boom increases with increase in system pressure. To increase the discharge twice, the pressure has to increase by four times.

Field Performance :

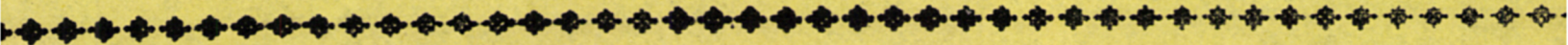
1. Effect of both, system pressures and travel speeds on spray deposition at some locations was found to be significant.
2. At all system pressures (3, 6 and 9 kg/sq.cm) and travel speeds (1.0, 1.5 and 2.0 kmph), droplet density decreases from bottom to top of the grape canopy.
3. Droplet density increases with increase in system pressure, whereas droplet density decreases with increase in travel speed.
4. Maximum droplet density (31 droplets per square cm) was found at treatment combination of N_1P_3 i.e. travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm.
5. Treatment combination of N_1P_3 i.e. travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm is most suitable for spraying in grape vineyards as it meets the requirement of 20 droplets/sq.cm for effective control of most insects and pests.
6. At all the combinations of system pressures and travel speeds, droplet density at the top of the grape canopy was very less. But due to sunlight, attack of most of the insects and pests on top portion is somewhat minimum as compare middle and bottom portion of grape pendal.

7. With hydraulic energy sprayer, droplet density on back side of leaf is considerably lower than that of front side due to insufficient leaf movement. So, attempt should be made to develop air assisted sprayer to get optimum droplet density on back side of leaf and at top portion of pedal.
8. The value of UC was found to be 1.96 at treatment combination of N_1P_3 i.e. travel speed 1.0 kmph and system pressure 9.0 kg/sq.cm. This value showed more uniform size of droplets.

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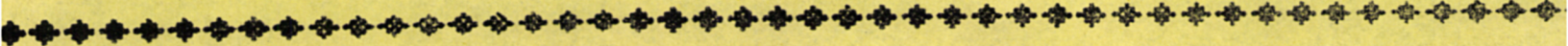
Suggestions For Future Work




6 . SUGGESTIONS FOR FUTURE WORK

1. Attempt should be made to compare designed sprayer with conventional system in view of effective pest control.
2. Power tiller operated boom sprayer should be tested with different nozzle types and arrangements to verify the difference in uniformity.
3. Attempt should be made to design and test a set of boom for different grapevine layout patterns (training systems).
4. Sprayer should be tested for higher pressures to get more uniformity of spraying.
5. Attempt should be made to design and develop power tiller operated air assisted sprayer for effective penetration of spray droplets into the canopy.

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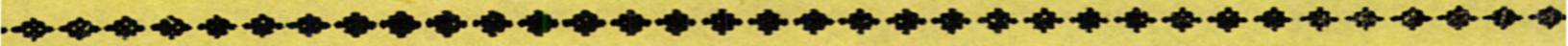
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Appendices



APPENDIX-A

LABORATORY TESTING RESULTS

Table A1. Spray cone angle of nozzle NMD/S 60450 at different pressures

Number of replications = 5

Sr. No.	Working pressure kg/sq.cm	Spray cone angle degrees					Average spray cone angle degrees
		Replications					
		1	2	3	4	5	
1	02	56	56	55	54	55	55
2	03	60	61	60	59	60	60
3	04	66	65	65	64	65	65
4	05	72	69	70	69	70	70

Table A2. Discharge rate of nozzle NMD/S 60450 at different pressures

Number of replications = 5

Sr. No.	Working Pressure, kg/sq.cm	Discharge cc/min					Av. discharge, cc/min
		Replications					
		1	2	3	4	5	
1.	02	360	365	370	355	360	362
2.	03	430	428	425	428	429	428
3.	04	480	475	470	470	475	474
4.	05	525	535	532	530	533	531

Table A3. Spray distribution of nozzle (NMD/S 60450)

Operating pressure = 2 kg/sq.cm

Diameter of tube = 2.1 cm

Distance between
Nozzle tip to channel = 54 cmDistance between two
consecutive channels = 3.17 cm

Time taken for reading = 1 min

Number of replications = 3

Channel No.	Left from centre			Right from centre		
	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected
0	16.40	56.80	5.12	16.40	56.80	5.12
1	17.00	58.88	5.30	17.20	59.57	5.37
2	22.30	77.23	6.96	17.80	61.65	5.55
3	22.00	76.19	6.81	20.10	69.61	6.27
4	22.60	78.27	7.05	22.00	76.19	6.87
5	24.00	83.12	7.49	22.20	76.89	6.93
6	21.10	73.08	6.58	23.30	80.70	7.27
7	12.90	44.68	4.02	19.00	65.80	5.93
8	10.30	35.67	3.21	10.00	34.63	3.12

Table A4. Spray distribution of nozzle (NMD/S 60450)

Operating pressure = 3 kg/sq.cm

Diameter of tube = 2.1 cm

Distance between
nozzle tip to channel = 54 cmDistance between two
consecutive channels = 3.17 cm

Time taken for reading = 1 min

Number of replications = 3

Channel No.	Left from centre			Right from centre		
	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected
0	18.00	62.34	5.75	18.00	62.34	5.75
1	18.20	63.03	5.81	21.20	73.42	6.77
2	18.10	62.69	5.78	21.40	74.12	6.84
3	20.20	69.96	6.45	21.50	74.46	6.87
4	21.00	72.73	6.71	23.00	79.66	7.35
5	21.20	73.42	6.77	22.00	76.19	7.03
6	15.00	51.95	4.79	12.00	41.56	3.83
7	13.00	45.02	4.15	10.00	34.63	3.19
8	11.00	38.09	3.51	9.00	31.17	2.87
9	9.20	31.86	2.94	7.80	27.01	2.49

Table A5. Spray distribution of nozzle (NMD/S 60450)

Operating pressure = 4 kg/sq.cm

Diameter of tube = 2.1 cm

Distance between
nozzle tip to channel = 54 cmDistance between two
consecutive channels = 3.17 cm

Time taken for reading = 1 min

Number of replications = 3

Channel No.	Left from centre			Right from centre		
	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected
0	14.20	49.18	4.84	14.20	49.18	4.84
1	14.40	49.87	4.90	15.20	52.64	5.18
2	14.40	49.87	4.90	17.00	58.88	5.79
3	14.30	49.52	4.87	18.40	63.73	6.27
4	18.00	62.34	6.13	19.60	67.88	6.68
5	18.20	63.03	6.20	18.00	62.34	6.13
6	16.00	55.41	5.45	13.00	45.02	4.43
7	15.00	51.95	5.11	11.00	38.10	3.75
8	10.40	36.02	3.54	9.40	32.55	3.20
9	10.40	36.02	3.54	9.00	31.17	3.06
10	9.00	31.17	3.06	8.60	29.78	2.93

Table A6. Spray distribution of nozzle (NMD/S 60450)

Operating pressure = 5 kg/sq.cm

Diameter of tube = 2.1 cm

Distance between
nozzle tip to channel = 54 cmDistance between two
consecutive channels = 3.17 cm

Time taken for reading = 1 min

Number of replications = 3

Channel No.	Left from centre			Right from centre		
	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected	Av. height of liquid collected, cm	Volume collected from each channel, cc	Per cent of liquid collected
0	13.80	47.80	4.07	13.80	47.80	4.07
1	13.40	46.41	3.96	13.60	47.10	4.01
2	13.80	47.80	4.07	14.40	49.87	4.25
3	14.40	49.87	4.25	15.10	52.30	4.46
4	17.00	58.88	5.02	16.80	58.19	4.96
5	18.20	63.03	5.37	17.20	59.57	5.08
6	16.80	58.19	4.96	15.00	51.95	4.43
7	17.00	58.88	5.02	16.80	58.19	4.96
8	15.00	51.95	4.43	14.40	49.87	4.25
9	13.00	45.02	3.84	13.20	45.72	3.90
10	13.40	46.41	3.96	12.00	41.56	3.54
11	12.00	41.56	3.54	12.00	41.56	3.54

Table A7. Boom discharge rate at different pressures

Nozzle type	=	NMD/S 60450
Nozzle spacing	=	31 cm
Number of nozzles	=	8
Number of replications	=	3
Nozzle numbers	=	1 to 8

Sr. No.	Speed of pump, rpm	Working pressure, kg/sq.cm.	Discharge in cc/min (Average of 3 replications)								Total discharge of both booms, l/min
			1	2	3	4	5	6	7	8	
1	850	3.0	445	455	450	460	455	450	445	460	3.620
2	850	6.0	530	520	550	540	530	540	550	560	4.320
3	850	9.0	700	715	725	740	715	725	700	740	5.760
4	850	12.0	900	890	910	920	890	900	915	920	7.245

Table B3. Droplet size distribution analysis

System pressure -- 9.0 kg/sq.cm Ambient temperature -- 33°C
 Travel speed -- 1.0 kmph Relative humidity -- 59 Per cent
 Wind velocity -- 1.5 kmph

Number of droplets per sq.cm (Average of 3 replications)

Size range, μm	Average size, μm	Left						Position of spraying Centre						Right					
		Bottom		Top		Bottom		Top		Bottom		Top		Bottom		Top			
		F	B	F	B	F	B	F	B	F	B	F	B	F	B	F	B		
0-50	16.89	4	3	7	4	4	3	3	3	5	3	4	3	3	4	3	3		
50-100	51.09	7	3	5	4	6	6	4	5	8	4	5	4	8	4	5	4		
100-150	84.79	5	3	6	3	7	3	3	1	5	3	3	3	5	5	3	3		
150-200	118.58	4	3	3	2	8	3	4	3	4	4	3	4	4	3	4	3		
200-250	152.36	5	3	3	2	4	3	2	2	3	3	2	2	3	2	1	1		
250-300	186.14	2	2	2	1	4	2	2	1	4	2	1	4	2	2	3	1		
300-350	219.93	3	2	2	2	3	1	0	0	2	1	1	1	1	1	0	0		
350-400	253.71	3	2	1	1	2	0	2	1	3	0	1	2	3	0	1	2		
400-450	287.50	2	2	2	0	1	2	1	2	2	2	1	2	2	1	0	1		
450-500	320.91	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1		
VMD, μm	-----	230.12	193.45	218.45	150.00	180.12	210.33	162.11	139.44	189.03	230.89	167.99	145.23	189.03	230.89	167.99	145.23		
MMD, μm	-----	84.98	99.99	73.23	87.00	98.73	101.11	100.25	102.22	103.51	84.44	85.27	106.83	103.51	84.44	85.27	106.83		
UC	-----	2.70	1.93	2.83	1.72	1.82	2.08	1.61	1.51	1.83	2.73	1.97	1.35	1.83	2.73	1.97	1.35		
DPD, No./sq.cm	-----	36	24	33	21	40	24	22	19	37	23	24	19	37	23	24	19		

F -- Front B -- Back

Table B5. Droplet size distribution analysis

System pressure -- 6.0 kg/sq.cm Ambient temperature -- 33°C
 Travel speed -- 1.5 kmph Relative humidity -- 62 Per cent
 Wind velocity -- 1.4 kmph

Number of droplets per sq.cm (Average of 3 replications)

Size range, μm	Average size, μm	Actual size, μm	Position of spraying Centre												
			Left				Centre				Right				
			Bottom		Top		Bottom		Top		Bottom		Top		
0-100	33.78	4	3	2	2	3	5	2	2	2	2	5	3	2	2
100-200	101.68	5	2	3	2	2	5	3	3	2	2	4	2	3	3
200-300	169.25	3	1	2	1	3	3	2	2	1	4	4	2	2	1
300-400	226.82	2	1	2	2	2	5	1	2	2	2	4	2	1	2
400-500	304.39	3	2	2	2	2	2	2	2	0	2	2	1	2	2
500-600	371.95	2	2	1	0	1	1	1	1	1	1	1	2	2	1
600-700	439.52	2	0	2	2	2	2	0	1	2	2	2	1	2	1
700-800	507.09	1	1	0	1	1	1	1	1	1	1	1	2	1	0
800-900	574.66	0	1	1	1	1	0	0	0	0	0	1	1	1	0
900-1000	641.89	1	1	1	1	1	1	1	1	1	1	0	1	1	1
VMD, μm	-----	318.48	330.41	271.23	260.59	357.99	310.52	280.60	270.73	321.48	277.77	280.60	260.49	260.60	260.49
WMD, μm	-----	145.45	109.52	120.12	133.98	88.49	101.01	120.20	111.87	140.16	132.27	120.20	116.71	120.20	116.71
UC	-----	2.18	3.01	2.25	1.94	4.04	3.07	2.33	2.42	2.29	2.10	2.33	2.23	2.33	2.23
DPD, No./sq.cm	-----	23	14	16	15	25	13	15	12	24	17	17	13	17	13

F -- Front B -- Back

Table B6. Droplet size distribution analysis

System pressure -- 9.0 kg/sq.cm Ambient temperature -- 31°C
 Travel speed -- 1.5 kmph Relative humidity -- 64 Per cent
 Wind velocity -- 1.5 kmph

Number of droplets per sq.cm (Average of 3 replications)

Size range, μm	Average size, μm	Position of spraying Centre											
		Left				Centre				Right			
		Bottom		Top		Bottom		Top		Bottom		Top	
0-75	37.50	10	4	3	2	9	3	3	4	5	4	3	3
75-150	112.50	6	7	5	3	7	4	4	3	9	3	2	5
150-225	187.50	5	6	4	3	6	4	4	3	6	4	3	2
225-300	262.50	1	2	2	2	4	2	2	2	3	2	2	3
300-375	337.50	1	2	2	1	3	1	2	1	3	2	2	2
375-450	412.50	1	2	2	2	4	0	1	1	3	2	1	3
450-525	487.50	1	2	0	1	2	0	2	2	3	0	1	2
525-600	562.50	2	1	1	0	3	2	0	2	2	2	0	2
600-675	637.50	2	0	0	2	2	1	1	0	1	1	1	1
675-750	712.50	1	1	1	1	1	1	1	1	2	0	2	0
VMD, μm		253.48	303.21	270.54	267.94	308.35	297.38	260.29	249.21	272.01	250.35	271.65	253.05
MMD, μm		132.48	100.84	109.25	101.30	82.08	97.00	121.35	103.55	73.02	81.94	118.87	100.44
UC		1.78	3.00	2.47	2.64	3.75	3.06	2.14	2.40	3.72	3.05	2.28	2.51
DPD, No./sq.cm		30	27	20	17	41	18	22	19	37	20	17	21

F -- Front B -- Back

Table B8. Droplet size distribution analysis

System pressure -- 6.0 kg/sq.cm Ambient temperature -- 30°C
 Travel speed -- 2.0 kmph Relative humidity -- 65 Per cent
 Wind velocity -- 1.5 kmph

Number of droplets per sq.cm (Average of 3 replications)

Size range, μm	Average size, μm	Actual size, μm	Position of spraying Centre											
			Left			Right								
			Bottom	F	Top	Bottom	F	Top						
0-120	60	40.54	3	2	1	4	2	2	2	2	2	2		
120-240	180	121.95	2	2	2	3	1	1	1	3	2	2		
240-360	300	203.04	3	1	1	4	2	1	2	1	2	1		
360-480	420	284.12	2	2	1	2	1	1	1	2	2	1		
480-600	540	365.20	1	2	2	2	1	2	2	1	2	2		
600-720	660	446.28	2	1	1	1	1	1	1	2	1	1		
720-840	780	527.36	1	1	1	2	0	0	1	2	1	0		
840-960	900	608.44	2	0	0	0	0	0	0	1	0	0		
960-1080	1020	689.52	1	0	0	0	1	0	0	0	1	2		
1080-1200	1140	770.26	1	1	1	1	0	1	1	1	2	1		
VMD, μm		-----	316.21	271.97	293.89	320.45	310.53	280.44	271.39	271.39	299.12	302.77	289.02	273.43
MMD, μm		-----	161.85	132.96	150.59	103.35	153.85	160.09	135.19	134.60	158.49	139.12	140.18	138.97
UC		-----	1.95	2.04	1.95	3.10	2.01	1.75	2.00	2.01	1.88	2.17	2.06	1.96
DPD, No./sq.cm		-----	18	12	09	10	19	14	11	09	17	13	15	09

F -- Front B -- Back

Table B9. Droplet size distribution analysis

System pressure -- 9.0 kg/sq.cm. Ambient temperature -- 29°C
 Travel speed -- 2.0 kaph Relative humidity -- 65 Per cent
 Wind velocity -- 1.5 kaph

Number of droplets per sq.cm (Average of 3 replications)

Size range, μm	Average size, μm	Position of spraying Centre													
		Left				Centre				Right					
		Bottom		Top		Bottom		Top		Bottom		Top			
0-50	16.89	2	0	2	1	3	0	0	1	3	3	2	2	2	0
50-100	51.09	4	2	3	2	5	4	4	3	2	5	3	3	3	4
100-150	84.79	5	2	4	2	5	3	3	4	3	4	2	2	3	3
150-200	118.58	4	2	3	2	5	2	2	2	2	2	2	2	2	2
200-250	152.36	4	2	2	1	1	2	1	1	2	4	1	1	2	1
250-300	186.14	1	1	0	1	2	1	2	2	2	1	1	1	1	2
300-350	219.93	2	1	1	1	2	1	1	1	0	2	1	1	1	1
350-400	253.71	0	0	1	1	1	0	0	0	1	0	0	0	0	0
400-450	287.50	1	2	2	0	0	0	0	0	1	1	1	1	1	0
450-500	320.91	1	1	0	1	1	1	1	1	0	1	0	2	1	1
VMD, μm	-----	300.77	254.69	266.20	260.99	310.01	302.41	280.71	273.45	307.26	302.51	255.88	255.88	255.88	255.88
WMD, μm	-----	159.67	119.48	140.61	100.00	101.78	118.47	136.70	119.48	102.19	100.46	129.42	119.76	119.76	119.76
UC	-----	1.88	2.13	1.89	2.60	3.04	2.55	2.05	2.28	3.01	3.01	1.97	2.13	2.13	2.13
DPD, No./sq.cm	-----	24	13	18	12	25	14	15	16	23	13	17	14	14	14

F -- Front B -- Back

Table B10. Droplet density at left, centre and right portion of pendal

Travel speed, kmph	System pressure, kg/sq. cm	Droplet density (No./sq.cm) [*] (Average of 3 replications)					
		Left		Centre		Right	
		Bottom	Top	Bottom	Top	Bottom	Top
1.0	3	20	15	21	14	20	16
1.0	6	23	17	28	19	23	20
1.0	9	30	27	31	24	30	22
1.5	3	14	11	15	12	15	12
1.5	6	19	16	19	14	21	15
1.5	9	29	19	30	21	29	19
2.0	3	13	10	12	08	11	09
2.0	6	15	10	12	10	15	12
2.0	9	19	15	20	16	18	16

* Average density of front (F) and back (B) side of the leaf

APPENDIX-C

MAJOR SPECIFICATIONS OF POWER TILLER OPERATED BOOM SPRAYER

A. TECHNICAL INFORMATION OF POWER TILLER :

- | | | |
|-------------------------------|----|--------------------------------------|
| 1. Type | __ | Water cooled Mitsubishi power tiller |
| 2. Model | __ | Mitsubishi Shakti C.T. 85/V.W.H. 120 |
| 3. Horse power | __ | 10 HP |
| 4. Cooling | __ | By water (Radiator) |
| 5. Fuel used | __ | Diesel |
| 6. Engine R.P.M. | __ | 2400 |
| 7. Weight | __ | 346 kg |
| 8. Size of tyre | __ | 6 x 12 (Rubber tyre) |
| 9. Distance between two tyres | | |
| Maximum | __ | 100 cm |
| Minimum | __ | 65 cm |

ENGINE SPECIFICATIONS :

1. Type __ Horizontal, 4 stroke diesel engine
2. Cooling __ By water (Radiator)
3. Stroke length __ 95 mm (3.74 inch)
4. Bore diameter __ 92 mm (3.62 inch)
5. Compression ratio __ 21 : 1
6. Displacement volume __ 631 cc (38.5 cu. inch)
7. Specific fuel consumption __ 190 gm/hp.hr
8. Light capacity __ 6 to 8 volts, 25 watts
9. Dry weight of engine __ 119 kg
10. Tank capacity __ 10 litres
11. Air cleaner __ Oil bath type

POWER TILLER SPECIFICATIONS :

Clutch -- Multiple plate dry disc clutch
 Brake ___ Hand operated, internal expansion,
 metallic shoe type

Weight excluding engine ___ 230 kg

Speeds ___ 6 forward and 2 reverse speeds

Forward speeds : Six gears

Gear I - 1.75 kmph
 Gear II - 2.50 kmph
 Gear III - 3.45 kmph
 Gear IV - 6.20 kmph
 Gear V - 9.50 kmph
 Gear VI - 15.00 kmph

Reverse speeds : Two gears

Gear I - 0.90 kmph
 Gear II - 3.80 kmph

B. DETAILS OF THE BOOM SPRAYER**I. Pump**

1. Type of pump - HTP (Horizontal triplex piston pump)
2. Power required - 3 hp
3. R.P.M. - 950
4. Discharge - 36 lit/min
5. Pressure - 20 kg/sq.cm

II. Pressure gauge

1. Range - 0 to 70 kg/sq.cm
2. Least count - 2.5 kg/sq.cm

III. Boom

1. Number of booms - 2
2. Type of nozzle - Hollow cone nozzle(NMD/S 60450)

3. Number of nozzles - 8
4. Nozzle spacing - 31 cm
5. Shape of boom - Inverted L

IV. Trailed type unit

1. Channel for hitching
2. Tank carrier

V. Tank

1. Capacity - 200 litres
2. Agitation - Hydraulic agitation

APPENDIX-D

BOOM DESIGN

Boom of sprayer is a spray bar carrying more than one nozzle. Various types of booms suitable for orchards, vineyards, open fields and row crop fields are available. For effective spraying, boom should be perfectly designed. It was decided to design a boom suitable for grape vineyards.

1. Design of boom for grape vineyards

1.1 Plant factors

1. Crop : Grape
2. Row to row spacing : 2.4 m
3. Plant to plant spacing : 1.8 m
4. Height of vine upto pendal : 1.8 m
5. Vine canopy thickness : 0.60 - 0.75 m
6. Spread of vine branches on either side of stem : 2.0 - 3.0 m

1.2 Boom type

Generally two horizontal booms bellow the vine pendal are used for suitable adjustment of height and vertical distance.

1.3 Material used

Pressure that can be developed by HTP pump is 20 to 25 kg/sq.cm. Nozzle pressure for effective spraying is 5 to 15 kg/sq.cm, also discharge through each boom was 1.79 l/min. Therefore, 16 mm diameter G.I. pipe was selected for boom.

1.4 Shape of boom

The plant canopy of grape vineyard was of pendal shape. Some of the grape vines are in hanging position along the length of main stem. The horizontal straight boom was not sufficient to spray that vertical portion of canopy. Therefore, for complete and uniform spraying, instead of designing straight boom, two "inverted L" shaped booms were designed and two adjustable nozzles were fixed on vertically downward part of inverted L shaped boom on either sides.

1.5 Length of boom

Average canopy width per row was 2.4 m. so, effective swath requirement of boom was 2.4 m. Considering spray cone angle in view and central distance for adjustments, total length of one boom was decided to be 2.125 m and that of both booms is 4.250 m (four nozzles on each boom as shown in Fig. 4.7).

1.6 Selection of nozzle

Total requirement of liquid for spraying one hectare of grape vineyard is in the range of 900 to 1200 litres. Plant canopy swath per row was 2.4 m and for design, average speed of power tiller in grape field was considered as 1.0 kmph Therefore,

Total nozzle output in l/min

$$= \frac{\text{liquid required (l/ha)} \times \text{speed (kmph)} \times \text{swath width (m)}}{600}$$

$$= \frac{900 \times 1.0 \times 2.4}{600}$$

$$= 3.6 \text{ l/min}$$

Total nozzle output in l/min

$$= \text{Total discharge through booms}$$

$$= 3.6 \text{ l/min}$$

Total output required through each boom

$$= \frac{3.6}{2}$$

$$= 1.8 \text{ l/min}$$

On each boom , there were four nozzles

Therefore,

Discharge required through each nozzle

$$= \frac{1.8}{4}$$

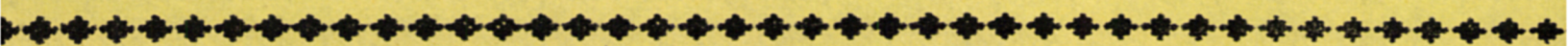
$$= 0.450 \text{ l/min}$$

$$= 450 \text{ cc/min}$$


Therefore, eight nozzles of NMD/S 60450 (discharge 450 cc/min, cone angle 60°) on equal spacings of 310 mm each considering 29.5 per cent overlap for complete and uniform coverage, were selected. NMD/S 60450 nozzle was also useful for getting finer droplets with reduced drift, uniform coverage and adequate discharge. Required discharge was correctly adjusted by increasing or decreasing pump pressure.

Boom was fabricated in workshop as per design and tested in the laboratory and on the field.

Chapter Opener Page



Vita



VITA

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A candidate for the degree

of

MASTER OF TECHNOLOGY

in

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1998

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