INSECTICIDE DEPOSITS AND RESIDUES ON PADDY WITH REFERENCE TO VOLUME OF SPRAY FLUID APPLIED AT DIFFERENT GROWTH STAGES OF THE CROP

BY
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THESIS
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I hereby declare that this thesis entitled "Insecticide deposits and residues on paddy with reference to the volume of spray fluid applied at different growth stages of the crop" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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C E R T I F I C A T E

Certified that this thesis, entitled "Insecticide deposits and residues on paddy with reference to the volume of spray fluid applied at different growth stages of the crop" is a record of research work done independently by Sri THOMAS BIJU MATHEW under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

Introduction of improved agricultural technology has been accompanied with the emergence of several serious pest problems. Introduction of high yielding varieties of crops and the improved crop husbandry practices had been conducive to the pest build up and maximisation of production without adequate plant protection measures became an unrealistic proposition. The very reason for non realisation of 'green revolution' in crops like rice is attributed to the high level of pest incidence on the crops.

The introduction of synthetic organic pesticides undoubtedly opened up a new era in the field of plant protection and without the availability of these potent pesticides the very existence of high yielding varieties in the farms would have been doubtful. The extensive and intensive use of these toxicants for ensuring attractive returns from the high cost crops were initially promising. But in due course the pesticide based plant production strategy created several serious problems like pest resistance, pest resurgence, secondary pest outbreak and above all the contamination of non-target areas in the agro ecosystem. In minimising these undesirable side effects and achieving desired level of pest control, the adoption of proper application techniques is as vital as the choice of proper pesticides. When pesticides are used in the field, the proper coverage of plant parts with least contamination of non-target areas in the ecosystem will be ideal. The volume of pesticidal formulation used for the control of pests will obviously decide the deposit and coverage of pesticides on plant parts and the extent of contaminating the crop environment. The level of deposits formed on crops sprayed with varying volumes of pesticide formulations have been studied with reference to fungicides and it has been reported that the varying volumes used in the sprays did not influence the levels of deposits on crop (Courshee, 1960; Fulton, 1965; Matthews, 1979). Contrary findings showing correlation between the volumes of pesticides used and the levels of deposits on the crops are also available (Evans and Martin, 1935; Hensill and Tihenko, 1939; Taylor, 1939; Horsfall, 1945). Extensive investigations on the effect of varying the quantity of formulations applied on crops, on the bio efficacy and contamination of pesticides are lacking. Similarly the varying levels of leaf area of the crop as influenced by the variety used and the crop husbandry practices adopted also have not been considered in such studies. The recommendations made for the different growth stages of crops like rice (Aquino and Heinrichs, 1978) and maize (Anon. 1969) are done in an arbitrary way. In this context investigations were carried out on the following aspects of insecticide application on rice:

(a) Effect of spraying different volumes of carbaryl suspension on the deposition of pesticide on the leaves and stalk of rice crop, at varying stages of crop growth, using a pnuematic knapsack sprayer as well as a mist blower.

(b) Assessing optimum volume of carbaryl suspension required to give highest levels of insecticide deposits on the leaves of rice at different growth stages when sprayed with different type of sprayers and deriving statistical models for estimating optimum volumes of spray fluids required at different growth stages of the crop, in terms of leaf area indices, under different methods of application.

(c) Assessing the contamination of irrigation water in paddy fields sprayed with different volumes of spray fluids, at different growth stages of the crop, using a pneumatic knapsack sprayer as well as a mist blower.

(d) Assessing the efficacy of spraying different volumes of carbaryl suspension on rice using the two different types of sprayers, on the larval population of rice leaf roller Cnaphalocrocis medinalis and on the extent of damage caused by rice case worm Nymphula depunctalis.

REVIEW OF LITERATURE

1. REVIEW OF LITERATURE

The references available on the high and low volume spraying of pesticides, the effect of varying volumes, on the deposits, coverage and bio-efficacy of pesticides and the extent of contamination due to the spraying of different volumes under different methods of spraying have been briefly reviewed here.

1.1 Classification of spraying based on volume of spray fluid used.

Spraying methods were classified on the basis of volume of spray fluid used, by the United States Department of Agriculture (1966), as ultra low volume in which the total volume of spray fluid used is 5.6 l/ha or less, low volume in which the total volume of spray fluid used is adequate to cover the crop uniformly, but not to the point of run-off and full cover spraying in which the total volume of spray fluid used is to cover the crop throughly, up to the point of run-off (quoted by Matthews, 1979). Bindra and Singh (1971) classified spraying methods as high volume spraying which require 1,500 to 2000 litres of spray fluid/ha in the case of orchard crops and 500 to 1000 l/ha in the case of field crops, low volume spraying which require 12 to 125 litres of spray fluid per hectare, semi-low volume spraying which require volume of spray fluid in between the range of high volume and low volume and ultra low volume spraying which require 0.5 to 0.6 litres of spray fluid/hectare.

Matthews (1979) classified spraying as high, medium, low, very low and ultra low volume spraying in which the volumes of spray fluid used for field crops were 600, 200 to 600, 50 to 200, 5 to 50 and < 5 litres/ha respectively and for trees and bushes these were > 1000, 500 to 1000, 200 to 500, 50 to 200 and < 50 respectively.

1.2 Optimum spray volumes recommended for various crops.

Patel, (1960) recommended 40 to 80 gallons of spray fluid for covering 1 ha of paddy under high volume application. Desirable volumes of spray fluid recommended for different growth stages of maize were 500, 700, 1000 and 1000 litres per ha at 10, 20, 30 and 40 days after sowing (Anon 1969). For brown plant hopper control in rice, 333, 500 and 1000 litres of water/ha were found optimum to spray the crop at 15, 35 and 60 days after transplanting (Aquino and Heinrichs, 1978). For good coverage of 1 ha of paddy, 200 litres of spray fluid under low volume and 500 litres under high volumes were suggested (Anon 1982).

1.3 Volume of spray required in relation to growth parameters of crops.

1.3.1 Volume of spray in relation to plant height : Tunstall, et al (1961) increased the volume of spray applied on cotton according to plant height. For plants less than

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30 cm in height, 56 l/ha was applied, and for each subsequent increase in height of 30 cm, the volume was increased by 56 litres upto a maximum of 280 l/ha. Morgan (1964) opined that volume of spray fluid may be selected in relation to height of the trees in the case of orchard crops. The volume of spray fluid was arbitrarily fixed for cotton, according to plant height, as 5 gallons for plants less than 15", 10 gallons for plants less than 30" and 25 gallons for tall cotton (Johnstone and Matthews, 1965).

Matthews (1971) and Morton (1973) suggested to reduce swath width with increasing plant height for cotton under ULV spraying. Accordingly 6 m swath was used for plants less than 25 cm in height, 4 m swath for plants between 25 cm and 50 cm in height and 2 m swath for plants above 50 cm in height; Morton used 2.7 m swath for plants upto 50 cm height and 1.8 m swath for plants more than 50 cm height.

1.3.2 Volume of spray in relation to leaf area index: Leaf area index of the crop to be sprayed governs, to a considerable extent, the volume of spray fluid required (Potts, 1946). Morgan (1964) suggested the need for recommending volume of spray in terms of gallons/acre of sprayed area instead of gallons/acre of land area. Cours hee (1960) attempted a theoretical calculation of volume of spray on the basis of deposit required in $\mu g/cm^2$ and he found that 5000 litres of spray fluid would be required under high volume application to give a deposit level of 10 μg/cm² when the crop had a leaf area index of 5. He also stated that the actual volume of spray required under field conditions may be much higher ie. upto 4 times the theoretical value, considering the allowances for wastage of chemical and complete wetting of less accessible targets. Matthews (1971) reported that an estimate of the leaf area index is ideally required for estimating the spray fluid requirements per ground area, provided the volume of spray fluid required per unit area of leaf is known.

1.4 Effect of volume of spray on deposit.

1.4.1 Effect of varying volumes: Smith (1928) investigated spray coverage and residue of lead arsenate as influenced by the volume of application on apple in relation to control of codling moth. Data showed that deposition of the insecticide on the average leaf in the crown of apple accumulated according to the logarithm of the volume. Evans and Martin (1935) evaluated water soluble wetting agents as constituents of combined washes and found that deposition of spray fluid and suspensoids prior to run-off had a linear relation to rate of application in the case of horizontal sprayers. Similar linear relation between deposit and volume of spray had been observed by others also, (Hensill and Tihenko, 1939, Taylor, 1939, Horsfall, 1945).

Rich (1954) reported that initial deposit of Zineb is strictly proportional to the volume of spray remaining on the leaf surface and also to the concentration of spray fluid. But this proportionality was observed in the case of low volume spraying by Courshee (1960) whereas in high volume spraying, deposition was found to be proportional only to concentration and independent of spray volume. On further observation he found that increasing spray volume need not always increase the deposit because of the variation in exposure of target areas to the spray swath. The deposit increased in the most exposed leaves with little improvement in more concealed sites (Courshee, 1967). Deposit density was found independent of volume of spray fluid, but proportional to the concentration in the original spray, with loss occurring during run off after maximum initial retention on the target (Fulton, 1965; Matthews, 1979).

1.4.2 Effect of different spraying methods on deposits : Kilgore et al (1963) compared captan deposits on almond leaves when sprayed under high and low volume and found that there was no significant difference even though the volume applied under high volume was 19.5 times that of low volume Varma et al (1973) sprayed grape vine plants with naphthalene scarlet, a red dye and observed higher deposit per unit area for low volume than high volume application. Level of insecticide residue on leaves and fruits of bhindi significantly varied between methods of application with maximum in ultra low volume followed by low volume at 225 l/ha and 275 l/ha and minimum in high volume at 1000 l/ha, (Murugesan, 1979). Seetharaman (1977) obtained lower deposit on rice and cauliflower in ULV spraying than low volume and high volume and discussed that it was due to the short stature of rice and cauliflower plants.

1.5 Effect of volume of spray on coverage.

1.5.1 Varying volumes and coverage: Fajans and Martin (1937) found that coverage depended on the density and uniformity of distribution of the deposit over the surface. Horsfall et al (1940) recommended the increase of volume of spray to give more droplet density and thereby to reduce uncovered areas. But Matthews (1973 and 1979) suggested that an increase in spray volume did not necessarily result in improved coverage, even though the number of droplets increase. Menzies et al (1979) concluded that visual coverage ratings were directly related to volume of spray fluid used. He observed higher volumes per hectare producing highest and most uniform coverage ratings when spray coverage was evaluated under different volumes by flourescent dye deposits on peach leaves.

1.5.2 Spraying methods and coverage: Large uncovered areas between sparse droplets make low volume spraying less effective against immobile pests whereas complete film of deposit make high volume spraying more effective (Ripper, 1955). Fryer et al (1957) reported that high volume spraying led to a more uniform distribution through an open leaf canopy than low volume spraying. He attributed this phenomenon to the low impaction efficiency of droplets produced by high volume application which also had a greater chance of reaching obscure targets. Martin (1957) assessed coverage under high and low volume sprayings by comparing plaster of paris prints of stained copper deposits on potato leaves obtained from both the methods of application and observed that high volume spraying gave complete cover on the leaf surface whereas low volume gave poor coverage. Cooke et al (1976 b) compared spray deposits on the top, middle and base zones of apple trees as obtained from the application of high, low and ultra low volumes and observed heavy deposit coverage on upper and lower surfaces in all the three zones under high volume than low and ultra low volumes.

1.6 Effect of volume of spray on bio-efficacy.

1.6.1 Effect of varying volumes of spray fluid: Moore (1958) conducted an experiment with field dosage of lime sulphur sprayed in different volumes and validated the hypothesis, "in low volume spraying, control is in direct proportion to dosage of fungicide irrespective of volume applied". Hickey (1960) applied Dikar at 6.6 lb/acre to apple trees in different dilutions, viz. 20.5, 41 and 81.2 gallons/acre, by pneumatic sprayer and 11, 16 and 20 gallons/acre by a mist blower and found no significant difference in controlling powdery mildew disease. He repeated the experiments with other chemicals and obtained similar results. Volume of spray fluid is unimportant if adequate spray coverage and deposit is obtained, as reported by Lewis (1971). He compared the efficacy of different volumes of fungicide in controlling diseases of apple, such as powdery mildew, scab, cedar apple rot etc., keeping dose as constant and found no significant difference among varying volumes. Aquino and Heinrichs (1978) carried out studies to determine the relationship between volume of spray and control of rice pest, Nilaparvata lugens (Stal.). Results revealed that the level of control was same for all volumes of spray viz. 200, 400, 600, 800 and 1000 l/ha when dosage of the insecticide was kept constant (perthane at 0.75 kg ai/ha), though the officially recommended volume of water for such an application was 1000 l/ha.

1.6.2 <u>Different methods of spraying in relation to bio-efficacy:</u> Norman and Joyce (1954) observed that high and low volume application of same dosage of DDT did not show any significant difference on the mortality of cotton jassid <u>Amrasca biguttula biguttula</u>. However, high volume application was more effective in controlling the nymphs of <u>Bemisia tabaci</u>. Varma (1957) compared high and low volume applications of DDT and BHC for controlling cotton jassid and reported that both the methods were equally effective. In comparing the application of the same amount of endrin in a hand compression equipment and mist blower for controlling green peach aphid *Myzus persicae*, it was found that low volume gave better control (Young *et al*., 1957). Sugimoto *et al*. (1965) observed longer persistence when insecticide was applied under high volume against rice stem borer and explained it as caused by the running of spray fluid down the leaf blades into the cracks in the leaf sheath. Bindra and Singh (1971) reportedthat high volume application destroyed natural enemies to a lesser extent than low volume application when they were more mobile and active than the pest.

High volume application at 2700 l/ha was the most effective technique in controlling complex pest and disease situation on apple when compared to reduced volumes of 550 l/ha which could not penetrate to the hidden target organisms (Morgan, 1972). Low volume application of pesticides on apple gave equal control of pest, and diseases as in conventional high volume application (Morgan 1972; Cooke *et al*, 1976 a).

Singh and Khangura (1975) observed that high volume application was superior over low and ultra low volume applications, in controlling cotton white fly, *Bemisia tabaci* which was immobile in its immature stages. However, all the three methods of application were equally effective in controlling active insects such as aphids and jassids.

Experiment conducted to compare the efficacy of different spraying methods in controlling apple scab disease proved high volume application @ 2250 l/ha to be the most effective followed by low volume @ 229 l/ha and ultra low volume @ 22.5 l/ha (Cooke *et al.* 1976 b.). Khangura and Sandhu (1976) compared low and high volume application of different insecticides and found no significant difference between them in controlling ber leaf hopper *Zyginida pakistanica*. Cole and Zvenyika (1978) reported better pest control in tobacco with low volume application than high volume application.

Patel (1979) studied the performance of fenitrothion at 1 kg ai/ha in mist blower (50, 75 and 100 l/ha), hand compression foot and knapsack sprayers (500, 750 and 1000 l/ha) for the control of *Mythimna separata* (Wlk.) and found that the hand compression spray equipment using high volume spray was significantly superior in controlling the larvae than mist blower, the percentage reduction being 95 and 56 respectively. Thomas (1981) reported that high volume application of carbaryl at 1.25 kg ai/ha was superior to low volume spray in controlling brown plant hopper of rice, *Nilaparvata lugens* (Stal.)

1.7 Volume of spray fluid applied in relation to contamination of the crop environment.

Varma (1957) suggested that insecticide lost in run-off or dripping of the spray liquid resulting from high volume application could be reduced by restricting the volume. Fraser (1958) opined that spraying to run-off wasted 95% of the liquid and often did not completely wet the plant. Courshee (1960) observed that spray fluid lost due to run-off after reaching maximum initial retention from sprayed target and spray passing through the canopy missing the target contaminate the environment. On further investigation, he compared the wastage of spray fluid at different growth stages of fruit trees and estimated that about 80% of the volume applied reached the ground beneath the trees when they were dormant, but only 10% reached the ground when they were in full bloom. Morgan (1972) estimated the extent of pesticide wastage under different methods of spraying on apple and found that high volume spraying @ 5615 g of copper/ha in 2200 l deposited 1964 g on apple trees and wasted 3650 g/ha; while, ultra low volume application @ 119 g of copper/ha in 1.8 litres deposited 39 g and wasted 78 g, the proportion of spray fluid retained on the trees being same in both the methods, but total volume wasted in high volumes was 46 times that of ultra low volumes. Firman and Wallis (1960) increased volumes of spray fluid to spray coffee and found that proportion of spray retained on coffee leaves decreased as the volumes of spray increased. Run-off occured even at fairly low volumes of application and they observed that this was the main reason for low retention at higher volume rates of application. Johnstone (1973) reported that run-off started even with as low a volume as 100 litres of spray fluid when applied to a low, sparsely leaved crop. Himel (1974) reported that as much as one third of the spray applied to a crop might be lost to the soil.

Matthews (1979) observed that only a small proportion of active ingredient applied for the control of rice stem borer reached the correct site of action and much was lost in the irrigation water. In comparing the effect of low and high volume sprays of BHC and quinalphos on the level of water contamination, it was evident that the high volume sprays were much more harmful to Lepidocephalus thermalis than low volume sprays. (Thomas, 1981). The level of contamination in rice fields sprayed with carbaryl at different dosages was almost double under high volume spraying than that of low volume spraying (Thomas et al., 1982).

MATERIALS AND METHODS

2. MATERIALS AND METHODS

2.1 Fixing optimum quantity of spray fluid required at different growth stages of paddy when applied with a pneumatic knapsack sprayer

2.1.1 Raising the nursery: A wet nursery of a medium duration rice variety 'Jyothi' was raised in the Instructional farm, College of Agriculture, Vellayani.

2.1.2 Lay out of the experiment: Experiment was laid out as shown in Fig.1 during the second crop season of 1980-81, adopting a randomised block design with single replicate in each treatment. Fourty four plots of 8 m x 5 m size were laid out and the plots were separated from each other by 0.5 m wide bunds and 1 m wide buffer area. Necessary preparatory cultivations were done and the land was perfectly levelled facilitating controlled irrigation and drainage.

2.1.3 Planting: Twenty three day old seedlings were transplanted at two per hill and the spacing adopted was 20 cm x 10 cm.

2.1.4 Crop husbandry: All the crop husbandry operations, except plant protection, were carried out uniformly as per the package of practices recommended by Kerala Agricultural University (Anon. 1978)

Fig. 1 Lay out of the field experiment for fixing optimum quantity of spray fluid required at different growth stages of paddy when applied with different types of sprayers.

G2 V9	G3 V4	G4 V10	G1 V4	G2 V11	G4 V7	G3 V8	G1 V7	G2 V1	G1 V11	G3 V3
G3 V5	G2 V8	G3 V1	G1 V3	G3 V7	G1 V8	G2 V5	G3 V9	G4 V3	G3 V11	G4 V1
G4 V11	G3 V2	G1 V2	G2 V6	G4 V8	G4 V6	G1 V6	G4 V4	G2 V2	G4 V2	G2 V4
G2 V10	G1 V1	G2 V7	G4 V9	G3 V6	G1 V5	G4 V5	G3 V10	G1 V9	G2 V3	G1 V10

TREATMENTS

A. VOLUME OF SPRAYFLUID IN PNEUMATIC SPRAYER/ MIST BLOWER

V1 : 100/60 LITRES PER HECTARE
V2 : 150/90 LITRES PER HECTARE
V3 : 200/120 LITRES PER HECTARE
V4 : 250/150 LITRES PER HECTARE
V5 : 300/180 LITRES PER HECTARE
V6 : 350/210 LITRES PER HECTARE
V7 : 400/240 LITRES PER HECTARE
V8 : 450/270 LITRES PER HECTARE
V9 : 500/300 LITRES PER HECTARE
V10 : 550/330 LITRES PER HECTARE
V11 : 600/360 LITRES PER HECTARE

B. GROWTH STAGE

G1 : 30 DAS
G2 : 45 DAS
G3 : 60 DAS
G4 : 75 DAS

N

FIG. 1

2.1.5 Details of treatments: Carbaryl 0.2% suspension was applied at 100, 150, 200, 250, 300, 350, 400, 450, 500, 550 and 600 l/ha and at different growth stages of the crop viz. 30, 45, 60 and 75 days after sowing. Each of these treatments was done in separate plots so as to avoid repeated application of insecticides in any of the experimental plots.

2.1.6 Application of insecticide: Sevin 50 WP supplied by M/s Union Carbide India Ltd., Bombay was used for the experiment and it was suspended in water at 0.2% concentration. A hand compression pneumatic sprayer was used for spraying. Sprayer was calibrated and the effective swath width was standardised in such a way that the entire quantity of spray fluid to be applied in each plot could be sprayed in a single round.

Spraying was done between 8 A.M. and 10 A.M. when the air turbulence was least and two metre high wind screens were provided on all sides of the plot to avoid interplot drift, if any. While spraying, the lance was kept horizontally at a constant height from the canopy to ensure as uniform a coverage as possible. The pressure in the sprayer also was maintained uniformly by restricting the time of spraying after each pumping which was also done at a fixed level.

2.1.7 Assessment of insecticide deposits: The deposits of carbaryl on leaves and stalk in each treatment were estimated, using chemical assay techniques.

2.1.7.1 Preparation of standard curve and fitting of regression equation: A stock solution containing 1000 ug/ml of carbaryl was prepared using dichloromethane as solvent. Aliquots representing 0, 10, 20, 40, 60, 80 and 100 ug/ml were transferred to 25 ml volumetric flasks. A quantity of 15 ml coagulating solution (0.5 g ammonium chloride dissolved in 400 ml distilled water containing 1 ml orthophosphoric acid) was added and made upto 25 ml with acqueous acetone (10% v/v). A five ml aliquot was then transferred to B 19/26 tubes and colour was developed as per the methods of Benson and Finocchiare (1965). Intensity of colour was read as per cent transmittance at 477 u in Spectronic 20. The optical densities corresponding to the readings were worked out and a regression equation $y = ax + b$ was fitted with optical density as y and total carbaryl in sample as x.

2.1.7.2 Recovery test: Ten g of chopped paddy leaves and 24 g of stalks were taken in 250 ml beakers and fortified with 0, 5, 10 and 25 ug of carbaryl. Three such replicates were taken.

Insecticide was extracted by shaking the above fortified sample for 30 minutes with dichloromethane in quantities sufficient to immerse the material, using a mechanical shaker. Extract was filtered and passed through a bed of anhydrous sodium sulphate taken in a funnel plugged with cotton. After two to three washings, the filtrate was decolourised by shaking with activated charcoal in 250 ml conical flask and filtered through Whatman No.1 filer paper. Filtrate was collected in 250 ml beaker and the entire filtrate was evaporated to dryness under the fan.

The side of the beaker was rinsed down with 10 ml acqueous acetone and 15 ml coagulating solution in three to four lots and the washings were transferred to 25 ml volumetric flasks. This was made upto 25 ml with acqueous acetone, allowed to stand for 10 minutes with occasional shaking and was then filtered through Whatman No.42 filter paper.

A five ml aliquot was then transferred to B 19/26 tube and colour was developed and read in Spectronic 20. Quantities of recovered insecticide were calculated from the regression equation already worked out and the mean per cent recoveries were calculated.

2.1.7.3 Collection of samples: Plant samples from treated plots were collected at random two hours after spraying. Plants were cut at the soil level and put in polythene bags and brought to the laboratory. Three samples were collected from each plot. Each sample was taken as a replicate.

2.1.7.4 Processing of samples: Insecticide deposits on leaves and stalk were extracted separately. Leaf blade and stalk portions were taken in separate lots and chopped into small pieces. Ten g of leaves and twenty five g of stalk were weighed into labelled petri-dishes and stored below 5°C till analysis. The lower portion of the stalk from where deposits might have lost due to handling were excluded from the samples.

2.1.7.5 Estimation of carbaryl in samples: Insecticide was extracted from the leaves and stalk samples, cleaned up and estimated colourimetrically as described in item 2.1.7.2.

2.1.8 Estimating the leaf area index : Ten hills from each plot were observed at random and leaf area index was calculated at each stage adopting the method suggested by Gomez (1972). The value 0.75 was used as the adjustment factor for calculating the index. Mean of the observations taken from eleven plots to be treated at a particular growth stage of the crop was taken as the leaf area index relating to that particular crop stage.

2.2 Fixing optimum quantity of spray fluid required at different growth stages of paddy when applied with a mist blower

Experiment was conducted during the third crop season of 1980-'81 adopting randomised block design with 44 treatments. Lay out, planting and crop husbandry operations were carried out as in the experiment described under item 2.1.

2.2.2 Details of treatments: Carbaryl at 0.2% concentration was sprayed @ 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 l/ha and at four different growth stages of the crop viz. 30, 45, 60 and 75 days after sowing.

2.2.2 Application of insecticide: A power operated mist blower (star mist) was used for spraying. The sprayer was calibrated and the procedure followed in experiment under item 2.1.6 was adopted in this experiment.

2.2.3 Assessment of insecticide deposits: Insecticide deposits on paddy leaves and stalk were estimated at two hours after spraying as in the previous experiment.

2.3 Fitting of a statistical model for optimum volume of spray fluid required at different growth stages of paddy, under different methods of application in terms of leaf area index

The variance between leaf deposits at each stage of growth and under each method of application was tested for significance and the minimum volume giving highest deposit on leaves was selected as the optimum. Four optimum values were thus obtained for the four growth stages of the crop and under each method of application. Correspondingly, there were four mean leaf area indices for the different growth stages under each method of application. Simple correlation between the optimum volumes and the respective leaf area indices was worked out. Linear models of the form $y = a + bx$ was fitted for both the methods of application with optimum volumes as y and leaf area indices

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as x. Based on these models, the optimum volumes of spray under each method of application for different values of leaf area indices were computed and presented as a ready reckoner table.

2.4 Assessment of water contamination in paddy fields sprayed with different volumes of spray fluid using pneumatic knapsack sprayer

2.4.1 Lay out of the experiment: A field experiment was conducted in the first crop season of 1981-'82 in randomised block design with 24 treatment plots of size 6.25 m x 1.6 m with 0.25 m wide bunds and 1 m wide buffer area. Plots were perfectly levelled facilitating controlled irrigation and drainage. Planting and crop husbandry operations were carried out as in the previous experiment. A water level of 5 cm was maintained uniformly in all the plots at the time of treatment.

2.4.2 Details of treatment: Carbaryl at 0.2% concentration was sprayed at different levels using a pneumatic knapsack sprayer. The volume tried were 100, 200, 300, 400, 500 and 600 l/ha. All the 6 treatments were applied at different growth stages of the crop viz. 30, 45, 60 and 75 days after sowing.

Insecticide was applied as in the previous experiments. Varying volumes were applied in a single round by standardising the walking speed at each of the occasions.

2.4.3 Collection of water samples: Water samples of 100 ml each were drawn out immediately after spraying from 10 different locations in each plot and the samples were pooled to make up one litre. Four such one l samples were collected from each plot in wide mouth bottles and brought to the laboratory. Each sample was considered as a replicate.

2.4.4 Estimation of residue.

2.4.4.1 Recovery test: Irrigation water collected from untreated plot was fortified with 0, 5, 10 and 20 ug of carbaryl each in triplicate. Plant debris and other bio-matter were removed by passing through Whatman No.1 filter paper and 250 ml aliquot from each sample was transferred to 500 ml separating funnel. A quantity of 75 ml dichloromethane was added to it and it was thoroughly shaken for five minutes. When the two layers were separated, the lower layer was drained into 250 ml beaker after passing through a bed of anhydrous sodium sulphate. This step was done twice with fresh lots of 75 ml dichloromethane, but using the same sodium sulphate. The filtrate was mixed with activated charcoal and filtered through Whatman No.1 filter paper. The entire filtrate was evaporated to dryness and the insecticide recovered was estimated as in the case of previous experiments.

2.4.4.2 Estimation of residues in water samples: The insecticide residue in the samples collected were extracted, cleaned up and estimated as described under the item 2.4.4.1, following the method described by Benson and Finocchiare (1965).

2.5 Assessment of water contamination in paddy fields sprayed with different volumes of spray fluid, using a mist blower

An experiment applying 0.2% carbaryl suspension @ 60, 120, 180, 240, 300 and 360 l/ha with a mist blower was done as described under item 2.4.

2.6 The effect of different volumes of carbaryl suspension sprayed with a pneumatic knapsack sprayer on the incidence of rice case worm *Nymphula depunctalis* (Guen.)

2.6.1 Lay out: A case worm infested field at 45 days after sowing was selected and three blocks each with 11 treatment plots and one control plot (6.25 m x 1.6 m) were peg marked using rope and pegs. A buffer area of 1 m width was left on all sides of each plot to avoid interplot interference due to spray drift.

2.6.2 Application of insecticide: Carbaryl was sprayed at 0.2% concentration at different volumes as shown in Table 11.

2.6.3 Assessment of result: Intensity of damage by case worm was assessed one day before treatment and at 7 and 14 days after treatment. Infested leaves from 30 randomly selected hills were scored visually into four categories. Total number of leaves and number of damaged leaves in each category were recorded. The percentage of damage was calculated using the formula, P = (a x 1) + (b x 2) + (c x 3) +(d x 4) x 100/N x 4 where a is the number of leaves with 1 to 25% of leaf area damaged, b is the number of leaves with 26 to 56% damage, c is the number of leaves with 51 to 75% damage, d is the number of leaves with 76 to 100% damage and N is the total number of leaves per hill. The reduction of damage due to treatment when compared to pre-treatment infestation percentage were calculated and the data were statistically analysed.

2.7 The effect of different volumes of carbaryl suspension sprayed with a mist blower on the incidence of rice case worm *Nymphula depunctalis* (Guen.)

An experiment applying 0.2% carbaryl suspension @ 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 l/ha and control, with a mist blower, was done as described under item 2.6.

2.8 The effect of different volumes of carbaryl suspension sprayed with a pneumatic knapsack sprayer, on the incidence of rice leaf roller *Cnaphalocracis medinalis* (Guen.)

The experiment was laid out as described under item 2.6.1 and the insecticide was applied in different volumes as shown in Table 9, using a pneumatic knapsack sprayer. Stage of the crop was at 75 days after sowing at the time of treatment.

2.8.1 Assessment of results: Pre-treatment and post treatment larval counts were taken for comparing the efficacy of spraying different volumes of spray fluid. Larval counts from 50 randomly collected leaf rolls were taken a day before spraying and these larvae were released carefully into uninfested leaves in each plot after counting. Similar counts were taken 48 hrs after spraying and percentage reduction in the population was calculated and the data were statistically analysed.

2.9 <u>The effect of different volumes of carbaryl suspension sprayed with a mist blower, on the incidence of rice leaf roller *Cnaphalocrocis medinalis*</u> (Guen.)

The experiment was laid out as described under item 2.6.1 and the insecticide was applied at different volumes as shown in Table 10.

RESULTS

3. RESULTS

3.1 Deposit of carbaryl on the leaves of rice sprayed with different volumes of insecticide suspension at different growth stages of the crop, using a pneumatic knapsack sprayer

The data relating to the experiment are presented in Table 1 and Fig.2. At 30 DAS (days after sowing) the maximum insecticide deposit of 7.77 ppm was observed in plots treated with the suspension at 200 l/ha while in 250 l/ha, the deposit was 7.14 ppm. The two treatments were on par. The rate of 300 l/ha, the third in ranking was significantly inferior to the best treatment of 200 l/ha and was on par with all other higher volumes tried and the lower volumes of 100 and 150 l/ha.

At 45 DAS, the maximum deposit of 10.17 ppm was observed in plots treated with the suspension at 350 l/ha and it was closely followed by the treatments of 500, 300, 450, 550 and 400 l/ha, the deposits being 9.32, 9.20, 9.20, 8.97 and 8.97 ppm respectively. The deposits in plots treated at the above levels did not vary significantly. The least deposit was in treatment with 100 l/ha of suspension which was followed by 150 l/ha and the deposit in these treatments did not vary significantly. The deposit observed in other treatments were of an intermediate level.

Table 1. Deposit of carbaryl on leaves of rice sprayed with different volumes of the insecticide suspensions at different growth stages of the crop, using a pneumatic knapsack sprayer

Volume of suspension sprayed (1/ha)	Dosage kg ai/ha	Mean deposit (ppm) on plants treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
100	0.2	4.86	3.16	1.17	1.89
150	0.3	5.72	3.51	2.23	4.39
200	0.4	7.77	5.24	3.16	5.05
250	0.5	7.14	6.03	3.68	8.97
300	0.6	5.93	9.20	4.21	12.51
350	0.7	5.81	10.17	4.90	17.91
400	0.8	5.73	8.97	8.63	19.88
450	0.9	6.06	9.20	9.79	20.04
500	1.0	5.98	9.32	13.19	24.36
550	1.1	6.08	8.97	11.47	25.74
600	1.2	5.40	8.55	10.37	23.43

Abstract of Anova:	df	Mean squares			
Treatments	10	3.36**	19.09**	51.93**	227.31**
Error	20	0.52	0.81	0.60	1.50
C.D. for comparing the treatments		1.31	1.54	1.32	2.09

** Data significant at 0.01 level

DAS Days after sowing

Recovery of pesticide from fortified leaf samples : 90.86 to 96.45%

Fig.2 Effect of spraying different volumes of carbaryl suspension, on the levels of deposit obtained on leaf surface of rice, at different growth stages of the crop, (Sprayed with a pneumatic knapsack sprayer).

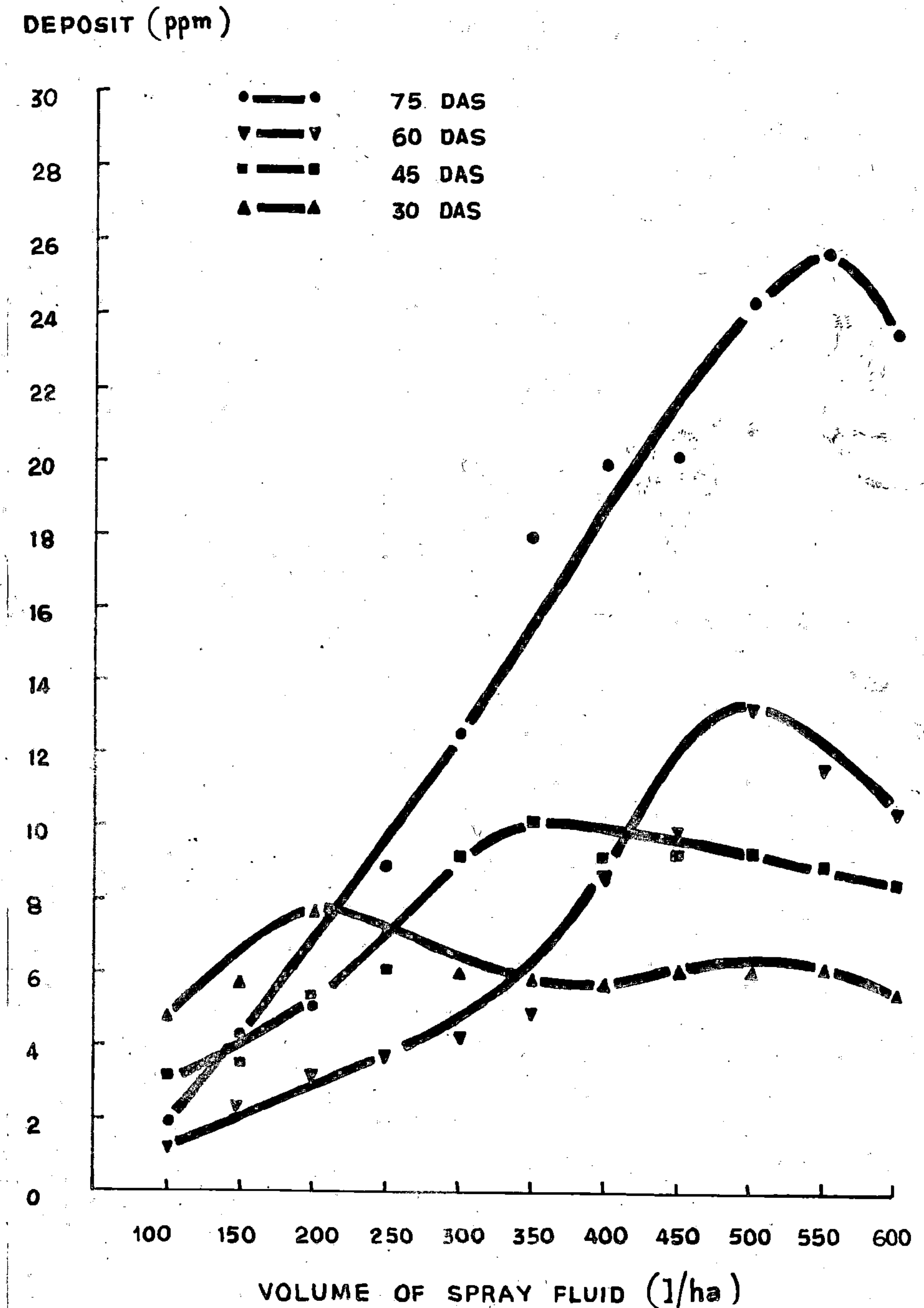

DEPOSIT (ppm)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
75 DAS
60 DAS
45 DAS
30 DAS
100
150
200
250
300
350
400
450
500
550
600
VOLUME OF SPRAY FLUID (l/ha)

FIG. 2

At 60 DAS the deposit obtained in plots treated with the insecticide suspension at 500 1/ha had the maximum deposit of 13.19 ppm and it was superior to all other treatments. The higher volumes of 550 and 600 1/ha gave 11.47 and 10.37 ppm deposit respectively, there being no significant difference between them. With reference to the volumes lower than the optimum, the deposits formed were in a descending scale for 450 1/ha to 100 1/ha, the range being 9.97 to 1.17 ppm.

At 75 DAS the highest deposit of 25.74 ppm was observed in plots treated with 550 1/ha of suspension and it was closely followed by 500 1/ha with a deposit of 24.36 ppm, there being no significant difference between the two treatments. The deposit in 600 1/ha was lower than the above two treatments but that did not vary significantly from the rate of 550 1/ha. The lower ranges of 450 1/ha to 100 1/ha showed a steady decline in the extent of deposit ranging from 20.04 ppm to 1.89 ppm.

The recovery of the pesticide from fortified samples estimated with the technique of Benson and Finocchiaro (1965), ranged from 90.86 to 96.45%.

3.2 <u>Carbaryl deposit on the leaves of rice sprayed with different volumes of the insecticide suspension at different growth stages of the crop, using a mist blower.</u>

The data relating to the experiment are presented in Table 2 and Fig.3. At 30 DAS the highest deposit of 8.85 ppm was observed in plots treated with the insecticide suspension at 90 l/ha. The higher volumes of 120, 180, 210, 240, 270, 300 and 330 l/ha also were on par with the optimum volume 90 l/ha. The remaining levels of 150, 360 and 60 l/ha gave low deposits of 7.33, 6.94 and 6.82 ppm respectively.

At 45 DAS the volume of 120 l/ha was found to be the best which gave the maximum deposit of 10.5 ppm. The lower rates of 90 and 60 l/ha gave low deposit of 8.53 and 5.73 ppm respectively. The levels of spray fluids higher than the optimum did not show any significant variation among themselves and were on par with the rate of 120 l/ha.

At 60 DAS the plots treated with the insecticide suspension at 180 l/ha had the maximum deposit of 14.15 ppm and this was on par with all the higher volumes tried. With reference to the volumes lower than optimum, the deposits obtained were in a descending order from 150 to 60 l/ha, the range of deposit being 9.89 to 4.39 ppm.

At 75 DAS the plants treated with suspension at 180 l/ha had the maximum deposit of 15.84 ppm and were on par with the plants treated with higher volumes of 210, 240 and 270 l/ha. It was followed by 330, 300 and 360 l/ha, showing deposits in the range of 14.03 to 13.05 ppm. All the volumes below the optimum were significantly inferior and the deposits formed were in a regular descending scale.

Table 2. Deposit of carbaryl on leaves of rice sprayed with different volumes of the insecticide suspensions at different growth stages of the crop, using a mist blower

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean deposit (ppm) on plants treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
60	0.12	6.82	5.73	4.39	4.66
90	0.18	8.85	8.53	6.03	7.55
120	0.24	8.53	10.50	7.55	9.44
150	0.30	7.35	10.13	9.89	11.47
180	0.36	8.09	10.01	14.15	15.84
210	0.42	8.29	9.81	13.19	15.65
240	0.48	7.79	9.56	13.07	15.03
270	0.54	7.97	9.30	12.78	14.74
300	0.60	8.31	10.13	12.43	13.59
330	0.66	7.89	9.44	12.98	14.03
360	0.72	6.94	9.21	12.58	13.05

Abstract of Anova:	df	Mean squares			
Treatments	10	1.22*	5.12**	33.56**	39.64**
Error	20	0.45	0.92	1.02	1.02
C.D. for comparing the treatments		1.14	1.64	1.72	1.72

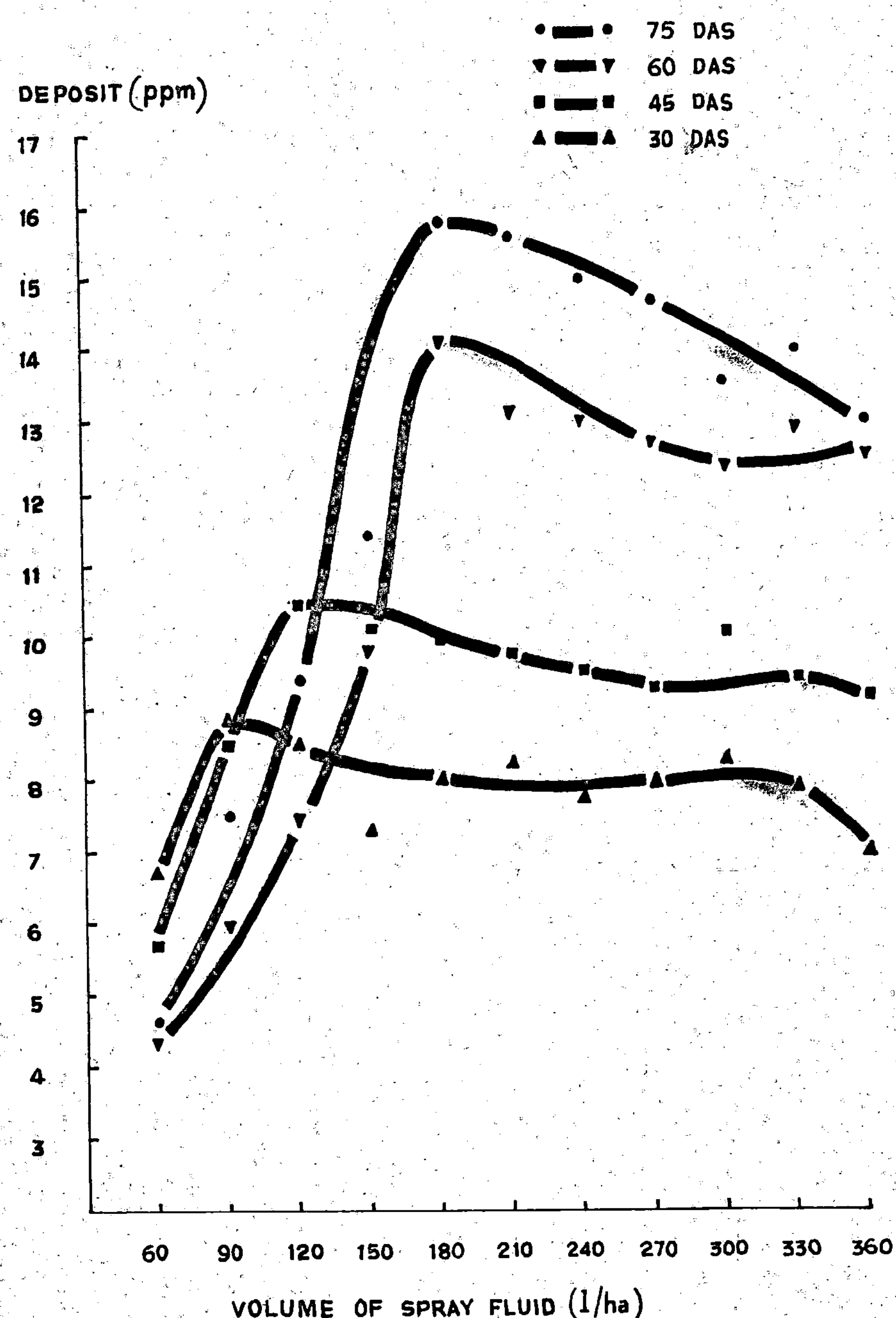
* Data significant at 0.05 level

** Data significant at 0.01 level

DAS Days after sowing

Recovery of pesticide from fortified leaf samples: 90.86 to 96.45%

Fig.3 Effect of spraying different volumes of carbaryl suspension, on the levels of deposit obtained on leaf surface of rice, at different growth stages of the crop, (sprayed with a mist blower).



75 DAS
60 DAS
45 DAS
30 DAS
DEPOSIT (ppm)
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
60
90
120
150
180
210
240
270
300
330
360
VOLUME OF SPRAY FLUID (l/ha)

FIG. 3

3.3 Carbaryl deposit on stalks of rice sprayed with different volumes of insecticide suspension at different growth stages of the crop, using a knapsack sprayer.

The data are presented in Table 3 and Fig.4. At 30 DAS the volume of suspension at 550 l/ha formed the highest deposit of 6.32 ppm on stalk followed by the volumes of 500, 600, 450, 400 and 350 l/ha in descending order. The levels lower than 350 l/ha formed deposit in a descending scale, there being no significant difference among them and the range was 4.54 to 2.81 ppm.

At 45 DAS the highest volume of 600 l/ha was found to give the maximum deposit of 4.09 ppm which was closely followed by 550 and 500 l/ha with deposits of 3.53 and 2.96 ppm respectively, there being no significant difference between the treatments. The treatments next in rank were 450, 400 and 350 l/ha without significant difference among them and these were followed by 250, 200, 150, 300 and 100 l/ha.

At 60 DAS the deposit obtained from plots treated with 600 l/ha of suspension was the maximum (3.26 ppm) and the deposit in all the lower levels of treatment were in a descending scale from 550 l/ha to 150 l/ha, the range of deposit being 3.00 to 1.49 ppm. The lowest treatment of 100 l/ha formed minimum deposit in stalk and was significantly poorer than all the other treatments.

Table 3. Deposit of carbaryl on stalks of rice sprayed with different volumes of the insecticide suspensions at different growth stages of the crop, using a pneumatic knapsack sprayer

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean deposit (ppm) on plants treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
100	0.2	2.81	1.28	0.83	1.53
150	0.3	3.47	1.71	1.49	2.45
200	0.4	3.66	1.84	1.66	2.73
250	0.5	4.28	1.88	1.97	3.06
300	0.6	4.54	1.66	2.38	3.26
350	0.7	4.66	1.97	2.58	3.46
400	0.8	5.37	2.38	2.62	3.10
450	0.9	5.90	2.52	2.76	2.96
500	1.0	6.08	2.96	2.87	2.58
550	1.1	6.32	3.53	3.00	2.62
600	1.2	5.96	4.09	3.26	2.29

Abstract of Anova:	df	Mean squares			
Treatments	10	4.27**	2.24**	1.64**	8.57**
Error	20	0.98	0.14	0.13	0.09
C.D. for comparing the treatments		1.69	0.63	0.62	0.50

** Data significant at 0.01 level

DAS Days after sowing

Recovery of pesticide from fortified stalk samples: 87.11 to 92.63%

Fig.4 Effect of spraying different volumes of carbaryl suspension, on the levels of deposit obtained on surface of the stalk, at different stages of the crop, (sprayed with a pneumatic knapsack sprayer).

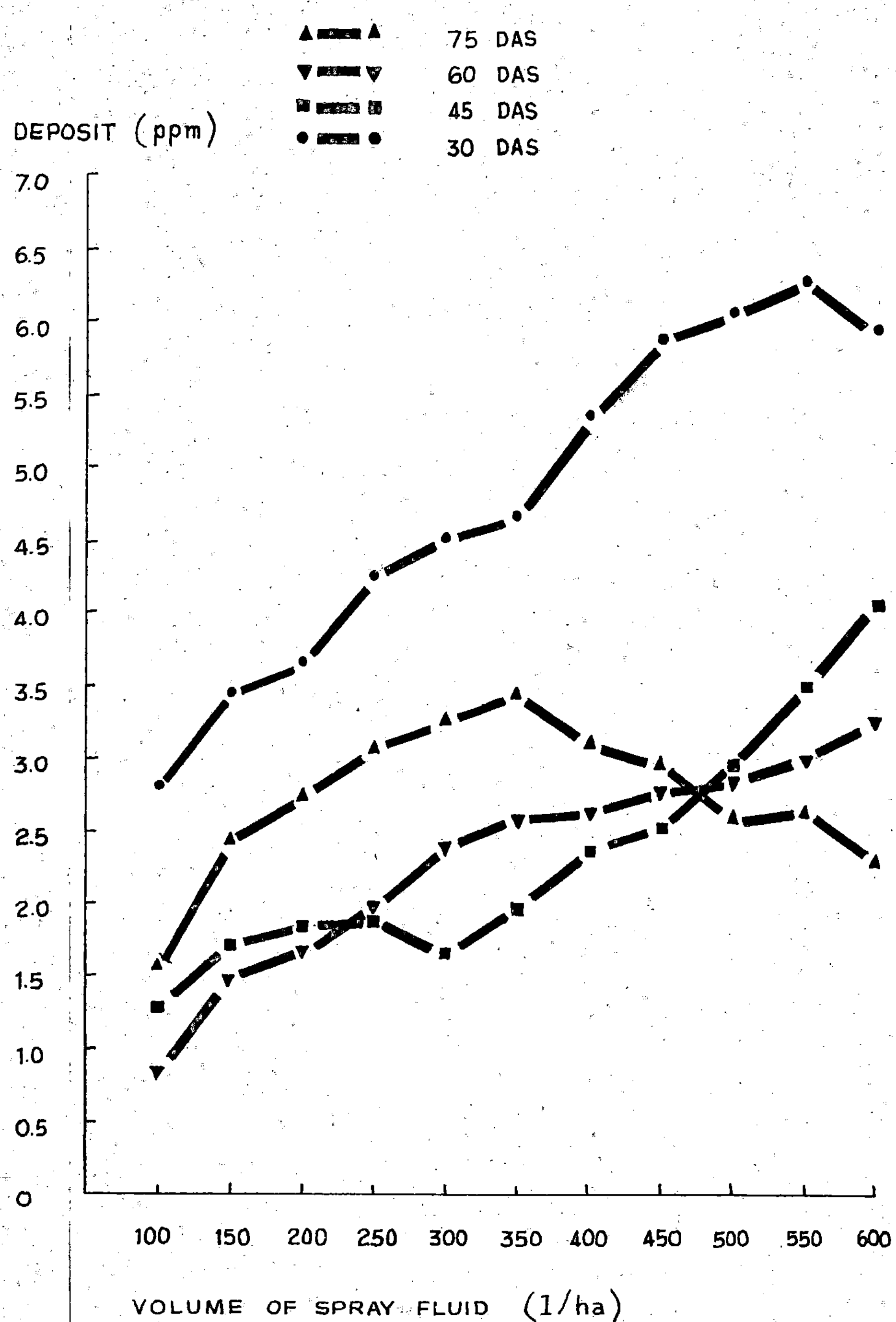

75 DAS
60 DAS
45 DAS
30 DAS
DEPOSIT (ppm)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
100
150
200
250
300
350
400
450
500
550
600
VOLUME OF SPRAY FLUID (1/ha)

FIG. 4

At 75 DAS the highest deposit of 3.46 ppm was obtained in plot treated with 350 l/ha of suspension and it was closely followed by 300, 400 and 250 l/ha with deposit levels of 3.26, 3.10 and 3.06 ppm respectively, there being no significent difference among the three. The deposit in the higher treatment levels of 600 l/ha was on par with that in 150 l/ha and deposits in these were significantly lower than the deposit formed in intermediate levels of 200, 550 and 500 l/ha. Plants treated at 100 l/ha of suspension showed a low deposit of 1.53 ppm only.

The recovery of the pesticide from fortified stalk samples estimated with the technique of Benson and Finocchiaro (1965) ranged from 87.11 to 92.63%.

3.4 Carbaryl deposit on the stalks of rice sprayed with different volumes of insecticide suspension at different growth stages of the crop, using a mist blower

Results relating to the experiment are presented in Table 4 and Fig.5. At 30 DAS the plot treated with the highest volume of suspension i.e. 360 l/ha had the maximum deposit of 5.12 ppm and the plots treated with lower rates from 330 to 150 l/ha showed deposits ranging from 5.07 to 3.51 ppm. The levels of deposit formed in 360, 330 and 300 l/ha did not vary significantly, but were significantly superior to the deposit in 270 l/ha. With reference to the lower volumes of 150, 120 and 90 l/ha, the deposit formed

Table 4. Deposit of carbaryl on stalks of rice sprayed with different volumes of the insecticide suspension at different growth stages of the crop, using a mist blower

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean deposit (ppm) on plants treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
60	0.12	2.96	1.41	0.54	2.86
90	0.18	3.16	1.92	0.95	2.49
120	0.24	3.10	2.10	1.16	2.02
150	0.30	3.51	2.24	1.33	1.88
180	0.36	3.87	3.08	1.93	1.79
210	0.42	3.77	2.96	2.51	1.66
240	0.48	3.83	3.15	2.42	1.93
270	0.54	4.48	3.78	2.76	1.66
300	0.60	4.84	3.67	2.51	1.54
330	0.66	5.07	4.09	2.61	1.93
360	0.72	5.12	4.21	2.90	2.21

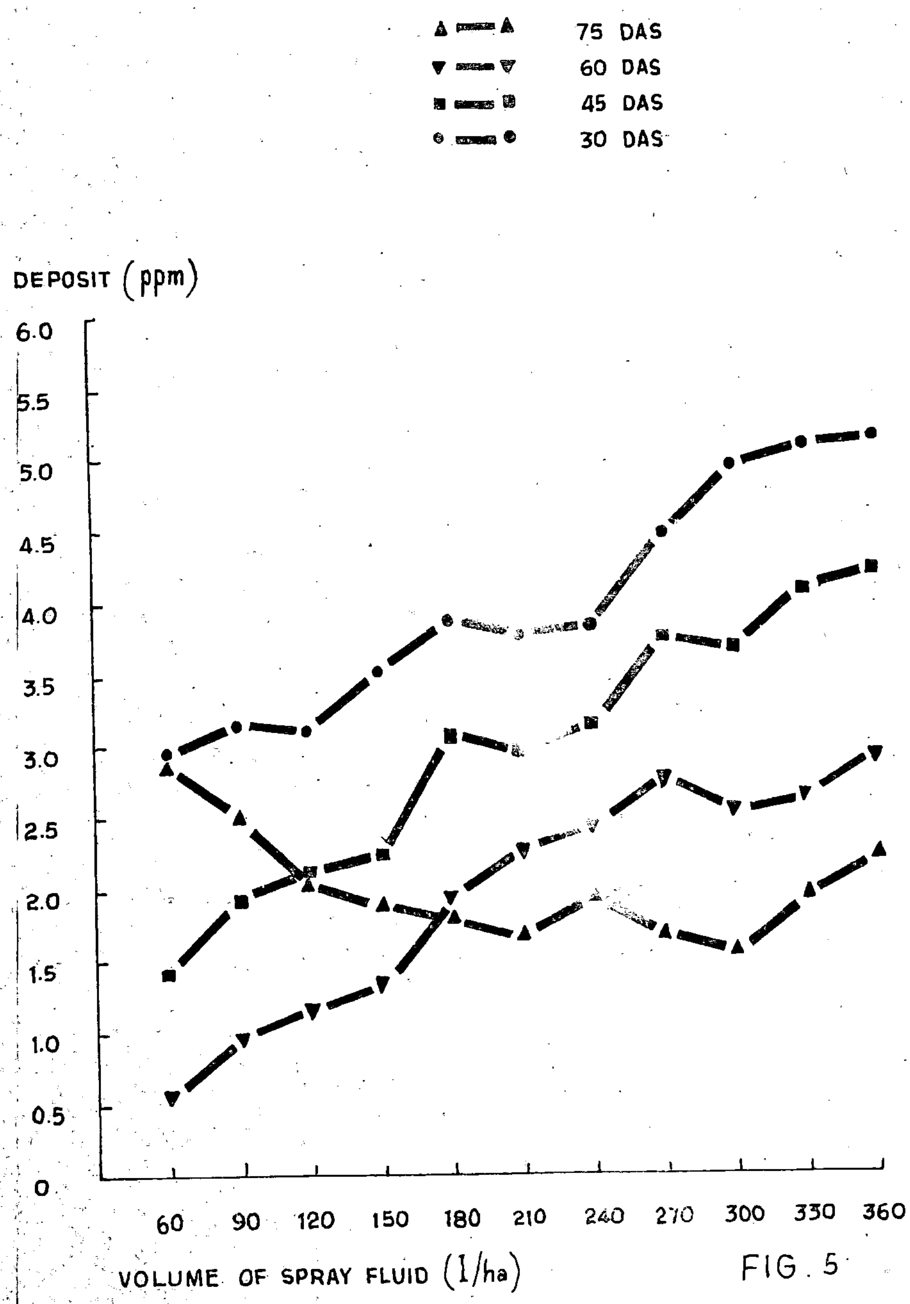
Abstract of Anova:	df	Mean squares			
Treatments	10	1.88**	2.64**	2.08**	4.60**
Error	20	0.10	0.15	0.05	0.12
C.D. for comparing the treatments		0.55	0.66	0.37	0.59

** Data significant at 0.01 level

DAS Days after sowing

Recovery of pesticide from fortified stalk samples : 87.11 to 92.63%

Fig.5 Effect of spraying different volumes of carbaryl suspension, on the levels of deposit obtained on surface of the stalk, at different stages of the crop, (sprayed with a mist blower).



75 DAS
60 DAS
45 DAS
30 DAS
DEPOSIT (ppm)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
60
90
120
150
180
210
240
270
300
330
360
VOLUME OF SPRAY FLUID (l/ha)

FIG. 5

were on par and were significantly lower than those in higher volumes. The least deposit was in treatment with 60 l/ha of suspension.

At 45 DAS also a decreasing trend was observed with the deposits formed by decreasing levels of spray fluid used. The higher volumes of 360, 330, 270 and 300 l/ha gave 4.21, 4.09, 3.78 and 3.67 ppm respectively, there being no significant difference among them. The deposit obtained in plots treated with the suspension at the rate of 150, 120 and 90 l/ha were also on par and were in a descending order, the range being 2.24 to 1.92 ppm. The deposit formed by the suspension at 60 l/ha was the poorest and significantly inferior to all other treatments.

At 60 DAS the level of deposit formed on the plots treated with 360, 270 and 330 litres of insecticde suspension/ha did not vary significantly and these were closely followed by 300, 210 and 240 l/ha, the range of deposit in the treamments being 2.90 to 2.42. The other treatments caused deposits in a regular descending scale ranging from 1.93 ppm to 0.54 ppm.

At 75 DAS the trend was different from all the other crop stages. Highest deposit of 2.86 ppm was obtained in plots treated with the insecticide suspension at 60 l/ha and it was closely followed by the treatment at 90 l/ha and then the highest volume of 360 l/ha. The deposits in

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these treatments were 2.86, 2.49 and 2.21 ppm respectively. Other treatments were inferior and there was no significant difference among them. The lowest deposit of 1.54 ppm was obtained in the plots treated at 300 l/ha of the insecticide suspension.

5.5 Statistical model for optimum volume of spray fluid required at different growth stages of rice in terms of leaf area index, under different methods of application.

With reference to pneumatic knapsack sprayer, the optimum quantities of spray fluid required at 30, 45, 60 and 75 DAS were 200, 300, 500 and 500 l/ha respectively which were the minimum volumes giving significantly high levels of deposit on leaves. Corresponding leaf area indices at these stages were 0.58, 1.63, 1.97 and 2.04 respectively. The correlation between optimum volumes and leaf area indices were significant at 0.05 level.

The regression equation for optimum volume of spray fluid in terms of leaf area indices was $y = 58.57 + 203.49x$ (approximately $y = 59 + 203x$) where y = volume of spray fluid and x = leaf area index.

With reference to mist blower, the optimum quantities of spray fluid required at 30, 45, 60 and 75 days after sowing were 90, 120, 180 and 180 l/ha respectively and the corresponding leaf area indices were 0.63, 1.58, 2.24 and 2.31. Correlation coefficient was significant at 0.05 level.

The regression equation for calculating optimum volume of spray fluid in terms of leaf area indices was y = 47.92 + 55.96 x (approximately y = 48 + 56 x).

A ready reckoner for optimum volume of spray fluid in terms of leaf area index was prepared for both the types of sprayers and are presented in Table 5 and 6.

3.6 Contamination of irrigation water in paddy fields sprayed with different volumes of carbaryl suspension at different growth stages of the crop, using a pneumatic knapsack sprayer.

The data relating to this experiment are presented in Table 7 and Fig.6. At 30 DAS the residues in water was relatively higher than in other growth stages of the crop. For the different volumes of spray fluid tried there was a corresponding variation in the level of residues. The residues caused by spray at 100, 200, 300, 400, 500 and 600 l/ha of suspension were 0.214, 0.264, 0.294,0.415, 0.488 and 0.651 ppm respectively.

At 45 DAS the level of contamination was far less than that at 30 DAS, the level of residues in water being reduced to 1/4th of the level at 30 DAS. The residues increased in a regular ascending scale from the rate of 300 l/ha to 600 l/ha of spray fluid.

At 60 DAS the level of contamination decreased further when compared to previous growth stages. For the increase

Table 5. Ready reckoner for optimum volume of spray fluid (l/ha) in terms of leaf area index required to spray rice using a pneumatic knapsack sprayer.

Leaf Area Index	0.0	0.2	0.4	0.6	0.8
0		99.27	139.97	180.67	221.36
1	262.06	302.76	343.46	384.17	424.85
3	465.55	506.25	546.95	587.65	628.34
4	669.04	709.74	750.44	791.13	831.83
5	872.13	913.23	953.93	994.63	1045.32
6	1076.02	1116.72	1157.42	1198.12	1238.81
7	1483.00	1523.70	1564.39	1605.09	1645.79

Data predicted based on the equation

$$y = 58.57 + 203.49\,x$$

$$(r = 0.93)$$

Table 6. Ready reckoner for optimum volume of spray fluid (l/hh) in terms of leaf area index required to spray paddy using a mist blower.

Leaf Area Index	0.0	0.2	0.4	0.6	0.8
0		59.11	70.30	81.49	92.69
1	103.88	115.07	126.26	137.46	148.65
2	169.84	171.03	182.22	193.41	204.61
3	216.80	226.99	238.18	249.38	260.57
4	271.76	282.95	294.14	305.34	316.53
5	327.72	338.91	350.10	361.29	372.49
6	383.68	394.87	406.06	417.26	428.45
7	439.64	450.83	462.02	473.22	484.41

Data predicted based on the equation

$$y = 47.92 + 55.96\, x$$

$$(r = 0.97)$$

Table 7. Contamination of irrigation water in paddy fields sprayed with different volumes of carbaryl suspension at different growth stages of the crop, using a pneumatic knapsack sprayer

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean residue (ppm) in water when treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
100	0.2	0.214	0.059	0.004	BDL
200	0.4	0.264	0.056	0.012	0.001
300	0.6	0.294	0.081	0.041	0.012
400	0.8	0.415	0.110	0.056	0.034
500	1.0	0.488	0.143	0.058	0.038
600	1.2	0.651	0.219	0.063	0.063

Abstract of Anova:	df	Mean squares			
Treatments	5	0.108**	0.015**	0.003**	0.002**
Error	15	0.0006	0.00006	0.00003	0.00002
C.D. for comparing the treatments		0.036	0.012	0.008	0.007

** Data significant at 0.01 level

DAS Days after sowing

BDL Below detectable level

Recovery of pesticide from fortified water samples : 94.3 to 97.12%

in the volume of spray fluids, there was a corresponding increase in the levels of residue. For the volumes ranging from 100 to 600 l/ha the residue ranged from 0.004 to 0.063 ppm.

At 75 DAS also the level of contamination showed an increasing trend from 200 l/ha to 600 l/ha, the extent of contamination being less than that of previous growth stages (0.001 to 0.063 ppm). There was significant variation among the treatment except between 2 intermediate levels of 400 and 500 l/ha. The residue was below detectable level at 100 l/ha.

3.7 <u>Contamination of irrigation water in paddy fields sprayed with different volumes of carbaryl suspension at different growth stages of the crop, using a mist blower.</u>

Data relating to this aspect are presented in Table 8 and Fig.7. The extent of water contamination under low volume application using mist blower was much lower than that caused by the spraying with a pneumatic sprayer.

At 30 DAS the extent of water contamination in plots treated at higher volumes of 300 and 360 l/ha of suspension was high and these treatments were on par. Other treatments showed a regular increasing trend of residue with increasing levels of spray fluid used and there was no significant difference among them.

Table 8. Contamination of irrigation water in paddy fields sprayed with different volumes of carbaryl suspension at different growth stages of the crop, using a mist blower

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean residue (ppm) in water when treated at			
		30 DAS	45 DAS	60 DAS	75 DAS
60	0.12	0.008	0.012	BDL	BDL
120	0.24	0.026	0.008	0.004	BDL
180	0.36	0.062	0.017	0.006	0.001
240	0.48	0.107	0.041	0.012	0.004
300	0.60	0.132	0.068	0.038	0.014
360	0.72	0.143	0.077	0.033	0.022

Abstract of Anova:	df	Mean squares			
Treatments	5	0.013**	0.004**	0.001**	0.0003
Error	15	0.00009	0.00003	0.00002	0.00002
C.D. for comparing the treatments		0.015	0.008	0.007	0.007

** Data significant at 0.01 level

DAS Days after sowing

BDL Below detectable level

Recovery of pesticide from fortified water samples : 94.3 to 97.12%

Fig.6 Levels of carbaryl residues in irrigation water in rice fields sprayed with different volumes of the insecticide at different growth stages of the crop, using a pneumatic knapsack sprayer.

Fig.7 Levels of carbaryl residue in irrigation water in rice fields sprayed with different volume of the insecticide at different growth stages of the crop, using a mist blower.

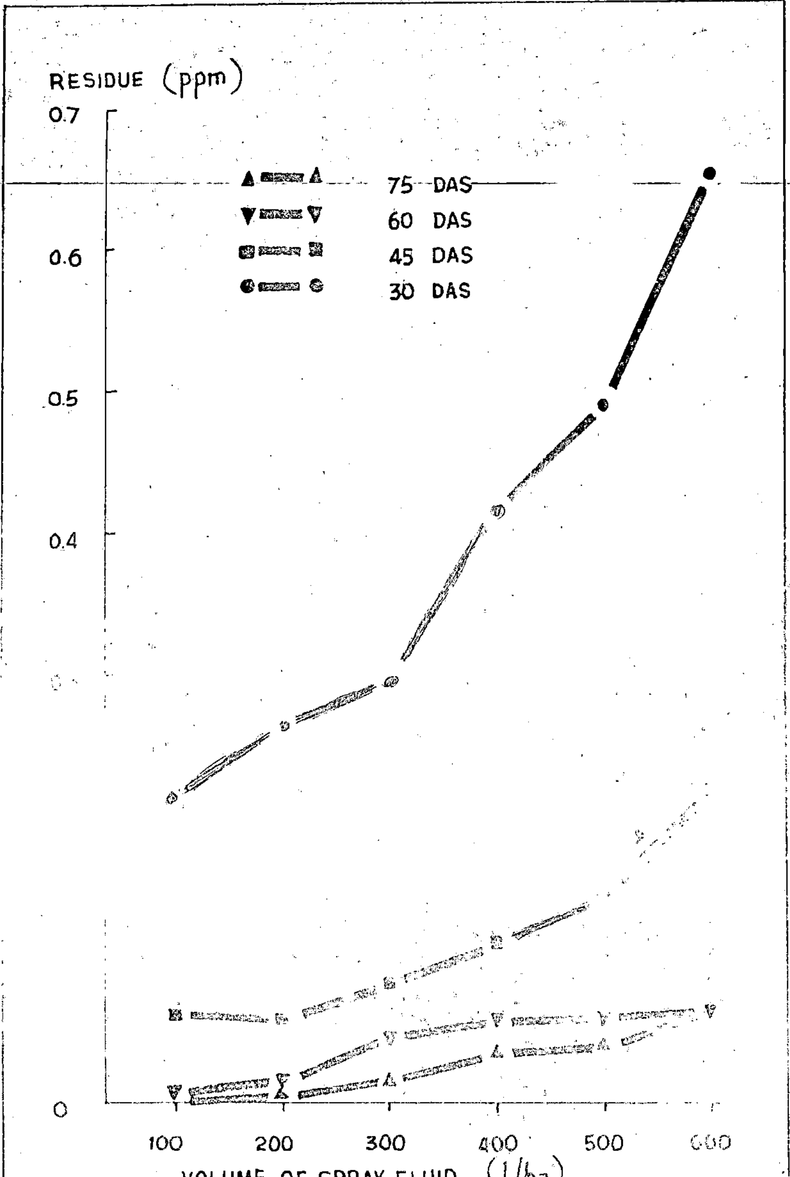

RESIDUE (ppm)
0.7
0.6
0.5
0.4
0
75 DAS
60 DAS
45 DAS
30 DAS
100
200
300
400
500
VOLUME OF SPRAY FLUID (l/ha)

FIG. 6

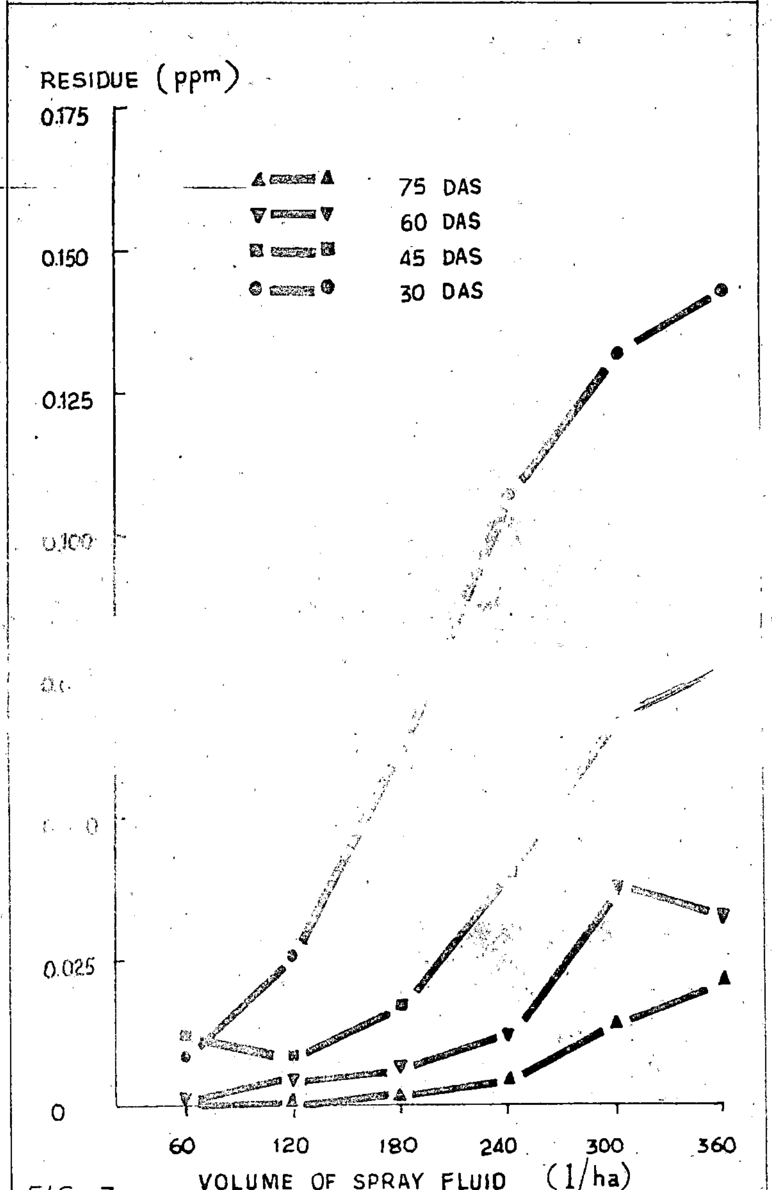

RESIDUE (ppm)
0.175
0.150
0.125
0.025
0
75 DAS
60 DAS
45 DAS
30 DAS
60
120
180
240
300
360
VOLUME OF SPRAY FLUID (l/ha)

FIG. 7

At 45 DAS the higher volumes of 240, 300 and 360 l/ha caused relatively higher levels of residues in irrigation water i.e. 0.041 to 0.077 ppm. At lower levels of 180, 120 and 60 l/ha, the residues were 0.017, 0.008 and 0.012 ppm respectively and they were on par.

At 60 DAS the level of contamination was much lower than that of the previous stages and for the range of volumes used viz. 60 to 360 l/ha the deposit ranged from 0 to 0.033 ppm only.

At 75 DAS the different volumes of insecticide suspensions showed a very low level of contamination. In the plots treated at 60 and 120 l/ha the residues were not detectable and in the remaining treatments the residues ranged from 0.001 to 0.022 ppm only.

3.8 Effect of spraying different volumes of carbaryl suspension on rice using a pneumatic knapsack sprayer, on the larval population of rice leaf roller *Cnaphalocrocis medinalis* (Guen.)

The results relating to this experiment are presented in Table 9 and Fig.8. At 48 hrs after treatment, maximum reduction of larval population was observed in plots treated with insecticide suspension at 550 and 600 l/ha the percentage reduction being 67.99 and 77.29 respectively and there was no significant difference between the treatments. Insecticide suspensions at 500 and 450 l/ha, were next in rank and on par and they were superior to all other

Table 9. Effect of spraying different volumes of carbaryl suspension on rice, using a pneumatic knapsack sprayer, on the larval population of rice leaf roller, *Cnaphalocrocis medinalis* (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean per cent reduction in population over pre-treatment count at 48 hrs. after treatment	
100	0.2	44.41	(41.79)
150	0.3	59.09	(50.24)
200	0.4	62.37	(52.16)
250	0.5	37.82	(37.95)
300	0.6	56.94	(48.99)
350	0.7	62.78	(52.40)
400	0.8	59.75	(50.62)
450	0.9	65.38	(53.96)
500	1.0	73.23	(58.84)
550	1.1	87.99	(69.72)
600	1.2	77.29	(61.54)
Control	0.0	10.35	(18.77)

Abstract of Anova:	df	Mean squares
Treatments	11	494.97**
Error	22	10.12
C.D. for comparing the treatments		5.39

** Data significant at 0.01 level

Figures in parentheses are transformed values, angles

Treatment was given at 75 days after sowing

treatments. The effect of 350, 200, 400, 150 and 300 l/ha were equal and the reduction in population was 62.78, 62.37, 59.75, 59.09 and 56.94 respectively. The treatments at 100 l/ha and 250 l/ha were on par and inferior to all other levels in controlling the pest. The control plot showed a natural mortality of 10.35% only.

3.9 Effect of spraying different volumes of carbaryl suspension on rice, using a mist blower, on the larval population of rice leaf roller *Cnaphalocrocis medinalis* (Guen.)

The results are presented in Table 10 and Fig.9. At 48 hrs after treatment, maximum reduction of larval population was observed in plots treated with insecticide suspension at 90 l/ha which was on par with 60 l/ha, the percentage reductions being 70.32 and 65.43 respectively. The higher rate of 300, 120, 210, 150, 240 and 180 l/ha were on par, the reduction in population being 55.14, 53.12, 52.63, 47.23, 44.98 and 44.25% respectively. The higher volumes of 360 and 330 l/ha of suspension were found equal and inferior to other treatments. The control plots showed a natural mortality of 11.21% which was again much less than the treated plots.

3.10 Effect of spraying different volumes of carbaryl suspension on rice, using a pneumatic knapsack sprayer, on the extent of damage caused by the rice case worm, *Nymphula depunctalis* (Guen.)

The results are presented in Table 11 and Fig.10. At

Table 10. Effect of spraying different volumes of carbaryl suspension on rice, using a mist blower, on the larval population of rice leaf roller, *Cnaphalocrocis medinalis* (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean per cent reduction in population over pre-treatment count at 48 hrs after treatment	
60	0.12	65.43	(53.99)
90	0.18	70.32	(56.99)
120	0.24	53.12	(46.79)
150	0.30	47.23	(43.42)
180	0.36	44.25	(41.71)
210	0.42	52.63	(46.51)
240	0.48	44.98	(42.12)
270	0.54	41.03	(39.83)
300	0.60	55.14	(47.96)
330	0.66	23.11	(28.73)
360	0.72	25.09	(30.06)
Control	0.00	11.21	(19.57)

Abstract of Anova:	df	Mean squares
Treatments	11	347.13**
Error	22	19.66
C.D. for comparing the treatments		7.51

** Data significant at 0.01 level

Figures in parentheses are transformed values, angles

Treatment was given at 75 days after sowing

Fig.8 Effect of different volumes of carbaryl suspension on the extent of control of rice leaf roller C. *medinalis* in comparison with the levels of deposits on leaf surface at corresponding stage of the crop, (sprayed with a pneumatic knapsack sprayer).

Fig.9 Effect of different volumes of carbaryl suspension in the extent of control of rice leaf roller C. *medinalis* in comparison with the levels of deposits on leaf surface at corresponding stage of the crop, (sprayed with a mist blower).

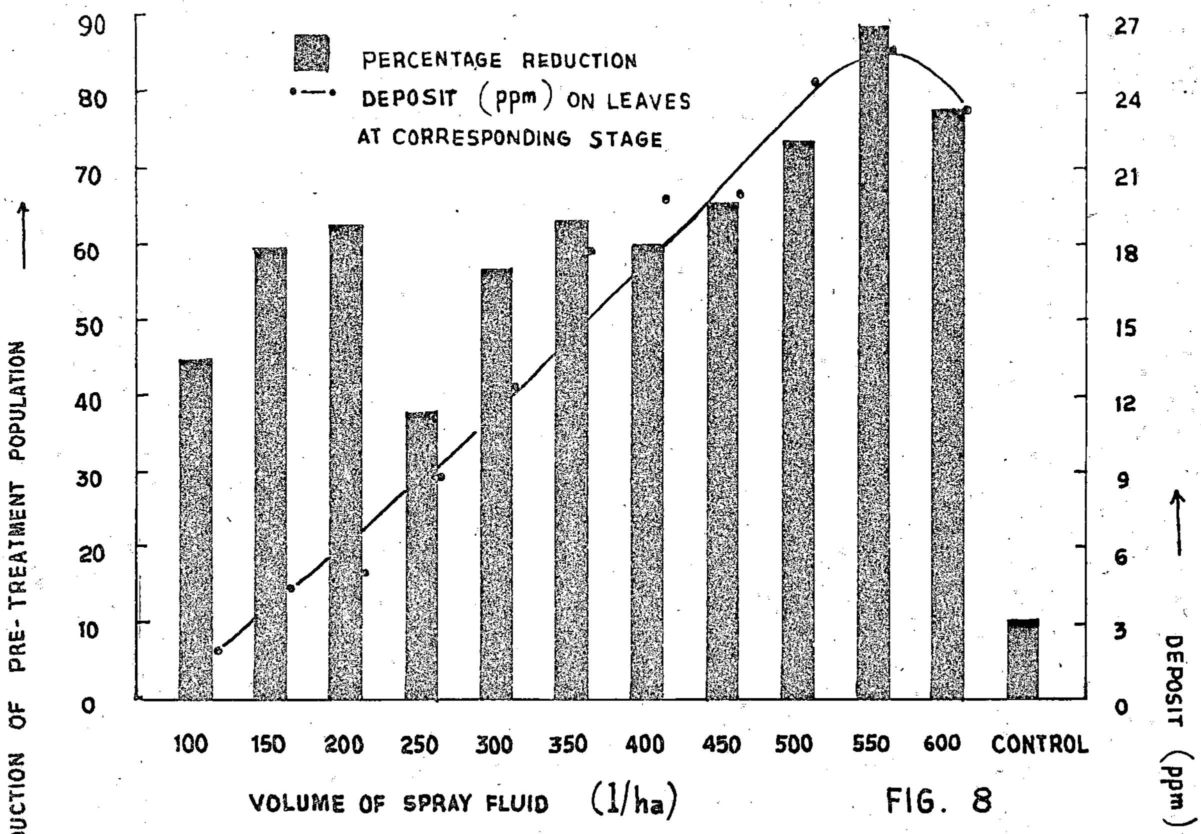

PERCENTAGE REDUCTION
DEPOSIT (ppm) ON LEAVES
AT CORRESPONDING STAGE
MEAN PERCENTAGE REDUCTION OF PRE-TREATMENT POPULATION
DEPOSIT (ppm)
0
10
20
30
40
50
60
70
80
90
0
3
6
9
12
15
18
21
24
27
100
150
200
250
300
350
400
450
500
550
600
CONTROL
VOLUME OF SPRAY FLUID (l/ha)

FIG. 8

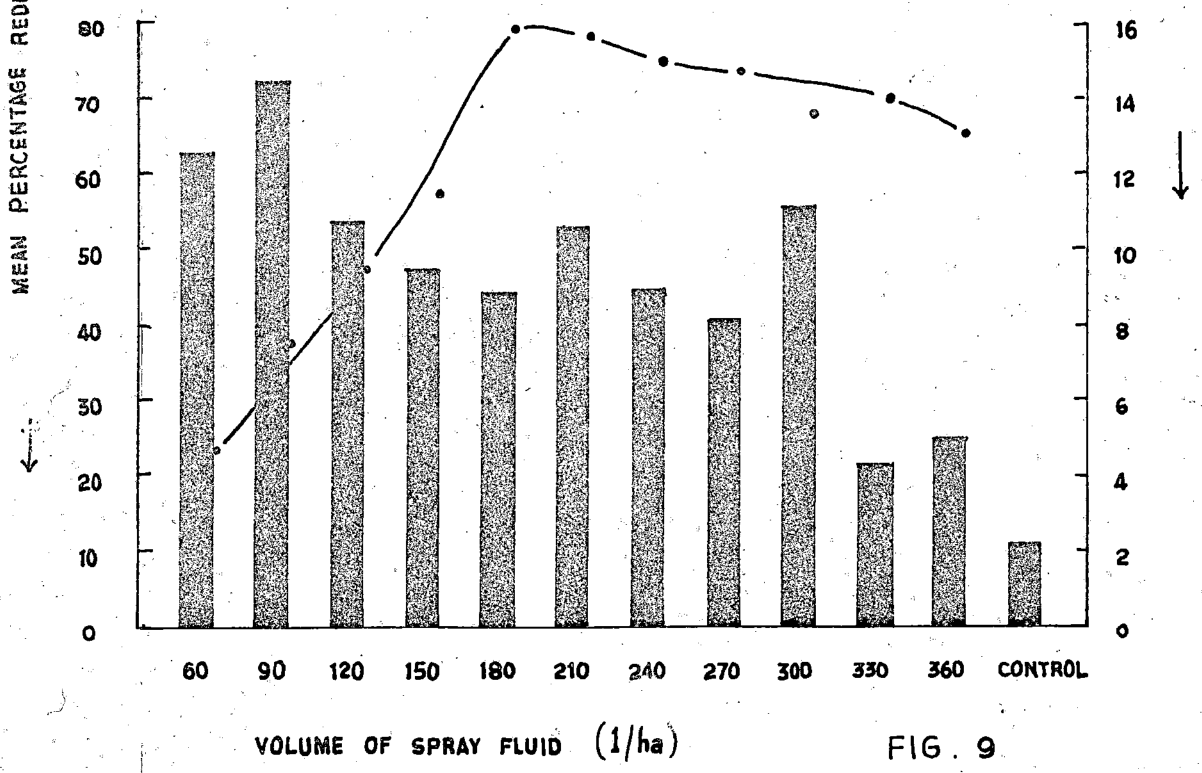

0
10
20
30
40
50
60
70
80
0
2
4
6
8
10
12
14
16
60
90
120
150
180
210
240
270
300
330
360
CONTROL
VOLUME OF SPRAY FLUID (l/ha)

FIG. 9

7 days after treatment the plots treated at the higher rates of 550 and 600 l/ha were found to most effective, on par and superior over other treatments with respect to reduction of damage caused by case worm, the mean reductions in the damage being 38.92 and 36.02 per cent respectively. These were followed by the treatments of 300, 500 and 450 l/ha which were also on par. The treatments next in ranking significantly varied in their efficacy in reducing case worm infestation in a descending scale. However, the two higher rates of 350 and 400 l/ha also came at intermediate positions in efficacy. The reduction in damage observed in control plot was only 4.86%.

At 14 days after treatment the treatments at 300 l/ha of insecticide suspension came top in rank with reference to the reductions in the extent of damage by case worm. The volumes @ 600 and 250 l/ha closely followed it and there was no significant difference among the three. The insecticide suspension at 500, 550 and 200 were of intermediate rank in efficacy and the other levels were inferior to the higher volumes of 500 and 550 l/ha, in controlling the pest. The mean reduction of damage in control plot was only 13.82 per cent.

3.11 Effect of spraying different volumes of carbaryl suspension on rice using a mist blower, on the extent of damage caused by the rice case worm, *Nymphula depunctalis* (Guen.)

The result obtained are shown in Table 12 and Fig.11

Table .11 Effect of spraying different volumes of carbaryl suspension on rice, using a pneumatic knapsack sprayer, on the extent of damage caused by the rice case worm, Nymphula depunctalis (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean reduction in the percentage of infested leaves, compared to pre-treatment percentage, observed at different intervals after treatment (days)			
		7		14	
100	0.2	6.90	(15.24)	18.64	(25.58)
150	0.3	13.84	(21.84)	26.76	(31.15)
200	0.4	21.24	(27.44)	48.69	(44.25)
250	0.5	24.26	(29.51)	54.48	(47.57)
300	0.6	30.01	(33.22)	56.67	(48.88)
350	0.7	17.30	(24.58)	30.85	(33.74)
400	0.8	7.03	(15.38)	22.91	(28.60)
450	0.9	27.64	(31.72)	44.53	(41.86)
500	1.0	29.62	(32.97)	49.63	(44.79)
550	1.1	38.92	(38.60)	49.60	(44.77)
600	1.2	36.02	(36.88)	55.76	(48.31)
Control	0.0	4.86	(12.73)	13.82	(21.82)

Abstract of Anova:	df	Mean squares	
Treatments	11	230.05**	280.75**
Error	22	1.20	0.82
C.D. for comparing the treatments		1.86	1.53

** Data significant at 0.01 level

Figures in parentheses are transformed values, angles

Treatment was given at 45 days after sowing

Table .12 Effect of spraying different volumes of carbaryl suspension on rice, using a mist blower, on the extent of damage caused by the rice case worm, Nymphula depunctalis (Guen.)

Volume of suspension sprayed (1/ha)	Dosage kg ai/ha	Mean reduction in the percentage of infested leaves, compared to pre-treatment percentage, observed at different intervals after treatment(days)	
		7	14
60	0.12	7.31 (15.69)	18.49 (25.47)
90	0.18	16.30 (23.81)	28.84 (32.48)
120	0.24	42.21 (40.52)	65.12 (53.80)
150	0.30	39.40 (38.88)	59.45 (50.45)
180	0.36	36.87 (37.39)	51.21 (45.75)
210	0.42	36.25 (37.02)	64.01 (53.14)
240	0.48	33.16 (35.16)	44.05 (41.58)
270	0.54	35.46 (36.55)	59.83 (50.68)
300	0.60	34.42 (35.92)	46.81 (43.17)
330	0.66	22.23 (28.13)	43.72) (41.39)
360	0.72	8.52 (16.97)	14.53 (22.41)
Control	0.00	7.45 (15.84)	13.18 (21.29)

Abstract of Anova:	df	Mean squares	
Treatments	11	276.65**	425.55**
Error	22	0.58	0.38
C.D. for comparing the treatments		1.29	1.04

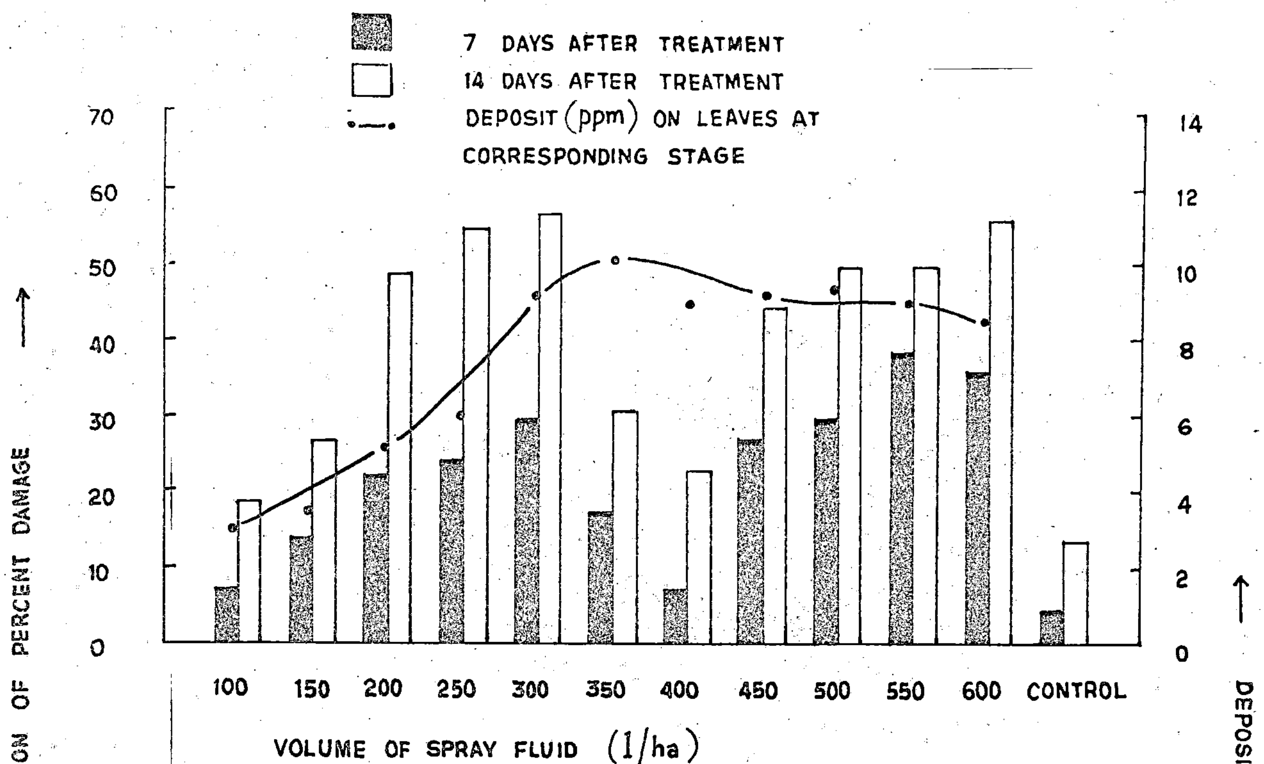
** Data significant at 0.01 level

Figures in parentheses are transformed values, angles

Treatment was given at 45 days after sowing

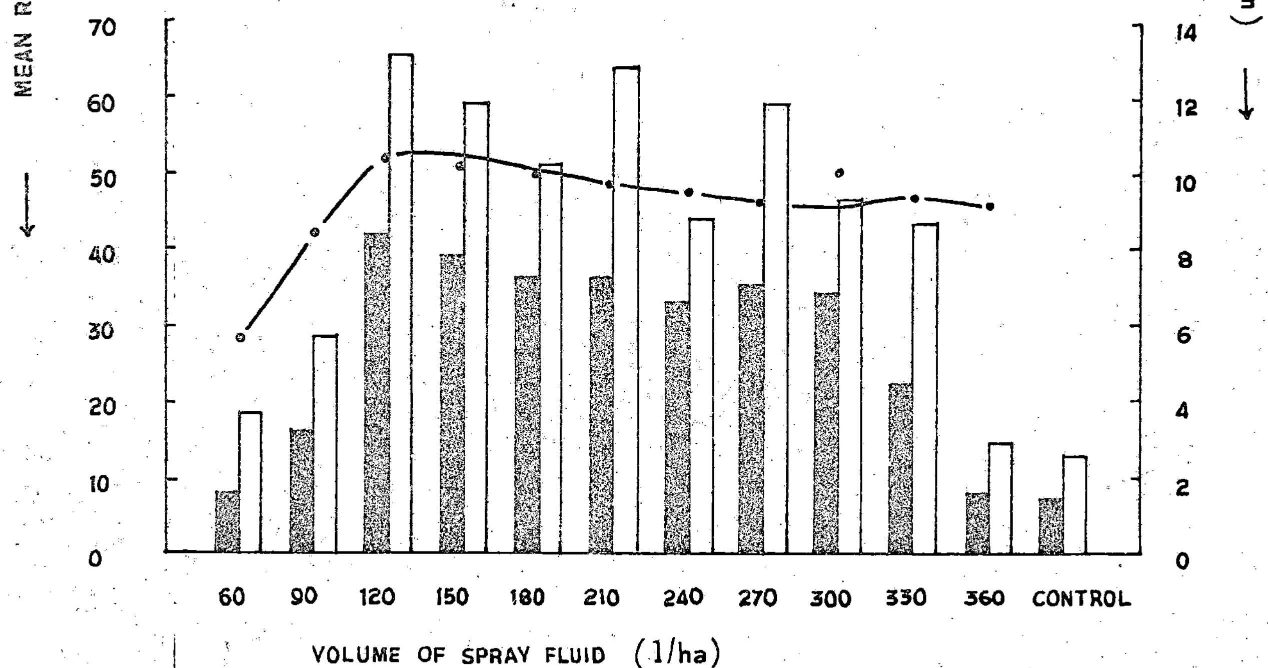
Fig.10 Effect of different volumes of carbaryl suspension on the extent of control of N. depunctalis in comparison with deposits on leaf surface at corresponding stage of the crop, (sprayed with pneumatic knapsack sprayer).

Fig.11 Effect of different volumes of carbaryl suspension on the extent of control of N. depunctalis in comparison with deposits on leaf surface at corresponding stage of the crop, (sprayed with mist blower).



7 DAYS AFTER TREATMENT
14 DAYS AFTER TREATMENT
DEPOSIT (ppm) ON LEAVES AT CORRESPONDING STAGE
MEAN REDUCTION OF PERCENT DAMAGE
DEPOSIT (ppm)
0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
100
150
200
250
300
350
400
450
500
550
600
CONTROL
VOLUME OF SPRAY FLUID (l/ha)

FIG. 10



0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
60
90
120
150
180
210
240
270
300
330
360
CONTROL
VOLUME OF SPRAY FLUID (l/ha)

FIG. 11

At 7 days after treatment the highest reduction in damage was observed in plots treated with 120 l/ha of the suspension, the reduction in damage being 42.21%. It was followed by the level at 150 l/ha which was significantly inferior to 120 l/ha with respect to control of case worm, the mean reduction of damage being 39.40%. The extent of control in other treatments i.e. 180 to 330 l/ha was in a more or less descending order. The lowest rate of 60 l/ha was found to be as good as the highest level of 360 l/ha and the reductions in damage due to these two treatments were on par. In the control plot also there was a fall of 7.45 per cent of damage. At 14 days after treatment the relative merits of the different treatments were almost the same as these at 7 days after spraying. The damage in control plots also because less on the 14th day by 13.18 per cent over the pretreatment percentage.

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DISCUSSION

4. DISCUSSION

When pesticides are applied to areas occupied by pests, its bio-efficacy will depend on dose, distribution and coverage of the toxicant on the target areas (Bindra and Singh, 1971). Excessive use of chemicals will obviously contaminate the environment by the quantum of chemicals drifting out of the target areas. While spraying, many droplets fall between the foliage, especially in the inter row spaces and contaminate the irrigation water and soil. Droplets which impact on the foliage may coalesce to such an extent that it may drip down to the lower leaves and to the soil. The usually recommended method of spraying to run off level to ensure complete wetting of the target surface may sometimes lead to less retention of the chemicals on leaves than when the spraying is stopped just before the run off level. Such run off, referred to as the endo-drift (Himel, 1974) often results in appreciable reduction of bio-efficacy of pesticides in treated surface. Selection of optimum volume of the spray fluid which gives the maximum deposit of the toxicant on the target area and which pollutes the environment least is obviously a desired factor in the effective and safe usage of pesticides. But unfortunately the choice is now left mostly to the users' discretion. Some recommendations give a range as wide as 200 to 1000 l/ha even without referring to the crop involved, the growth stage of the crop or other ecological factors.

Informations available on the optimum spray volumes required for different growth stages of paddy are extremely meagre. Patel (1960) recommended 40-80 gallons of spray fluid for 1 ha of paddy under high volume application. For brown plant hopper control 333, 500 and 1000 litres of spray fluid per ha was found optimum at 15, 35 and 60 days after transplanting (Aquino and Heinrichs, 1978).

In the first experiment, attempts were made to fix the optimum volumes of carbaryl suspension to be sprayed on different growth stages of rice crop, using a pneumatic sprayer and taking the insecticide deposits on leaves as an index of efficacy of the toxicant. The residues were estimated adopting standard chemical assay methods. When sprayed at 30 days after sowing, the extent of deposit showed a gradual increase with the volumes of 100, 150 and 250 l/ha (vide Table I, Fig. 2). In higher volumes applied, the extent of deposit showed a significant initial decline and then was maintained on a more or less steady level. The results indicate that the optimum coverage of the leaf surface was obtained at 200 l/ha beyond which the increase in volume of the spray fluid did not cause any enhancement of the levels of deposit, probably due to the onset of run off loss. At 45 days after sowing, the optimum level of spray requirement with pneumatic knapsack sprayer was obtained at

350 l/ha which was statistically on par with the deposit obtained in plots treated at 300 l/ha and the latter level was chosen as the optimum effective rate for that stage of the crop. Similarly, at 60 and 75 days after sowing a spray volume of 500 l/ha was the lowest volume which gave deposits at levels significantly higher than those of other treatments on leaf surface.

The leaf area indices of the crop at the above four growth stages were 0.58, 1.63, 1.97 and 2.04 respectively. Using the regression equation derived from the values of insecticide deposits and leaf area indices, the quantities of spray fluid estimated as optimum for the various levels of leaf area indices were calculated and are presented in Table 5 . It may be seen that for every increase of the leaf area to the extent of 0.1, an approximate enhancement of the volume by 20 litres may have to be made. Similar estimation of the volume of the spray fluid required for unit increase of height in cotton crop has been worked out earlier (Tunstall et al., 1961).

In the second experiment, the crop was sprayed with a mist blower the other details being the same as in the first experiment. At 30 Days after sowing, highest insecticide deposit was obtained in plots treated with the suspension at 90 l/ha. The deposit formed at all the higher levels of spraying were lower than and on par with this treatment. This indicated the possible commencement of run off at the spray level at 90 l/ha. At 45 days after sowing optimum level of deposit was obtained with a volume of 120 l/ha. At 60 and 75 days after sowing the minimum volume required for obtaining a deposit significantly higher than in other treatments was found to be 180 l/ha.

The leaf area indices of the crop at the above four growth stages were 0.63, 1.98, 2.24 and 2.31 respectively. Using the regression equation derived, the optimum quantities of spray fluid required for the various levels of leaf area indices were worked out and the data are presented in Table 6. It may be seen that for every increase of the leaf area index to the extent of 0.1, an approximate enhancement of the volume by 11 litres may have to be made.

The extent of deposit formed on the stalk from the varying levels of insecticide suspension sprayed with a pneumatic knapsack sprayer, at 30 days after sowing (Table 3, Fig. 4) it was observed that even with a maximum volume of 600 l/ha the peak level of deposit was not reached. With reference to the next two stages of the crop, namely 45 DAS and 60 DAS also, the same trend was noticed with reference to the levels of deposit recorded on the stalk. But at 75 days after sowing the level of deposit reached a peak with 350 l/ha of spray fluid. For the higher levels of spray volumes used there was a gradual reduction in the levels of deposit formed. In general the deposits obtained on 30 day old crop were higher than those formed in other growth stages. This may be due to the sparse nature of leaves at the early stages of the crop and consequent spread of the spray fluid down to the stalk portion. Obviously for the control of pests infesting stalk portion of the crop, like brown plant hopper, the spraying of the optimum volumes fixed by this experiment may not be adequate.

The levels of deposit formed on the stalk when the suspension was sprayed with a mist blower also showed the same trend as in the case of pneumatic knapsack sprayer. The crop at 30 days after sowing showed higher levels of deposit at all the different levels of volume tried. The deposit levels on plants at 45 DAS were higher than those on plants at 60 DAS. The levels of deposit on crop at 75 DAS were found to be somewhat erratic, being higher than those on earlier crop stages with lower levels of volumes tried and lower with higher volumes sprayed.

The level of the insecticide residues in irrigation water caused by the application of different levels of insecticide sprays (Table 7, Fig.6) showed that the use of higher quantities of spray fluid causes a proportionately higher level of contamination of the irrigation water. At 30 DAS the residue levels ranged from 0.214 to 0.651 whereas at 45, 60 and 75 days after sowing the ranges of deposits were 0.060 to 0.219, 0.002 to 0.063 and 0.001 to 0.063 respectively. This shows that at early stages of the crop the use of the spray fluid in higher rates contaminate the rice eco-system with the toxicant and hence the spray volumes at these stages are to be restricted judiciously.

The data presented in Table 8 and Fig.7 revealed that the level of contamination can be considerably reduced by spraying the insecticide with a mist blower. Even for the same volumes of spray fluid applied by pneumatic sprayer and mist blower, the levels of contamination in irrigation water was found to be less for the latter. This observation holds good for all the growth stages of the crop.

The relative efficacy of different volumes of carbaryl suspension applied with a pneumatic sprayer for the control of Cnaphalocrocis medinalis is presented in Table 9 and the extent of control obtained in comparison with the different levels of leaf deposit observed for similar volumes are presented in Fig.8. There was an overall correlation between levels of deposits and the extent of control obtained except for the erratic values seen with reference to the first three lower volumes of 100, 150 and 200 l/ha.

The relative efficacy of spraying the different volumes of insecticide suspension using a mist blower (Table 10, Fig.9) showed the same trend as in the case of pneumatic sprayer. The lower volumes of 90 and 60 showed the highest reduction in population level. The optimum volume of 180 litres chosen for a 75 day old crop gave effective control of the pest in comparison with control and it came superior to the higher volumes of 270, 330 and 360 l/ha, and on par with all other higher volumes used.

The extent of control of Nymphula depunctalis obtained by spraying varying volumes of carbaryl suspension using a pneumatic sprayer (Table 11) and its relationship with the different levels of deposits obtained from similar volumes of spray (Fig.10) revealed that they were significantly correlated. The volume of spray fluid which gave significantly superior levels of deposit gave more effective control of the pest as shown by the reduction in the extent of damage observed at 7 and 14 days after spraying.

A similar experiment using a mist blower also revealed the reliability of the optimum volume chosen on the basis of the levels of deposit formed on the foliage by spraying varying volumes of the suspension. An optimum level of 120 l/ha of spray fluid gave the highest reduction in the extent of damage caused by N. depunctalis.

The optimum volumes of spray fluid chosen for treating rice crop at 30, 45, 60 and 75 days after sowing using a pneumatic sprayer are 200, 300, 500 and 500 l/ha respectively and when sprayed with a mist blower the corresponding volumes are 90, 120, 180 and 180 l/ha respectively. The active ingredient in these levels of spray suspension will range from 0.4 to 1 kg ai/ha in the case of volumes sprayed with pneumatic sprayer and 0.18 to 0.36 kg a. i/ha in the case of volumes sprayed with a mist blower. These dosages are far below the dosage of 1.25 kg ai/ha now recommended in Kerala (Anon. 1978 a). The possibility of reducing the currently recommended dosage of carbaryl for the control of rice pests has been suggested by earlier workers also (Das and Nair, 1976; Thomas and Karunakaran, 1977; Anon. 1978 b and Thomas, 1981). Velayutham et al (1973), Budhasamai et al (1979) and Valencia and Heinrichs (1979) recommended the spraying of carbaryl suspension at 0.05%, 0.01% and 0.04% respectively for the control of various rice pests.

SUMMARY

5. SUMMARY

In the present investigation a set of experiments were conducted with a view to finding the optimum volumes of carbaryl suspension to be sprayed on different growth stages of rice crop taking the extent of carbaryl deposit formed on the leaf and stalk of the plants as an index of bio-efficacy. This was done for a pneumatic knapsack sprayer as well as a mist blower. The level of contamination of irrigation water caused by the 'endo-drift' of the insecticide used also was assessed. A correlation between the levels of deposit and bio-efficacy of the pesticides was assessed from the extent of control obtained while the insecticide suspension was sprayed in different volumes against Cnaphalocrocis medinalis and Nymphula depunctalis.

In the first experiment the deposits formed on the leaves of rice from carbaryl suspension sprayed at the levels of 100, 150, 200, 250, 300, 350, 400, 450, 500, 550 and 600 l/ha, using a pneumatic knapsack sprayer, were estimated adopting the chemical assay method of Benson and Finocchiare (1965). Based on the extent of deposits the optimum volume chosen for the crop at 30, 45, 60 and 75 days after sowing were 200, 300, 500 and 500 l/ha respectively. Correlating these optimum volumes with leaf area indices of the respective growth stages of the crop, a statistical model was fitted and the regression equation

obtained was y = 58.57 + 203.49 x (where y is the optimum volume and x is the leaf area index). This model could be used for estimating the required volume of spray fluid relevant to any growth stage of the crop by assessing the leaf area index of the respective stage, while using a pneumatic sprayer.

In the second experiment the crops were sprayed with a mist blower at varying volumes of carbaryl suspension at 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 l/ha and the deposits formed on the leaves were estimated. Based on the levels of deposits formed the optimum volumes of spray fluid chosen for the crop at the growth stages of 30, 45, 60 and 75 days after sowing were 90, 120, 180 and 180 l/ha respectively. The regression equation derived for estimating optimum volumes relevant to intermediate stages of crop growth, based on the leaf area indices was y = 47.92 + 55.96 x.

The extent of carbaryl deposit obtained on the stalk in the above two experiments did not reach the maximum possible limit with the ranges of volumes of spray fluid tried in the experiments. This indicated a possible requirement of volumes spray fluid exceeding the upper limit of the quantity sprayed in these trials for effective control of the pest infecting the stalk portion of plants like brown plant hopper.

The level of carbaryl residues in the irrigation water sprayed with a pneumatic sprayer at different volumes were estimated adopting chemical assay technique in the third experiment conducted. For the varying levels of suspension used a corresponding increase in the level of residues in water, at all crop's growth stages was observed. The levels of residue were highest at 30 DAS and these were getting reduced at 45, 60 and 75 days after sowing in a descending scale.

The fourth experiment done as in the case of third experiment, but using a mist blower showed that the levels of contamination in the rice environment by the endo-drift of the insecticide, were relatively lower for this method of application at all growth stages of the crop.

The relative efficacy of different volumes of carbaryl suspension in controlling rice leaf roller C. medinalis, using pneumatic sprayer as well as mist blower, was assessed in the next four trials carried out in infested fields by peg marking the required number of plots for a randomised block design. The results showed an overall correspondence between the levels of insecticide deposits on leaves and the extent of larval mortality in C. medinalis and reduction in the percentage of infested leaves relating to N. depunctalis.

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APPENDICES

Appendix . i. Effect of spraying different volumes of carbaryl suspension on rice, using a pneumatic knapsack sprayer on the larval population of rice leaf roller, *Cnaphalocrocis medinalis* (Guen.)

Volume of Suspension sprayed (l/ha)	Dosage kg ai/ha	Mean larval counts observed at	
		24 hrs before treatment	48 hrs after treatment
100	0.2	21.00	11.67
150	0.3	18.67	7.67
200	0.4	16.00	6.00
250	0.5	20.00	12.67
300	0.6	22.00	9.67
350	0.7	17.00	6.67
400	0.8	14.67	6.00
450	0.9	18.00	6.33
500	1.0	17.00	4.67
550	1.2	13.00	1.67
600	1.2	22.33	5.00
Control	0.0	19.33	17.33

Appendix ii. Effect of spraying different volumes of carbaryl suspension on rice, using a mist blower on the larval population of rice leaf roller, Cnaphalocrocis medinalis (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean larval counts observed at	
		24 hrs before treatment	48 hrs after treatment
60	0.12	20.67	7.00
90	0.18	17.00	5.00
120	0.24	16.00	7.67
150	0.30	20.00	11.33
180	0.36	15.67	8.67
210	0.42	11.00	5.67
240	0.48	18.00	10.00
270	0.54	23.33	13.67
300	0.60	18.00	8.00
330	0.66	19.33	14.67
360	0.72	21.67	16.33
Control	0.00	18.67	16.67

Appendix iii. Effect of spraying different volumes of carbaryl suspension on rice, using a pneumatic knapsack sprayer, on the extent of damage caused by the rice case worm, *Nymphula depunctalis* (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean percentage of infested leaves observed at different intervals		
		Pre-treatment	Days after spraying	
			7	14
100	0.2	52.25	45.34	33.61
150	0.3	30.66	16.82	3.90
200	0.4	64.00	42.76	15.81
250	0.5	60.40	36.11	5.93
300	0.6	60.88	30.82	4.23
350	0.7	34.35	16.82	3.28
400	0.8	34.77	27.65	11.84
450	0.9	46.95	19.35	2.42
500	1.0	54.40	24.78	4.76
550	1.1	54.86	15.93	5.27
600	1.2	58.33	22.32	2.57
Control	0.0	49.42	44.53	35.55

Appendix iv. Effect of spraying different volumes of carbaryl suspension on rice, using a mist blower, on the extent of damage caused by the rice case worm, *Nymphula depunctalis* (Guen.)

Volume of suspension sprayed (l/ha)	Dosage kg ai/ha	Mean percentage of infested leaves observed at different intervals		
		Pre-treatment	Days after spraying	
			7	14
60	0.12	29.46	22.14	10.96
90	0.18	34.09	17.79	5.26
120	0.24	68.95	26.74	3.83
150	0.30	62.52	23.12	3.06
180	0.36	54.31	17.43	3.01
210	0.42	68.87	32.61	4.36
240	0.48	46.54	13.37	2.49
270	0.54	63.69	28.22	3.85
300	0.60	52.76	18.34	5.21
330	0.66	48.94	26.68	5.23
360	0.72	16.44	7.92	1.88
Control	0.00	31.82	24.36	18.62

ABSTRACT

A set of experiments were conducted for assessing the optimum volumes of carbaryl suspension required to spray rice at different growth stages of the crop, using a pneumatic knapsack sprayer and a mist blower. The levels of pesticide deposit formed by spraying the crop at varying levels of pesticide suspension were taken as the indices of bio efficacy and these were also correlated with the leaf area indices of the crop at different growth stages. The level of contamination of the rice eco-system was assessed in terms of pesticide residue in irrigation water of the treated plots. A correlation between different levels of pesticide deposits caused by varying the volumes of the spray fluid was assessed by trials conducted against leaf roller and case worm infesting rice.

In the first experiment, the crop was sprayed with 100, 150, 200, 250, 300, 350, 400, 450, 500, 550 and 600 l/ha of 0.2% carbaryl suspension using a pneumatic knapsack sprayer. Deposit on leaf and stalk of the plants, two hours after spraying, was estimated from the representative sa mples adopting the chemical assay method of Benson and Finocchiare (1965). The experiment was repeated at four different growth stages of the crop viz. 30, 45, 60 and 75 days after sowing. The results showed that the minimum levels of carbaryl suspension required to cause significantly

higher levels of deposit on the leaves were 200, 300, 400 and 500 l/ha for the crop at 30, 45, 60 and 75 days after sowing respectively. The leaf area indices at these different growth stages were also assessed adopting standard methods (Gomez, 1972). A statistical model was fitted using the data and the regression equation was obtained from the same as $y = 58.57 + 203.49\,x$ where y is the optimum volume and x is the leaf area index.

A second experiment was conducted on the same lines as the first one, using a mist blower. Carbaryl suspension was sprayed at 60, 90, 120, 150, 180, 210, 240, 270, 300, 330 and 360 l/ha. Based on the levels of deposits formed on the leaves, the optimum volumes of spray fluid for the above four growth stages of the crop were found to be 90, 120, 180 and 180 l/ha respectively. The respective regression equation derived was $y = 47.92 + 55.96x$.

Assessment of carbaryl deposit on the stalk showed that even 600 and 360 litres of spray fluid using the pneumatic sprayer and mist blower respectively did not give maximum possible deposit on the stalk. The deposits formed in early stage of the crop were higher in comparison with the later stages, probably due to the sparse leaf canopy. Obviously, for the control of pests infesting the stalk portions of the plants, (eg. brown plant hopper) quantities of suspension exceeding the upper limit used in these trials may be required.

The level of carbaryl residues in the standing irrigation water of plots treated with the same range of insecticide suspension as in the previous experiment (using a pneumatic sprayer) was assessed adopting standard chemical assay techniques. Levels of pesticide residue in water and the varying volumes of suspension used were directly correlated. The extent of contamination was higher in earlier growth stages of the crop obviously due to the increasing density of leaves in later growth stages.

Another experiment conducted in the same line as above using a mist blower also yielded similar results. In comparing the two types of sprayers used, with reference to the level of contamination, the mist blower was found to be safer at all levels of the spray fluid used and also at all the growth stages of the crop studied.

The effect of varying the volumes of spray suspension on the extent of control of rice pests was studied with reference to the rice leaf roller Cnaphalocrocis medinalis and the case worm Nymphula depunctalis in a series of experiments laid out, in fields severely infested by the pests. It was observed that the extent of reduction of leaf roller population and the extent of reduction of the leaf damage by the case worm varied with the different levels of spray fluid used and the data were statistically significant. When the extent of control was viewed in relation with the levels of insecticide deposits obtained for the different volumes used at the corresponding growth stage of the crop, it was observed that there was a broad correspondence between the two aspects, though the percentages relating to the lower ranges of the volumes used were somewhat erratic.