EFFECT OF VARYING VOLUMES OF PESTICIDE SPRAY FLUID ON THE CONTROL OF RICE PESTS

BY

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THESIS
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DECLARATION

I hereby declare that this thesis entitled "Effect of varying volumes of pesticide spray fluid on the control of the rice pests" 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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1987.

C E R T I F I C A T E

Certified that this thesis, entitled "Effect of varying volumes of pesticide spray fluid on the control of the rice pests" is a record of research work done independently by Sri. G. Viswanathan 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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INTRODUCTION

INTRODUCTION

The introduction of high yielding varieties in agriculture and the intensive crop cultural practices facilitated the fast build up of insect populations in the rice ecosystem. A number of pests reckoned as minor in earlier days have now assumed the status of devastating major pests on the crop. Extensive use of pesticides became inevitable for controlling these pests and to ensure the expected high yields from the crops which were grown by farmers incurring very heavy input costs. A wide range of pesticides available for this purpose were being used indiscriminately by farmers. This has created undesirable side effects like pest resistance to pesticides, secondary pest outbreaks, resurgence, environmental pollution and residue hazards.

Pesticide application was often being done without adequate emphasis on the dosage and method of application. The adverse effects of pesticides observed in the field were caused by the defects in the dosage selected and in the application techniques followed than by the toxicity of the compounds. Use of optimum quantities of pesticides will increase the bio-efficacy of the pesticides. Proper distribution of the pesticides on the target areas will also be of vital importance in ideal plant protection practices. These aspects have not been adequately studied for developing proper plant protection strategies.

The quantum of deposits and coverage of pesticides on target areas will depend on the volumes of spray fluid used in the treatments. This aspect had been indicated by researchers from time to time (Evans & Martin, 1935; Hensill and Tihenko, 1939; Taylor, 1939; Horsfall, 1945 and Mathew, 1982). But Courshee (1960) and Fulton (1965) observed that the varying volumes of spray fluid used did not influence the levels of pesticide deposits formed on the crop.

Investigations on the effect of varying volumes of pesticide formulations on the bioefficacy of pesticides in field are limited. Hence a series of field experiments were conducted to assess the bioefficacy of varying volumes of suspensions / emulsions of (1) Hexachlorocyclohexane (HCH) against _Nymphula depunctalis_ Guen. at 3 WAT, (2) quinalphos against _Cnaphalocrocis medinalis_ Guen. at tillering and bootleaf stages, (3) quinalphos against _Scirpophaga incertulas_ (Walker) at bootleaf stage, (4) methyl parathion against _Leptocorisa acuta_ (Fabricius) at heading stage, (5) Dithane (mancozeb) M 45 against brown leafspot disease at tillering stage and (6) Bavistin (carbendazim) against sheath blight and sheath rot at bootleaf stage. The deposits formed by the application of varying volumes of the spray fluids on rice, when applied at different growth stages of the crop, was assessed using the stain safranin as a tracer.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature available on the high and low volume spraying of pesticides, the effect of varying volumes on the deposits, coverage and bioefficacy have been reviewed here.

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

Spraying methods were classified by Bindra and Singh (1971) as high volume spraying which requires 500-1000 litres of spray fluid per hectare, in the case of field crops, low volume spraying which requires 12-125 litres of spray fluid per hectare, semilow volume spraying which requires volumes between the range of high and low volumes and ultra low volume spraying which requires 0.5 to 0.6 litre of spray fluid per hectare. Spray fluid volumes of 600, 200 to 600, 50 to 200, 5 to 50 and $<$ 5 litres per hectare for field crops were classified as high, medium, low, very low and ultra low volume spraying respectively by Mathews (1979).

1.2. Optimum spray volumes recommended for various crops

Forty to eighty gallons of spray fluid were recommended for one hectare of paddy under high volume application by Patel (1960). Desirable volumes of spray fluid recommended for different growth stages of maize were 500, 700, 1000 and 1000 litres/ha at 10, 20, 30 and 40 days after sowing (Anon., 1969). Two hundred litres of spray fluid under low volume and

500 litres under high volume were recommended for effective coverage of 1 hectare of paddy (Anon., 1982).

Mathew, [illegible]. (1982) suggested the optimum volumes of spray fluid for treating rice crop at 30, 45, 60 and 75 days after sowing using a pneumatic sprayer, as 200, 300, 500 and 600 l/ha respectively. The active ingredients in these levels of spray suspension ranged from 0.4 to 1 kg per hectare.

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

1.3.1. Volume of spray in relation to plant height:

The volume of spray fluid to be applied on cotton had to be increased according to plant height (Tunstall *et al*., 1961). Fifty litres were applied for plants less than 30 cm high and for each subsequent increase of 30 cm in height the volume had to be increased by 56 litres/ha up to a maximum of 280 l/ha. Morgan (1964) observed that the volume of spray fluid could be selected in relation to height in the case of orchard crops.

1.3.2. Volume of spray fluid in relation to leaf area index:

Potts (1946) observed that the volume of spray fluid required for a crop is governed to a large extent by the leaf area. Morgan (1964) discussed the need for recommending volume of spray in terms of gallons per acre of sprayed area instead of gallons per acre of land area. Courshee (1960) estimated through theoritical calculation that 5000 litres of spray fluid would be required under high volume application to give a deposit level of 10 $\mu g/cm^2$ when the crop had a leaf area index of 5. He also reported that the actual spray volume required under field conditions may be much higher when the allowances for wastage of chemical and complete wetting loss at accessible targets were considered. Mathews (1971) pointed out that an estimate of the leaf area index would be useful for assessing the spray fluid requirement per ground area, provided the volume of spray fluid required per unit area of the leaf was known.

1.4. Effect of varying volumes of spray on the deposit of insecticides on the target

Smith (1928) found that spray coverage and residue of lead arsenate, used for the control of codling moth on apple, were influenced by the volume of spray fluid used. The deposition of insecticide on the leaf in the crown was directly related to the logarithm of the volumes of the material sprayed.

Deposition of spray fluid and suspensions prior to run off had a linear relationship to the rate of application in the case of horizontal sprayers (Evans and Martin, 1935). Similar linear relationship had been established by other workers too (Hensill and Tihenko, 1939; Taylor, 1939; Horsfall, 1945.

Rich (1954) stated that the initial deposit of Zine was proportional to the volume of spray remaining on the leaf surface and also on the concentration of spray fluid used. But Courshee (1960) reported that in high volume spraying deposition was proportional only to concentration and independent of spray volume used. He also found that increase in spray volume did not always cause an increase in the deposit because of the variation in exposure of target areas to the spray swath. The deposit on the exposed leaves increased while little improvement was noted on concealed sites (Coursbee, 1967).

Fulton (1965) and Mathews (1979) reported that deposit density was independent of volume of spray fluid, but proportional to the concentration in the original spray, with the loss occurring during run off after maximum initial retention on the target.

Mathew, T.B. (1982) observed that when sprayed at 30 days after sowing, the extent of deposit showed a gradual increase for the volumes of 100, 150 and 250 l/ha. But in higher volumes applied the extent of deposit showed a significant initial decline and then it was maintained on a more or less steady level. The results indicated that the optimum coverage of 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 deposit, probably due to the onset of run off. At 45 days after sowing, the optimum level of spray requirement for pneumatic knapsac sprayer was seen as 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 the stage of the crop. At 60 and 75 days after sowing 500 l/ha was the optimum volume for the maximum deposit.

When crop was sprayed with a mist blower at 30 days after sowing highest insecticide deposit was obtained in plots treated with the suspension at 90 l/ha. At 45 days after sowing high 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 extent of deposit formed on the stalk from the varying levels of insecticide suspensions sprayed with a pneumatic sprayer was studied and at 30 days after sowing even with the maximum volume of 600 l/ha used the deposit had not reached the peak level. At 45 and 60 days also the same trend was noticed with reference to the levels of deposit recorded on the stalk. For the higher levels of spray volumes used, there was a gradual increase in the levels of deposit formed. In general the deposits obtained on 30 day o'ld crop were higher than those formed in other growth stages. 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 knapsac sprayer.

Kilgore et al. (1963) observed that deposits on almond leaves when sprayed under high and low volume did not show significant differences eventhough the volume applied under high volume was 19.5 times more than that of low volume. Verma 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. Levels of insecticide residue on leaves and fruits of bhindi significantly varied among 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 varying volumes of spray fluid on coverage of insecticide sprays

1.5.1. Varying volumes and coverage:

Coverage depended on the density and uniformity of the distribution of deposit over the surface (Fajans and Martin, 1937). Taylor (1939) reported that spray coverage and efficacy of insecticidal and fungicidal sprays are markedly influenced by spray volume used which in turn was a function of duration of spraying and volume delivery. Horsfall et al. (1940) recommended the increase of the volume of spray to give more droplet density and thereby reduce uncovered areas. But Mathews (1973 and 1979) observed that an increase in spray volume did not necessarily result in improved coverage eventhough the number of droplets increased. Menzies et al. (1979) observed that higher volumes per hectare produced maximum and most uniform coverage, when spray coverage was evaluated by using fluorescent dye technique.

1.5.3. Spraying methods and coverage:

Large uncovered areas between sparse droplets make low volume spraying less effective against immobile pests whereas complete film of deposit makes high volume spraying more effective (Ripper, 1955). Fryer et al. (1957) reported that high volume spraying gave a more uniform distribution on an open leaf canopy than low volume spraying. He attributed this phenomenon to the low impact 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 coverage on the leaf surface whereas low volume spraying gave poor coverage. Cooke et al. (1976) compared spray deposits on the top, middle and basal zones of apple trees obtained from the application of high, low and ultra low volumes of spray 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. Volume of spray fluids used and bio-efficacy of pesticides

1.6.1. Effect of varying volumes of spray fluid:

In an experiment using field dosage of lime sulphur sprayed in different volumes Moore (1958) found that in low volume spraying control obtained was in direct proportion to dosage of fungicide used irrespective of volume of spray applied. Application of Dikar at 6.6 l/acre in different dilutions using 20.5, 41 and 81.2 gallons of water/acre for pneumatic sprayer and 11, 16 and 20 gallons of water/acre for mist blower (Hickey, 1960) showed no difference in the control of powdery mildew disease of apple. Lewis (1971) stated that volume of spray fluid was not important if adequate spray coverage and deposit were obtained. He studied the efficacy of different volumes of fungicide in controlling diseases of apple such as powdery mildew, scale cedar apple rot, etc., keeping dose constant and found no significant difference among varying volumes. Studies were conducted by Aquino and Heinrichs (1978) to determine the relationship between the volume of spray and control of the rice brown plant hopper. The findings indicated that the level of control was the 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 recommended volume of water for such an application was 1000 litres per hectare.

Mathew (1982) found that the volumes of carbaryl spray giving higher deposits at various growth stages of rice, gave relatively higher kills of Cnaphalocrocis medinalis Guen. and Nymphula depunctalis Guen. in infested fields for high volume and low volume spraying.

1.6.2. Different methods of spraying in relation to bioefficacy:

Norman and Joyce (1954) found that there was no significant differences on the mortality of cotton jassid, Amrasca biguttula biguttula when high and low volume were applied at same dosage of DDT. However, high volume application was more effective in controlling the nymphs of Bemisia tabaci. 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 applications of the same amount of endrin in 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). Sugimote 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) reported that high volume application destroyed natural enemies to a lesser extent than low volume applications when they were more mobile and active than the pest.

High volume applications at 27000 l/ha was the most effective for controlling complex pest and disease situations on apple when compared to reduced volumes at 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).

Singh and Khangura (1973) 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 scale disease proved high volume application @ 2250 l/ha to be the most effective followed by low volume @ 225 l/ha and ultra low volume @ 22.5 l/ha (Cooke et al., 1976). 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 Zygimida 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 (Stål).

MATERIALS AND METHODS

2. MATERIALS AND METHODS

2.1. Raising the crop for experiment

The crop was raised in an area of 0.82 hectare in bulk and the different experiments were laid out by peg marking the required number of plots as and when pest incidence occurred.

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

2.1.2. Planting the main field: Main field was prepared by ploughing and levelling during the second crop season of 1984-85. Twenty four day old seedlings were transplanted at a spacing of 15 x 10 cm with two seedlings per hill.

2.1.3. Crop husbandry: All the crop husbandry practices recommended by the Kerala Agricultural University (Anon., 1982), excluding plant protection measures, were carried out.

2.2. Assessment of the efficiency of varying volumes of HCH suspension for the control of rice case worm, *Nymphula depunctalis* Guen.

The experiment was carried out in the field during the third week after planting when there was a severe incidence of *Nymphula depunctalis* Guen., in the field.

2.2.1. Treatments:

HCH 50% WP supplied by M/s. Premier Industries, Cochin, was used in the experiment. Spray fluid of 0.2 per cent HCH suspension in water was prepared and sprayed in varying volumes of 300, 350, 400, 450, 500 and 550 l/ha. Plots sprayed with water alone (500 l/ha) served as control.

In another experiment HCH suspensions at the volumes of 300, 350, 400, 450, 500 and 550 l/ha were sprayed keeping the dose in all treatments at the same level of 12.5 kg ai/ha by varying the concentrations of the insecticide in the suspensions sprayed at different volumes.

2.2.2. Lay out of the experiment:

Randomised Block Design was adopted for the experiment and each treatment was replicated thrice. Plots of 6.7 x 1.5 m were marked in the field using pegs and rope. One metre border was kept around each plot to reduce the interplot interference in treatment.

2.2.3. Application of pesticide:

Spraying was done using a pneumatic knapsac sprayer of 9 litre capacity. Sprayer was calibrated and the varying volumes were applied in a single round standardising the walking speed at each occasion.

Spraying was done between 8 A.M. and 10 A.M. when the air turbulence was least. Two metre high gunny screens were provided on all sides of the plot to avoid interplot drift. While spraying the lance was kept horizontally at a constant height from the canopy to ensure a uniform a coverage as possible in all the treatments. 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.

2.2.4. Assessment of results:

In the two experiments mentioned in para 2.2.1. the population of live case worm larvae was estimated one day prior to and 2 and 4 days after treatment. The number of cases with live larvae, on the plants and on water surface, were counted in one square metre area, selected at random in each plot.

Intensity of damage by case worm was also assessed one day prior to and seven days after treatment. Twenty hills were selected at random and the total number of leaves and the number of leaves damaged by the pest in each hill were counted. The percentage of infected leaves was calculated from the data. The effect of treatment was assessed in terms of the percentage decrease of pretreatment percentage using the formula $P_1 - P_2 \times 100/ P_1$ where P_1 and P_2 were the pre and post treatment percentages of damage respectively.

2.3. Assessment of the efficacy of the varying volumes of quinalphos emulsion for the control of *Cnaphalocrocis medinalis* Guen.

The experiment was done twice, once at the tillering stage and then at boot-leaf stage.

2.3.1. Treatments:

Ekalux 25 per cent EC supplied by M/s. Sandoz (India) Ltd., Cochin, was used in the experiment. Emulsion of the insecticide in water, at 0.05 per cent, was prepared and sprayed in varying volumes of 300, 350, 400, 450, 500 and 550 l/ha at tillering stage and in the volumes of 450, 500, 550, 600, 650 and 700 l/ha at boot-leaf stage. Plots sprayed with water alone 700 l/ha) were maintained as control.

In another experiment quinalphos emulsions at the volumes of 300, 350, 400, 450, 500 and 550 l/ha at tillering stage and 450, 500, 550, 600, 650 and 700 l/ha at boot-leaf stage were sprayed keeping the dose in all treatments at the same level of 250 g ai/ha. (Ekalux 1000 ml/ha) by varying the concentrations of the insecticide in the emulsions sprayed at different volumes.

2.3.2. Lay out of experiment: as described in para 2.2.2.

2.3.3. Application of insecticide: as described in para 2.2.3.

2.3.4. Assessment of results:

Leaf damages in the plots were estimated one day prior to treatment and 1, 2 and 3 weeks after treatment. Twenty hills were chosen at random and the total number of leaves and the number of leaves damaged by the pest in each hill were counted and the percentages of infected leaves were calculated from the data. Percentage decrease in the damage noted in different observations in relation to pretreatment percentages of infected leaves were calculated as described in para 2.2.4.

2.4. Assessment of efficacy of the varying volumes of quinalphos emulsions for the control of *Scirpophaga incertulas* (Walker)

2.4.1. Treatment: as described in para 2.3.1.

2.4.2. Lay out of experiment: as described in para 2.2.2.

2.4.3. Application of pesticide: as described in para 2.2.3.

2.4.4. Assessment of results:

The percentage of white earheads were assessed one week prior to harvest. Total number of hills, number of infested hills, number of panicles and number of white earheads were counted in one square metre area of each plot and the percentages of white earhead were calculated using the formula, Total number of white earhead x total number of infested hills x 100/ Total number of panicles observed x total number of hills observed.

2.5. Assessment of efficacy of varying volumes of methyl parathion emulsions in water for the control of *Leptocorisa acuta* (Fabricius)

The experiment was carried out in the field during the heading stage when there was a heavy incidence of rice bug.

2.5.1. Treatments:

Metacid 50 EC supplied by Bayer India Ltd., was used in the experiment. Insecticide emulsion of 0.05 per cent concentration in water was sprayed in varying volumes of 450, 500, 550, 600, 650 and 700 l/ha and plots sprayed with water alone (700 l/ha) were maintained as control.

In another experiment methyl parathion emulsion at the volumes mentioned above were sprayed keeping the dose in all treatments at the same level of 500 g ai/ha. (500 ml of 50% EC/ha), by varying the concentrations of the insecticide in the emulsions sprayed at different volumes.

2.5.2. Lay out of experiment: as described in para 2.2.2.

2.5.3. Application of pesticide: as described in para 2.2.3.

2.5.4. Assessment of results:

The population of rice bug was assessed by counting the number of bugs trapped in a cage consisting of an angle iron frame (1 x 1 x 1 m) covered with polythene sheet on five sides leaving one side open. The open end of the cage was lowered among the hills and the plants enclosed were disturbed from beneath. The bugs on the plants moved up and settled on the polythene sides of the cage and they were counted. It was done in the early morning hours when the bugs were relatively inactive. Such counts were taken at three locations in each plot.

The population was estimated one day prior to treatment and at 1, 2, 3, 4 and 5 days after the treatment. Percentage reductions in the number of rice bug due to treatment was evaluated with reference to the pretreatment counts made.

2.6. Assessment of efficacy of the varying volumes of mancozeb suspension for the control of brown leaf spot disease

The experiment was carried out in the tillering stage of the crop when there was significant incidence of brown leaf spot in the experimental area.

2.6.1. Treatments:

Dithane M 45 supplied by Indofil Chemicals, Bombay, was used for the experiment. Dithane suspension in water at 0.4% concentration was prepared and sprayed in varying volumes of 300, 350, 400, 450, 500 and 550 l/ha. Plots sprayed with water alone (550 l/ha) served as control.

In another experiment Dithane suspensions at the volumes mentioned above were sprayed keeping the dose in all treatments at the same level of 2 kg/ha by varying the concentration of pesticide in the suspensions sprayed at different volumes.

2.6.2. Lay out of experiment: as described in para 2.2.2.

2.6.3. Application of pesticide: as described in para 2.2.3.

2.6.4. Assessment of results:

Incidence of brown leaf spot was estimated one week before the treatment. The number of hills as well as infected hills were counted in one square metre area selected at random in each plot. The per cent incidence of brown leaf spot was arrived at using the formula, Number of hills infected x 100 / total number of hills observed. The effect of treatment was assessed one week after spraying. The per cent incidence of brown leaf spot one week after spraying was estimated as described above. Decrease in the incidence with reference to the percentage prior to treatment was calculated as detailed in para 2.2.4.

2.7. <u>Assessment of efficacy of the varying volumes of carbendazim suspensions for the control of sheath blight</u>

The experiment was carried out in the boot-leaf stage of the crop when there was uniform incidence of sheath blight in the field.

2.7.1. Treatments:

Bavistin 50 WP supplied by BASF, Bombay, was used for the experiment. Suspension of Bavistin in water at 0.1% concentration was sprayed in varying volumes of 450, 500, 550, 600, 650 and 700 l/ha. Plots sprayed with water alone (700 l/ha) served as control.

In another experiment Bavistin suspensions were sprayed at the volumes mentioned above keeping the dose in all treatments at the same level of 500 g/ha, by varying the concentrations of the pesticide in the suspensions sprayed at different volumes.

2.7.2. Lay out of experiment: as described in para 2.2.2.

2.7.3. Application of pesticide: as described in para 2.2.3.

2.7.4. Assessment of results:

Incidence of sheath blight was estimated one day prior to harvest. The total number of hills and the number of infected hills were counted in one square metre area selected at random in each plot and from these percentages of hills affected by sheath blight were calculated. The total number of earhead and the earheads affected by sheath rot in each plot were also counted and from the data the percentages of earheads affected by sheath rot in different treatments were calculated.

2.8. Assessment of the spray deposits caused by varying volumes of spray fluid on rice at different growth stages of the crop using safranin as a tracer

A colorimetric technique devised at I.R.R.I. was adopted for the study (Heinrichs, 1981).

2.8.1. Treatments:

Safranin supplied by Cochin Commerce Ltd., was used for the experiment. Ten per cent solution (v/v) of the stain was prepared using required quantity of water. This was sprayed in varying volumes of 300, 350, 400, 450, 500 and 550 at tillering stage, and 450, 500, 550, 600, 650 and 700 l/ha at booting and heading stages of the crop in field.

2.8.2. Lay out of experiment: as described in para 2.2.2.

2.8.3. Application of stain: as described in para 2.2.3.

2.8.4. Collection of samples: Five hills selected at random from each plot, were collected by cutting the plants at the base. The sample of an individual hill was tied together with a rubber band and washed as a whole in one litre of water moving it up and down to ensure that all the spray deposit was washed off from the plant. Deposit on remaining four samples from a plot were also washed into the same quantity of water one after another. From the wash an alequote of 100 ml was collected in a bottle and was kept labelled. These were brought to the laboratory.

2.8.5. Processing of sample and assessment of transmittance:

To remove soil particles, in the sample, if any, it was centrifuged. The transmittance of the processed sample was assessed in Spectronic-20 at 515 n.m. When measuring the percentage of transmittance of the samples, transmittance of a corresponding blank which consisted of washings of plants treated with water alone also was used and corrections, if any, were made in the data.

2.8.6. Preparation of standard curve for estimating the stain:

Six serial dilutions of 0.01, 0.02, 0.03, 0.04, 0.05 and 0.06 per cent of safranin were prepared in distilled water and transmittance was read directly using a Spectronic-20. Distilled water was used as blank. Transmittance at different wave lengths was tried and maximum transmittance was observed at 515 n.m. From the data a standard curve was plotted taking log. concentrations of the stain along the 'X' axis and the transmittance along the 'Y' axis.

2.8.7. Assessment of results:

From the transmittance of the samples prepared from various plots the concentrations of the dye washed out from five hills in one litre of water could be estimated using the standard curve. Comparison of the concentrations of stain in various samples gave an index of the relative amounts of deposits of the stain in various treatments.

2.8.8. Assessment of leaf area:

Leaf area indices were assessed at tillering, boot-leaf and heading stages of the crop, when the three experiments were carried out using the formula, Leaf area index = number of tillers of a hill x number of leaves of a tiller x length of leaf x breadth of leaf x 0.75 / area of a hill.

RESULTS

RESULTS

3.1 Effect of spraying varying volumes of HCH suspension on *N. depunctalis* infesting rice with fixed and varying doses of the chemical

The results of this experiment are presented in Table 1, Figure 1 and Appendix I. Two days after treatment the larval population in the control plots showed an increase of 74.5 per cent while in plots treated with 0.2 per cent suspension of HCH at the rate of 350 l/ha the highest reduction in population was observed the increase being -37.63 per cent. The above treatment was followed by 450, 300 and 400 l/ha of the suspension and all the treatments were statistically on par. But 350 l/ha and 450 l/ha were significantly superior to control. The treatments with 300, 400, 500 and 550 l/ha were on par among themselves and with control. Thus for the immediate reduction in population the spraying of 350 l/ha of the HCH suspension was found to be the best.

The data recorded at four days after the treatment also showed the relative superiority of spraying 350 l/ha, the increase in population observed being -36.63 per cent. This treatment alone remained significantly superior to control while all the other treatments came on par among themselves and with control.

The mean decrease in the percentage of leaves damaged by the pest is observed at 7 days after treatment also showed that the spraying of 350 l/ha was the best (27.76%) and it was followed by 300 l/ha (27.6%), the difference between the two being statistically insignificant. These treatments were significantly superior to the treatments with 400, 500 and 450 l/ha. Spraying 550 l/ha alone came on par with control. Thus by considering the effect on larval population observed at 2 and 4 DAT and the extent of damage caused by the pest at 7 DAT, the optimum volume of HCH to be used for the control of the pest which occurred during the third week after planting was 350 l/ha.

Results of the second experiment presented in Table 1 and Figure 1, the necessity for keeping the dosage of the chemical constant at the recommended level of 1.5 kg ai/ha was studied. The reductions in populations in various treatments were in general agreement with the reduction of populations observed in plots treated with 0.2% suspension in varying volumes. At 2 DAT, 350 l/ha was the best for reducing the larval population and it was followed by 400, 300, 550 and 450 l/ha, the differences among them being statistically insignificant. Among these 350 l/ha alone was seen statistically superior to control. At 4 DAT, 350 and 400 l/ha were found statistically superior to control. In the case of

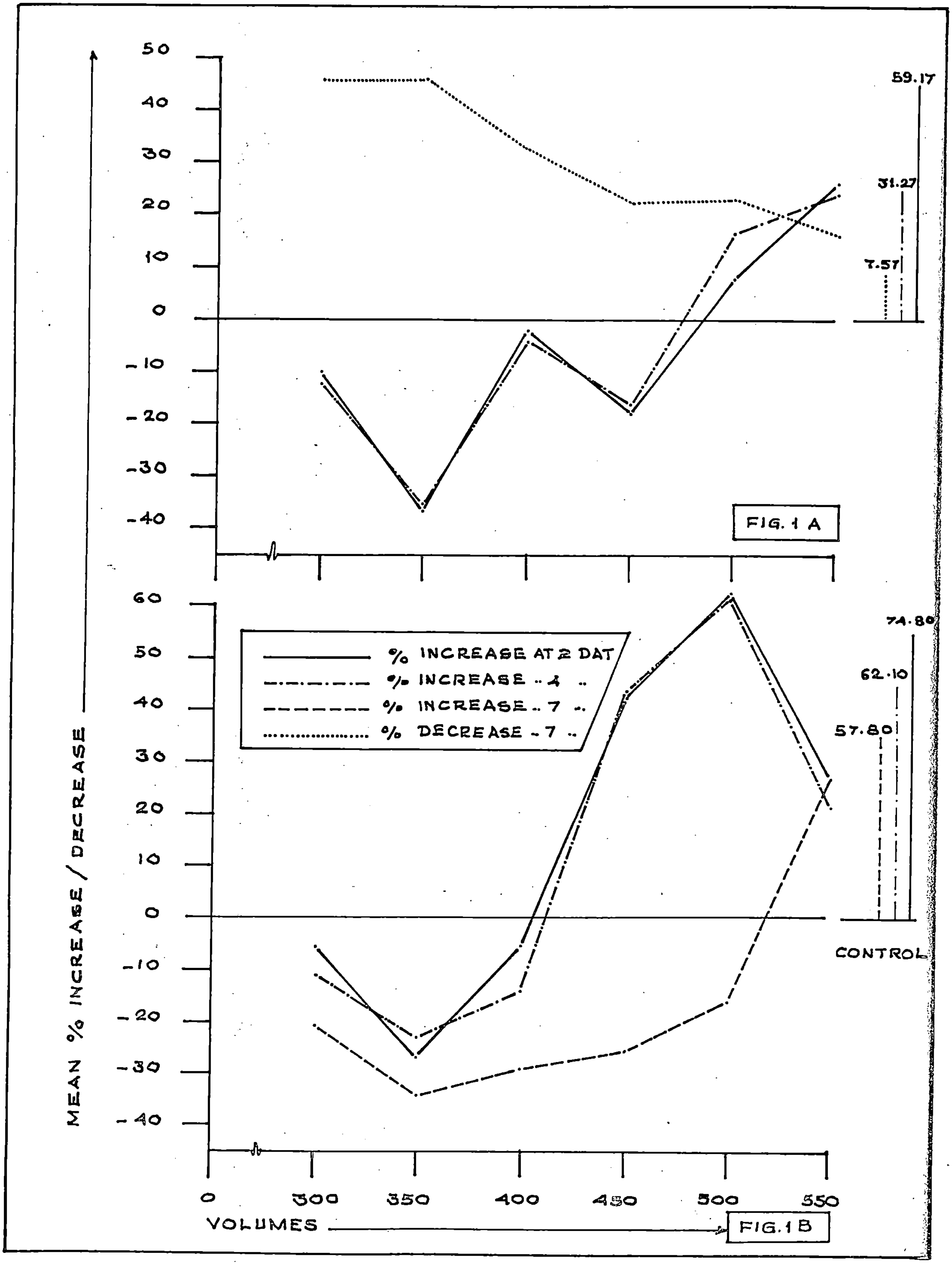
Table 1. Effect of spraying varying volumes of HCH suspension, keeping the dose of the insecticide per unit area constant/varying on *N. depunctalis* which occurred at tillering stage

Volume of spray fluid used (l/ha)	Insecticide applied at varying doses (A): Dose of HCH used (kg ai/ha)	Mean per cent increase of pretreatment larval number in 1 m^2 area observed at 2 DAT	Mean per cent increase of pretreatment larval number in 1 m^2 area observed at 4 DAT	Mean percent decrease of pre-treatment percentage of damage observed at 7 DAT	Insecticide applied at fixed dose (B): Dose of HCH used (kg ai/ha)	Mean per cent increase of pretreatment larval number in 1 m^2 area observed at 2 DAT	Mean per cent increase of pretreatment larval number in 1 m^2 area observed at 4 DAT	Mean percent increase of pre-treatment percentage of damage observed at 7 DAT
300	0.6	-10.05 (1.954)	-12.77 (1.941)	46.33 (27.60)	1.25	-5.38 (1.976)	-10.67 (1.951)	-20.31 (1.901)
350	0.7	-37.63 (1.795)	-36.63 (1.802)	46.58 (27.76)	1.25	-27.71 (1.861)	-23.34 (1.884)	-34.39 (1.817)
400	0.8	-2.95 (1.985)	-4.44 (1.980)	33.55 (19.60)	1.25	-5.50 (1.975)	-14.02 (1.924)	-29.21 (1.850)
450	0.9	-18.15 (1.913)	-16.52 (1.921)	23.28 (13.46)	1.25	42.30 (2.154)	43.60 (2.157)	-26.72 (1.865)
500	1.0	8.40 (2.035)	16.86 (2.065)	23.62 (13.66)	1.25	63.00 (2.212)	57.00 (2.196)	-15.67 (1.926)
550	1.1	26.20 (2.101)	24.70 (2.095)	16.81 (9.68)	1.25	27.20 (2.104)	20.71 (2.126)	27.47 (2.106)
Control	-	59.17 (2.192)	31.27 (2.118)	7.57 (4.34)	-	74.80 (2.243)	62.10 (2.21)	57.80 (2.198)
C.D. at 5% level	-	0.250	0.275	6.72		0.302	0.327	0.197

Figures in parentheses are log (x + 100) transformation / angular transformation.

DAT : Days after treatment.

Fig. 1. Effect of spraying varying and fixed doses of HCH, in varying volumes of spray fluid for the control of *N. depunctalis*.


50
40
30
20
10
0
-10
-20
-30
-40
59.17
31.27
7.57
FIG. 1 A
60
50
40
30
20
10
0
-10
-20
-30
-40
% INCREASE AT 2 DAT
% INCREASE - 4 -
% INCREASE - 7 -
% DECREASE - 7 -
74.80
62.10
57.80
CONTROL
MEAN % INCREASE / DECREASE
0
300
350
400
450
500
550
VOLUMES
FIG. 1 B

extent of damage caused by the pest also 350 l/ha was found to be the best and it was followed by the treatments with 400, 450, 300 and 500 l/ha, the difference among themselves being statistically insignificant. Reduction in leaf damage found in plot treated with 550 l/ha of the suspension was on par with that of control. These results showed that the volume of spray fluid applied in unit area of the treated field was important even when the same quantities of the chemical were applied in all the plots for the control of N. depunctalis.

Comparison of Figures 1A and 1B indicated that the efficacy of the treatments was more related to the volumes of spray fluid used than to the dose of the chemicals. In the experiment with varying doses of the pesticide the highest reduction in population as well as the extent of damage were observed in plots treated with 350 l/ha of the spray fluid containing 0.7 kg ai/ha of the chemical while in plots treated even with higher doses of the chemical ranging from 0.8 to 1.1 kg/ha, the effect was less.

3-2 Effect of spraying varying volumes of quinalphos emulsion on the population of C. medinalis with fixed and varying doses of the chemical

Two experiments were conducted for the control of the pest, one at the tillering stage and other at bootleaf stage of the crop. The results of the first experiment are presented in Table 2 and Figure 2. The maximum reduction in the percentage of leaf damage was noted in plots treated with 0.05 per cent emulsion of quinalphos @ 400 l/ha (increase -61.03 per cent) and this treatment was followed by the volumes of 350, 300, 450, 500 and 550 l/ha the difference among these being statistically insignificant. The damage in plots treated with 400 l/ha of the emulsion alone was significantly superior to control. Two weeks after the treatment the ranking of the treatments came in the following descending order, 350, 400, 450, 300 and 500 l/ha. All these treatments were significantly superior to control while the volume of 550 l/ha was found on par with control.

In plots treated with the insecticide at a constant dose of 0.25 kg ai/ha but with varying volumes of water also the extent of damages caused by the pest were seen varying. The maximum reduction was observed in plots treated with pesticide at the rate of 400 l/ha of the spray fluid as observed one week after the treatment. This treatment was followed by the treatments in which 300, 450 and 350 l/ha of the spray fluid were used, the differences among them being statistically insignificant. The increase in percentage of damage observed in control was on par with the increase percentages of damage observed in plots treated with the insecticide emulsion @ 500 and 550 l/ha. At two weeks after treatment, volumes of 350, 400, 450, 300 and 500 l/ha were seen on par and significantly superior to control.

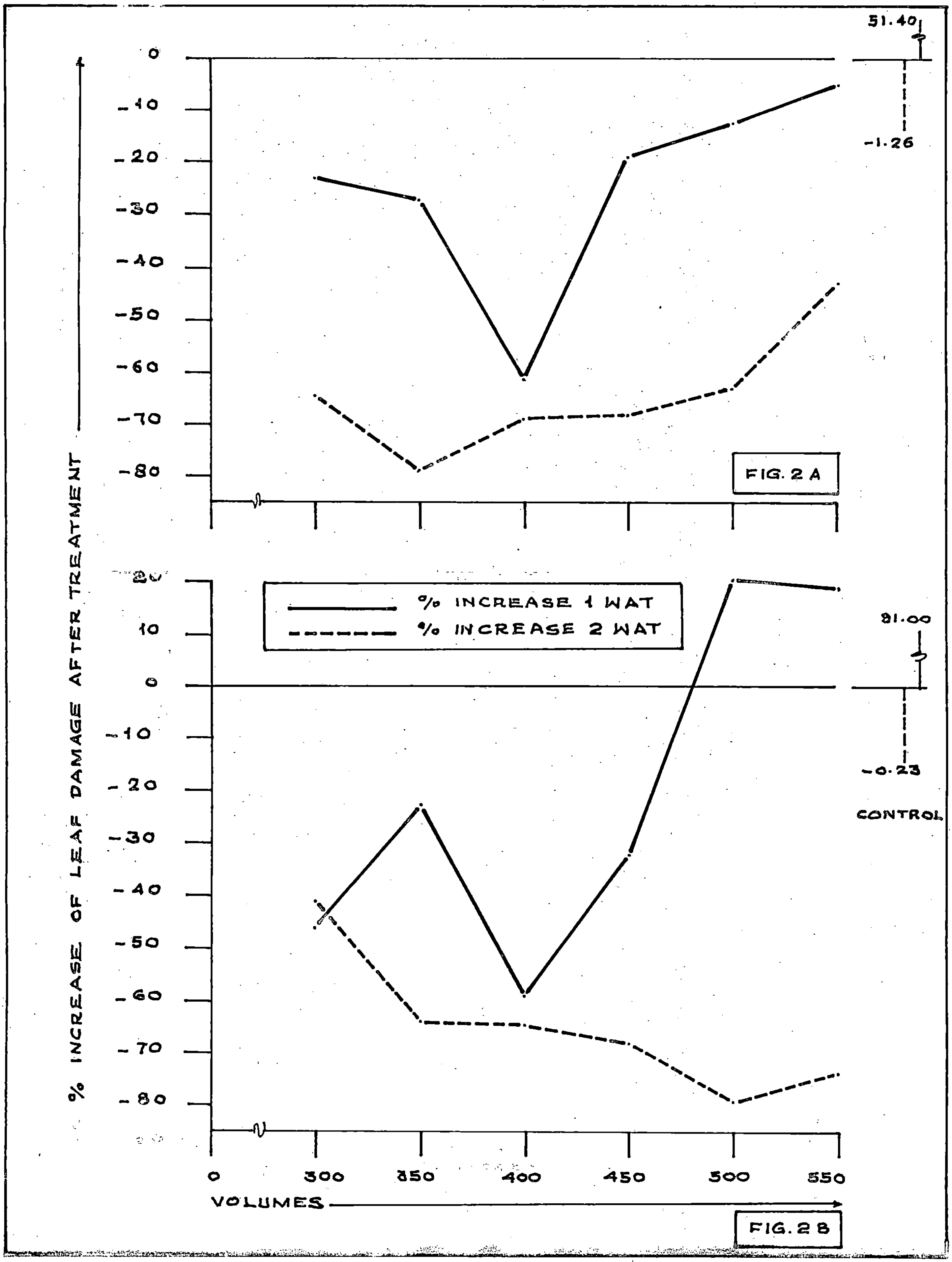
Table 2. Effect of spraying varying volumes of quinalphos emulsion, keeping the dose of the insecticide per unit area constant/varying on C. medinalis at tillering stage

Volume of spray fluid used (l/ha)	Insecticide applied at varying doses (A)			Insecticide applied at fixed dose (B)		
	Dose of quinalphos used (kg ai/ha)	Mean percent increase of pretreatment percentage of damage observed at 1 WAT	2 WAT	Dose of quinalphos used (kg ai/ha)	Mean percent increase of pretreatment percentage of damage observed at 1 WAT	2 WAT
300	0.15	-23.51 (1.88)	-65.27 (1.54)	0.25	-45.92 (1.73)	-41.47 (1.56)
350	0.175	-27.89 (1.85)	-79.03 (1.32)	0.25	-22.91 (1.88)	-64.76 (1.53)
400	0.20	-61.03 (1.59)	-69.22 (1.49)	0.25	-59.82 (1.60)	-65.35 (1.54)
450	0.225	-19.74 (1.84)	-68.11 (1.50)	0.25	-32.70 (1.83)	-68.45 (1.55)
500	0.25	-12.68 (1.83)	-63.16 (1.57)	0.25	20.50 (2.08)	-79.20 (1.66)
550	0.275	-10.16 (1.95)	-42.40 (1.76)	0.25	19.40 (2.08)	-74.30 (1.83)
Control	-	51.40 (2.18)	-1.26 (2.01)	-	91.00 (2.28)	-0.23 (1.95)
C.D. at 5% level	-	0.45	0.365	-	0.38	0.255

Figures in parentheses are log (x + 100) transformation

WAT : Week after treatment

Fig. 2. Effect of spraying varying and fixed doses of quinalphos, in varying volumes of spray fluid for the control of C. medinalis at tillering stage.


51.40
-1.26
FIG. 2 A
% INCREASE 1 WAT
% INCREASE 2 WAT
81.00
-0.23
CONTROL
% INCREASE OF LEAF DAMAGE AFTER TREATMENT
0
-10
-20
-30
-40
-50
-60
-70
-80
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
0
300
350
400
450
500
550
VOLUMES
FIG. 2 B

The results showed that 350 l/ha of the spray fluid was sufficient for reducing the damage caused by C. medinalis on rice for a period of two weeks when the pest incidence occurred in tillering stage of the crop.

Figure 2A and 2B clearly showed that the coverage with adequate volume of the insecticide emulsion was more important than keeping the doses in the treatments at constant level. The variations in damages observed in plots treated with fixed and varying doses of the insecticides were corresponding the varying volumes used.

The usuage of optimum volume of spray fluid at tillering will reduce the quantity of insecticide required per unit area of the field to be treated. When sprayed with 0.05% emulsion @ 350 l/ha the quantity of insecticide can be reduced from the recommended dose of 0.25 kg ai/ha to 0.175 kg ai/ha.

The results of the second experiment conducted during the booting stage of the crop are presented in Table 3 and Figure 3.

In the plots treated with quinalphos emulsion at fixed concentration of 0.05% and at varying volumes, the leaf damage in all treatments were seen reduced over the pretreatment level while in control there was significant increase during the corresponding period. In the data collected 1 WAT the maximum reduction was seen in plots treated with 550 l/ha of spray fluid but this treatment came on par with the other treatments also. All the treatments were significantly superiod to control. At 2 WAT the maximum reduction was in plots treated with 650 l/ha of the spray fluid and that treatment was on par with the remaining treatments too. All treatments were significantly superior to control. During the third week maximum reduction in damage was seen in plots treated with 600 l/ha of the suspension, but it was on par with other treatments too. The treatments except 550 and 600 l/ha were on par with control.

The observation recorded 1 WAT, in plots treated with the fixed dose of 0.25 kg ai/ha of quinalphos showed that the maximum reduction in damage was in plots treated with the insecticide emulsion at 550 l/ha and it was followed by 500, 700, 450, 650 and 600 l/ha the differences among these treatments being statistically insignificant. The damage in plots treated with the pesticide @ 550 l/ha alone was significantly superior to control. The extent of damage was showing an increase over the pretreatment level in the control plots in the observations recorded at 2 and 3 weeks after treatment while there was a decrease in all the plots treated with the insecticide. In the observations recorded at 2 and 3 weeks after treatment 600 l/ha of the insecticide emulsion showed the maximum reduction in damage and the spraying with 550, 500 and 450 l/ha came on par with the above treatment. At 2 WAT

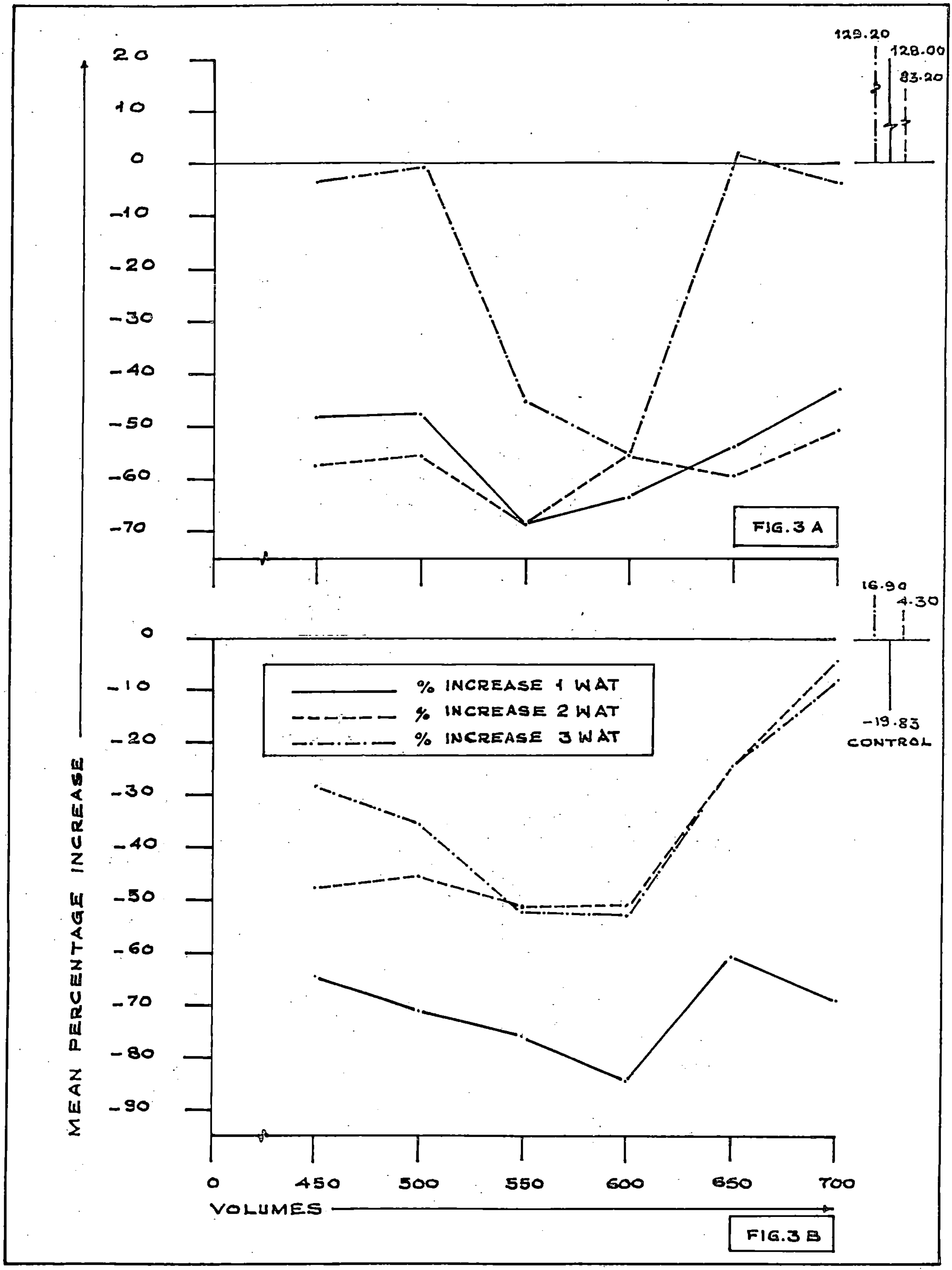
Table 3. Effect of spraying varying volumes of quinalphos emulsion, keeping the dose of the insecticide constant / varying, on *C. medinalis* which occurred at bootleaf stage

Volumes of spray fluid used (l/ha)	Insecticide applied at varying doses (A): Dose of quinalphos used (kg ai/ha)	Mean percent increase of pretreatment percentage of damage observed at			Insecticide applied at fixed dose (B): Dose of quinalphos used (kg ai/ha)	Mean percent increase of pretreatment percentage of damage observed at		
		1 WAT	2 WAT	3 WAT		1 WAT	2 WAT	3 WAT
450	0.225	-49.34 (1.704)	-58.97 (1.613)	-4.50 (1.980)	0.25	-64.52 (1.562)	-47.76 (1.718)	-28.29 (1.856)
500	0.25	-48.49 (1.711)	-56.76 (1.636)	-1.26 (1.994)	0.25	-70.62 (1.468)	-45.11 (1.740)	-35.67 (1.808)
550	0.275	-69.34 (1.485)	-69.61 (1.482)	-46.27 (1.730)	0.25	-76.83 (1.365)	-52.04 (1.681)	-52.04 (1.681)
600	0.30	-64.56 (1.549)	-56.81 (1.635)	-59.02 (1.612)	0.25	-84.90 (1.179)	-52.96 (1.673)	-52.94 (1.672)
650	0.325	-54.04 (1.643)	-60.19 (1.600)	1.6 (2.006)	0.25	-60.83 (1.593)	-24.94 (1.875)	-24.94 (1.875)
700	0.35	-43.87 (1.750)	-51.01 (1.689)	-4.04 (1.995)	0.25	-69.03 (1.491	-4.95 (1.978)	-0.81 (1.996)
Control	-	128.00 (2.358)	83.20 (2.262)	129.20 (2.360)	-	-19.83 (1.904)	4.30 (2.018)	16.90 (2.068)
C.D. at 5% level	-	0.504	0.526	0.421	-	0.592	0.173	0.192

Figures in parentheses are log (x + 100) transformation

WAT : Week after treatment

Fig. 3. Effect of spraying varying and fixed doses of quinalphos in varying volumes of spray fluid for the control of *C. medinalis* at bootleaf stage.


MEAN PERCENTAGE INCREASE
20
10
0
-10
-20
-30
-40
-50
-60
-70
129.20
128.00
83.20
FIG.3 A
16.90
4.30
-19.83
CONTROL
% INCREASE 1 WAT
% INCREASE 2 WAT
% INCREASE 3 WAT
-80
-90
0
450
500
550
600
650
700
VOLUMES
FIG.3 B

treatments 650 and 700 l/ha and at 3 WAT, 450, 500, 550 and 650 l/ha came on par with control while 550 and 600 l/ha remained superior to control. The results indicated that the level of 550 l/ha of the spray fluid may be chosen as the optimum volume of quinalphos emulsion for the control of C. medinalis at bootleaf stage while sprayed at a fixed concentration of 0.05% and also at the fixed dose of 0.25 kg ai/ha.

The results in Figures 3A and 3B have clearly showed that the efficacy of the treatments varied with the various volumes of the emulsion used for spraying when the dose of the insecticide was maintained at the fixed level of 0.25 kg of the toxicant per hectare or at the fixed concentration of 0.05 per cent. The dose of 0.275 kg ai/ha used in the optimum volume of 550 l/ha came on par with the treatments in which higher doses of 0.30, 0.32 and 0.35 kg ai/ha of the insecticide were used.

3.3. Effect of spraying varying volumes of quinalphos emulsion on S. incertulas infested rice in fixed and varying doses of the chemical

Results relating to the experiment are presented in Table 4 and Figure 4. The mean per cent incidence of white earhead showed that when quinalphos 0.05% emulsion was sprayed in varying volumes, the lowest incidence of white earhead occurred in plots treated with 550 l/ha of the emulsion (1.95%) and it was closely followed by the volumes of 600, 650 and 500 l/ha, the differences among these being statistically insignificant. But 650 and 500 l/ha were on par with the less effective treatment of 450 and 700 l/ha. All the treatments were significantly superior to control.

While the spraying was done with varying volumes of the insecticide emulsion keeping the dose per unit area at the constant level of 0.25 kg ai/ha also the levels of incidence of dead heart varied significantly in various treatments. The least incidence of 0.79 per cent was seen in plots treated with 600 l/ha of the emulsion and it was closely followed by the treatment with 550 l/ha, the two treatments being statistically on par. They were significantly superior to all other treatments. The volumes of 500, 650, 450 and 700 l/ha were on par among themselves and also with control.

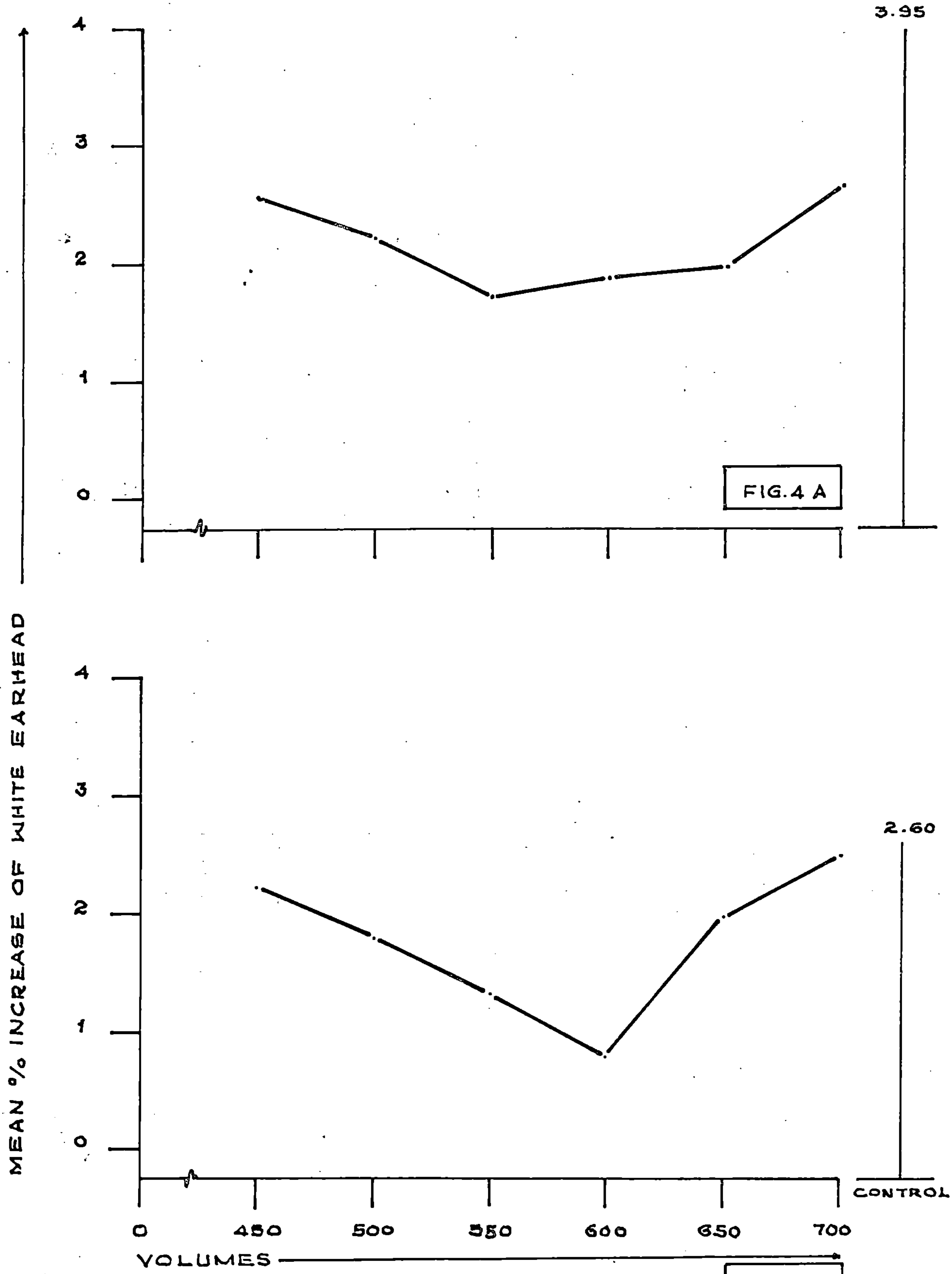
The relative efficacy of the spraying of constant and varying doses of the insecticide in varying volumes as shown in Figure 4 revealed that the volume of the pesticide used influenced the extent of control than the dose of the chemical. The trends in the extent of control obtained in plots treated with the constant dose of 0.25 kg ai/ha and in plots treated with the insecticide at varying doses ranging from 0.225 to 0.35 kg ai/ha were more or less similar. When the doses were varied the maximum reduction of white earhead was observed in

Table 4. Effect of spraying varying volumes of quinalphos emulsion, keeping the dose of insecticide per unit area constant/varying, on S. incertulas which occurred at bootleaf stage

Volumes of spray fluid used (l/ha)	Insecticide applied at varying doses (A)		Insecticide applied at fixed dose (B)	
	Dose of quinalphos used (kg ai/ha)	Mean percent incidence of white earhead observed at harvest	Dose of quinalphos used (kg ai/ha)	Mean percent incidence of white earhead observed at harvest
450	0.225	2.80 (9.684)	0.25	2.80 (8.600)
500	0.25	2.45 (9.050)	0.25	1.80 (7.658)
550	0.275	1.95 (8.092)	0.25	1.30 (6.475)
600	0.30	2.10 (8.297)	0.25	0.79 (5.102)
650	0.325	2.20 (8.555)	0.25	1.90 (7.951)
700	0.35	2.90 (9.823)	0.25	2.50 (9.040)
Control	-	3.95 (11.495)	-	2.60 (9.305)
C.D. at 5% level	-	1.331	-	1.497

Figures in parentheses are angular transformation

Fig. 4. Effect of spraying varying and fixed doses of quinalphos in varying volumes of spray fluid for the control of *S. incertulas*.


3.95
FIG.4 A
2.60
CONTROL
MEAN % INCREASE OF WHITE EARHEAD
0
1
2
3
4
450
500
550
600
650
700
VOLUMES
FIG.4 B

plots treated with 0.275 kg ai/ha while the higher doses of 0.325 and 0.35 kg ai/ha were seen significantly inferior to the former.

3.4 Effect of spraying varying volumes of methyl parathion emulsion on the population of rice bug when sprayed at fixed and varying doses of the chemical

The results of the experiment are presented in Table 5 and Figure 5. One day after treatment the percentages of the reduction of populations over the pretreatment levels were significantly higher in treatments than that of control. The highest reduction was in plots treated with 0.05% metacid emulsion at 550 l/ha and 600 l/ha and it was followed by 500, 450 and 650 l/ha. The least effective treatment of 700 l/ha was on par with 650, 450 and 500 l/ha also. Thus 550 and 600 l/ha of the emulsion had to be considered as optimum for the control of the pest which occurred on the heading stage of the crop. The data collected 2 days after treatment showed that the reduction in the populations in plots treated with 550, 700, 650, 450 and 500 l/ha were on par with that of control while plots treated with 600 l/ha alone was significantly superior to control. In the observation recorded at 3 DAT, 600, 550 and 650 l/ha were on par and significantly superior to the least effective treatment of 450 l/ha which was also on par with 500 and 700 l/ha. Population in control was significantly higher than those in treatments. At 4 DAT also populations of all the treatments were significantly lower than that of control and the highest reduction was seen in plots treated with 550 l/ha of the emulsion and it was on par with 600, 650, 500 and 700 l/ha also. All treatments were seen significantly superior to control. At the 5th day after treatment the lowest population level was seen in plots treated with 600 l/ha of the emulsion and it was on par with the treatment of 550 l/ha. The data thus revealed that with reference to the immediate control of the rice bug 550 l/ha of 0.05 per cent emulsion of methyl parathion was the optimum volume to be used. The persistent effect of the chemical observed during the second to fifth days after spraying also showed that the higher level of initial control obtained with 550 l/ha of the emulsion was maintained throughout the period of observation.

When methyl parathion was sprayed at the fixed dose of 0.25 kg ai/ha also the reduction of rice bug populations was varying with the different volumes of the insecticide emulsion used. One day after the spraying all the treatments were seen significantly superior to control. The maximum reduction of 100 per cent of the population was observed in plots treated with 550 and 600 l/ha of the emulsion. These were also on par with 500, 650 and 700 l/ha. Two days after treatment 550, 600 and 500 l/ha were seen on par and best. 500 l/ha was on par with the rest of the treatments also. All the treatments were seen significantly superior to control. The population recorded at 3 DAT also revealed that the highest reduction was in plots treated with 550 l/ha of the spray fluid and it was on par with the spray volumes of 600 and 500 l/ha. Remaining treatments were on par and also on par with control. Fourth day after the treatment the maximum reduction in population was recorded in plots treated with 550 l/ha of the emulsion and it was followed by 600, 500, 650 and 450 l/ha, the differences among them being statistically insignificant. The treatments 450 and 700 l/ha came on par. The reduction of population in control plot was significantly lower than those in the various treatments. At fifth day after the spraying the highest reduction was observed in plots treated with 600 l/ha, the differences among the treatments being statistically insignificant. The volumes of 650 and 450 l/ha were seen on par. The population was reduced to a significantly lower level in control. The results of the experiment thus showed that even when the constant dose of 0.25 kg ai/ha of the insecticide was applied in all the treatments the volume of 550 l/ha of the spray fluid caused the maximum initial reduction in population and also maintained the reduced level of population for the five subsequent days during which the data were collected.

Figures 5A and 5B revealed that the extent of reductions in rice bug populations in plots treated with methyl parathion

Table 5. Effect of spraying varying volumes of methyl parathion emulsion, keeping the dose of insecticide constant / varying, on L. acuta which occurred at heading stage

Volume of spray fluid used (l/ha)	Dose of methyl parathion used (kg ai/ha)	Insecticide applied at varying doses (A): Mean percent reduction of the pretreatment population in 1 m^2 area observed at 1 DAT	2 DAT	3 DAT	4 DAT	5 DAT	Dose of methyl parathion used (kg ai/ha)	Insecticide applied at fixed dose (B): Mean percent reduction of the pretreatment population in 1 m^2 area observed at 1 DAT	2 DAT	3 DAT	4 DAT	5 DAT
450	0.225	98.96 (81.73)	96.61 (75.029)	95.47 (72.691)	94.78 (71.411)	82.28 (55.369)	0.25	76.80 (50.177)	97.57 (77.349)	88.57 (62.336)	99.96 (70.04)	82.98 (56.076)
500	0.25	99.25 (82.961)	95.96 (73.665)	95.67 (73.075)	96.49 (74.77)	87.18 (60.665)	0.25	99.41 (83.75)	98.00 (78.523)	91.82 (66.661)	94.74 (71.338)	87.17 (60.659)
550	0.275	100.00 (90.00)	99.39 (83.665)	97.58 (77.367)	98.75 (80.946)	90.31 (64.573)	0.25	100.00 (90.00)	100.00 (90.00)	96.76 (75.381)	96.84 (75.556)	86.62 (60.022)
600	0.30	100.00 (90.00)	99.77 (86.143)	98.19 (79.104)	98.34 (79.543)	95.37 (72.506)	0.25	100.00 (90.00)	100.00 (90.00)	96.33 (74.422)	95.22 (72.218)	92.90 (68.284)
650	0.325	98.19 (79.104)	98.41 (79.777)	97.53 (77.244)	96.88 (75.64)	87.14 (60.62)	0.25	95.84 (73.42)	96.52 (74.834)	90.25 (64.49)	95.08 (70.178)	85.36 (58.607)
700	0.35	95.37 (72.48)	98.86 (81.334)	96.10 (73.956)	95.67 (73.075)	83.49 (56.604)	0.25	93.99 (70.03)	96.48 (74.756)	88.94 (62.801)	92.63 (67.864)	90.95 (65.44)
Control	-	85.32 (58.561)	93.94 (69.945)	89.23 (63.160)	86.39 (59.764)	75.09 (48.607)	-	44.29 (26.29)	86.97 (60.42)	84.06 (57.199)	82.38 (55.472)	68.82 (43.484)
C.D. at 5% level	-	11.738	14.569	4.279	8.325	8.255	-	27.81	11.587	12.441	5.953	10.516

Figures in parentheses are angular transformations

DAT : Days after treatment

Fig. 5. Effect of spraying varying and fixed doses of methyl parathion in varying volumes of spray fluid for the control of L. acuta.

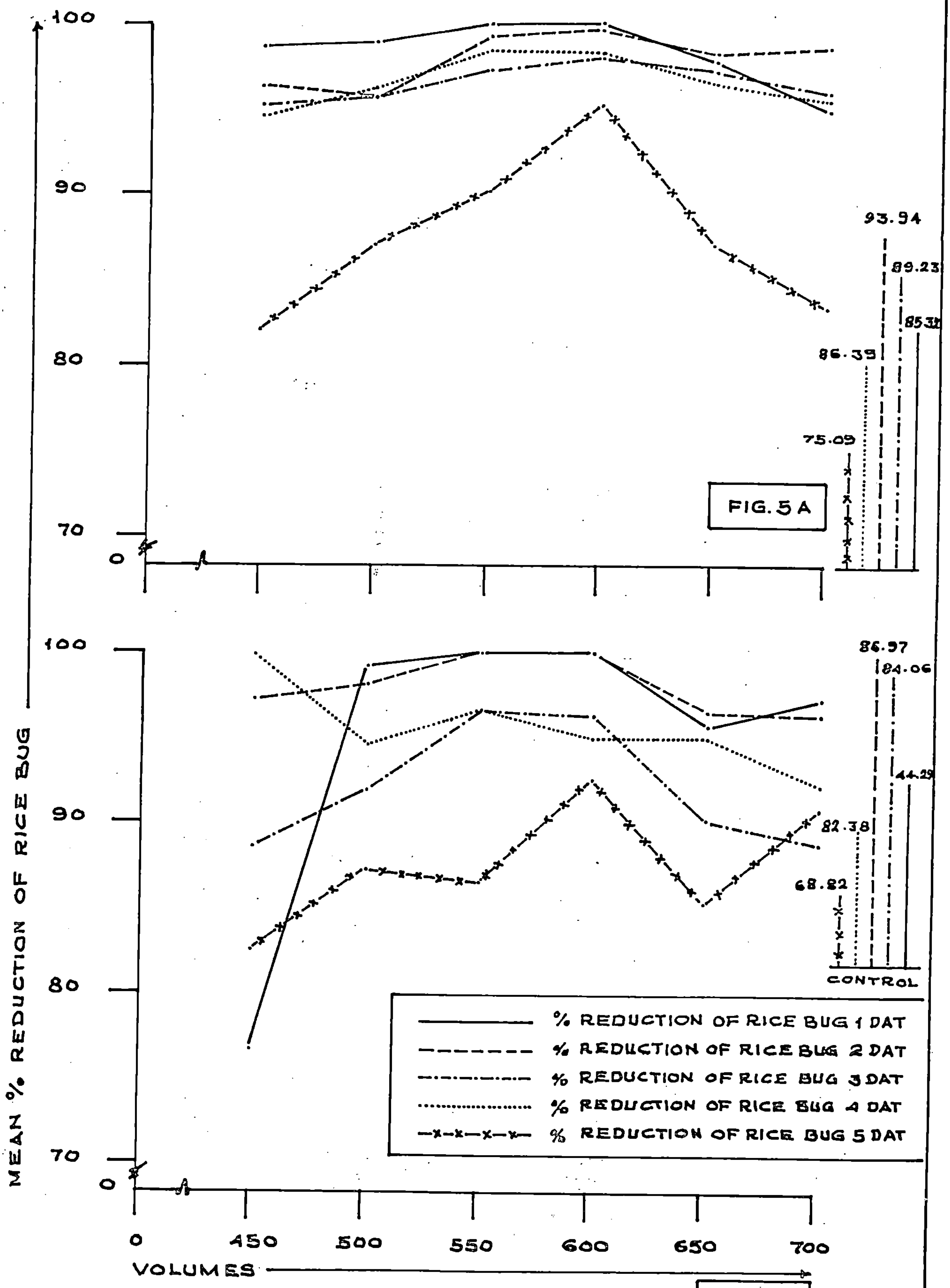

MEAN % REDUCTION OF RICE BUG
100
90
80
70
0
93.94
89.23
85.31
86.35
75.09
86.97
84.06
44.29
82.38
68.82
CONTROL
% REDUCTION OF RICE BUG 1 DAT
% REDUCTION OF RICE BUG 2 DAT
% REDUCTION OF RICE BUG 3 DAT
% REDUCTION OF RICE BUG 4 DAT
% REDUCTION OF RICE BUG 5 DAT
0
450
500
550
600
650
700
VOLUMES
FIG. 5 A

FIG. 5 B

emulsion at a constant dose of 0.25 kg ai/ha and at the varying doses ranging from 0.225 per cent to 0.35 kg ai/ha showed the same trend thus indicating that the volumes of spray fluid used in the treatments exerted a significant role in the extent of control obtained irrespective of the doses used.

3-5 Effect of using varying volumes of Dithane M-45 suspension, in fixed and varying doses, on the incidence of brown leaf spot of rice

The results of the experiment are presented in Table 6 and Figure 6. Though there was decrease in the intensity of the disease in untreated plots with reference to pretreatment incidence it was significantly lower when compared with the reduction in the disease incidence in plots treated with 0.4 per cent suspension of the fungicide in varying volumes. The highest reduction of 41.27 per cent of the disease over pretreatment count was observed in plots sprayed with 400 l/ha of the suspension and it was clearly followed by 450 and 350 l/ha of the suspension, the differences among the treatments being statistically insignificant. The higher volumes of 500 and 550 were less effective and they were on par but significantly inferior to 350 l/ha.

When the fungicide was sprayed at the constant dose of 2 kg/ha, but using varying volumes of spray fluid, 350 l/ha of the spray fluid gave the maximum reduction (31.08 per cent) and it was

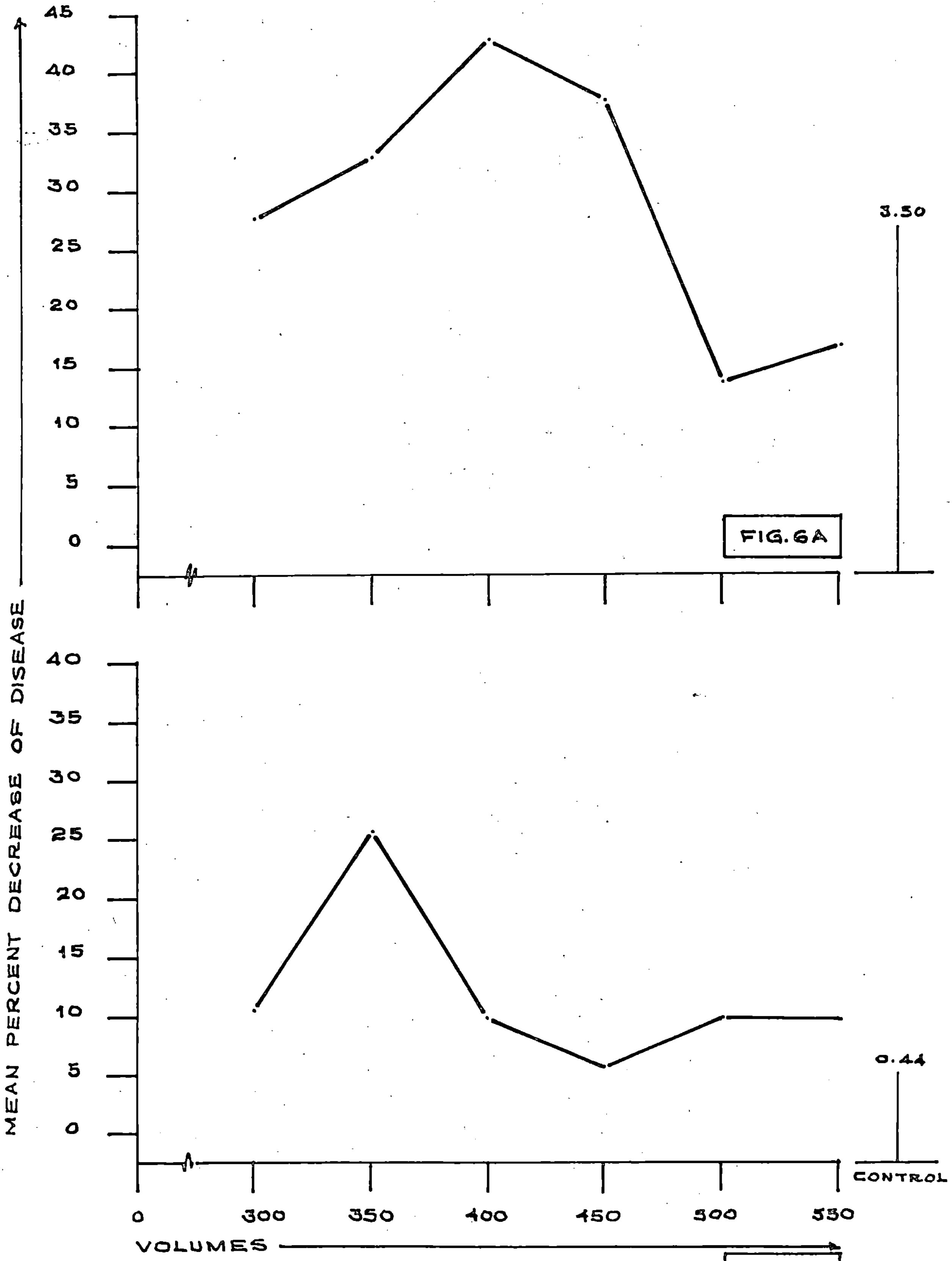
Table 6. Effect of spraying varying volumes of Dithane M 45 suspension, keeping the dose of the fungicide per unit area constant / varying which occurred at tillering stage

Volumes of spray fluid used (l/ha)	Fungicide applied at varying doses (A)		Fungicide applied at fixed dose (B)	
	Dose of mancozeb used (kg/ha)	Mean percent decrease of pretreatment percentage of damage observed at 1 WAT	Dose of mancozeb used (kg/ha)	Mean percent decrease of pretreatment percentage of damage observed at 1 WAT
300	1.2	28.50 (32.29)	2.0	11.10 (19.45)
350	1.4	33.30 (35.24)	2.0	26.60 (31.08)
400	1.6	43.50 (41.27)	2.0	10.00 (18.42)
450	1.8	38.8 (38.51)	2.0	6.9 (15.20)
500	2.0	14.20 (22.18)	2.0	10.00 (18.41)
550	2.2	17.60 (25.62)	2.0	9.90 (18.33)
Control	-	3.50 (11.99)	-	0.44 (3.82)
C.D. at 5% level	-	6.61	-	2.781

Figures in parentheses are angular transformations

WAT : Week after treatment

Fig. 6. Effect of spraying varying and fixed doses of Dithane M 45 in varying volumes of spray fluid for the control of brown leaf spot.



MEAN PERCENT DECREASE OF DISEASE
45
40
35
30
25
20
15
10
5
0
3.50
40
35
30
25
20
15
10
5
0
0.44
CONTROL
0
300
350
400
450
500
550
VOLUMES

FIG. 6A

FIG. 6 B

significantly superior to all other treatments. It was followed by the volumes of 300, 400, 500 and 550 l/ha of the spray fluid, the differences among them being statistically insignificant. The reduction of disease in plots treated with 450 l/ha of the suspension was the lowest among the treatments and the reduction in control was significantly lower than any of the treatments. Figures 6A and 6B clearly show the influence of spray volume on the bioefficacy of the fungicide rather than the doses used.

3.6 Effect of spraying varying volumes of Bavistin 50 WP suspension, keeping the dose of the fungicide at constant and varying levels, on sheath blight and sheath rot of rice

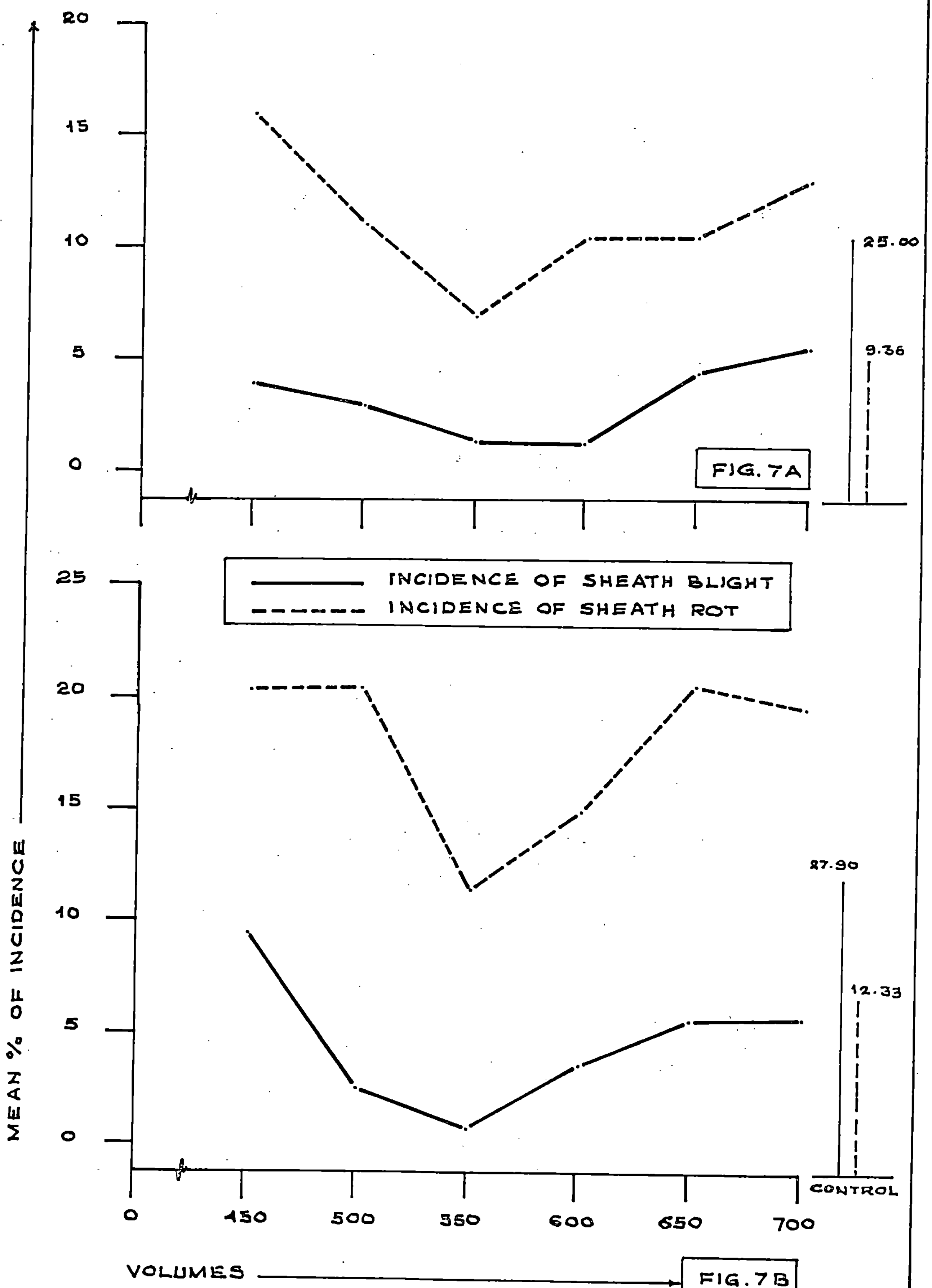
The results of the experiment are given in Table 7 and Figure 7. When sprayed with 0.1 per cent Bavistin suspension in varying volumes the lowest incidence of sheath blight (1.60%) was seen in plots treated with 600 l/ha of the spray fluid. It was closely followed by 550, 500, 650, 450 and 700 l/ha the differences among them being statistically insignificant. Volumes of 450 and 700 l/ha came on par with control. When the fungicide was applied at the fixed dose of 500 g/ha the least incidence of the disease was observed in plots treated with 550 l/ha of suspension and it came on par with 600, 500 and 700 l/ha of the spray fluid. The treatment 600 l/ha of the spray fluid came on par with the rest of the treatments and the volumes of 650 and 450 l/ha were on par with control also. Among the treatments which came

Table 7. Effect of spraying varying volumes of Bavistin 50 WP suspension keeping the dose of the fungicide per unit area constant/varying, on sheath blight and sheath rot of rice which occurred at bootleaf stage

Volumes of spray fluid used (l/ha)	Fungicide applied at varying doses (A)			Fungicide applied at fixed dose (B)		
	Dose of Bavistin used (kg/ha)	Mean percentage of sheath blight infected hills 1 m^2 observed one day prior to harvest	Mean incidence of sheath rot infected earheads observed one day prior to harvest	Dose of Bavistin used (kg/ha)	Mean percentage of sheath blight infected hills 1 m^2 observed one day prior to harvest	Mean incidence of sheath rot infected earheads observed one day prior to harvest
450	0.45	4.86 (10.41)	16.20 (23.61)	0.5	10.10 (15.52)	21.70 (26.70)
500	0.50	2.90 (8.02)	11.30 (20.01)	0.5	3.73 (11.06)	21.16 (27.34)
550	0.55	1.76 (6.19)	7.00 (15.22)	0.5	1.30 (5.31)	12.56 (20.75)
600	0.60	1.60 (5.92)	10.36 (18.59)	0.5	4.00 (9.37)	15.76 (23.13)
650	0.65	4.83 (9.73)	10.46 (18.86)	0.5	6.43 (14.15)	21.30 (27.46)
700	0.70	5.56 (13.63)	13.20 (21.18)	0.5	6.26 (11.86)	20.93 (26.49)
Control	-	9.66 (17.80)	25.00 (29.97)	-	12.33 (20.48)	27.90 (31.78)
C.D. at 5% level	-	7.81	4.66	-	7.94	9.86

Figures in parentheses are angular transformations

Fig. 7. Effect of spraying varying and fixed doses of Bavistin 50 WP in varying volumes of spray fluid for the control of sheath blight and sheath rot.



20
15
10
5
0
25.00
9.36
FIG. 7A
INCIDENCE OF SHEATH BLIGHT
INCIDENCE OF SHEATH ROT
25
20
15
10
5
0
27.90
12.33
MEAN % OF INCIDENCE
CONTROL
0
450
500
550
600
650
700
VOLUMES

FIG. 7B

on par and effective 500 l/ha may be treated as desirable volume to be chosen .

When sprayed with 0.1 per cent suspension of Bavistin the incidence of sheath rot was found to be least in plots treated with 550 l/ha of the spray fluid. This came on par with 600 and 650 l/ha also. The incidence in control plot was significantly higher than those of treatments. The least effective treatment was 450 l/ha and it came on par with 700 and 500 l/ha also.

When the fungicide was used at a constant dose of 0.5 kg ai/ha there was no significant difference in the levels of sheath rot incidence between control and treatments or among treatments. However, the percentages of the disease incidence were varying with the varying volumes of the fungicides. Figure 7 indicates that the extent of counts of sheath blight and sheath rot on rice varied with the volumes of the spray fluid used rather than the dosage of the fungicides used. The trend was similar in fixed and varying doses of the fungicide.

3-7 Spray deposits caused by varying volumes of spray fluid used on rice at different growth stages of the crop using safranin as a tracer

The standard curve used for the estimation of the concentrations of the stain in the extract from various treatments is shown in Figure 9. The data presented in Table 8 showed that at tillering stage the deposit of the stain was maximum in plots treated with 350 l/ha of stain solution and it was significantly superior to all other treatments. The deposit of the stain was in descending order in plots treated with 400, 450, 500, 550 and 300 l/ha of the solution.

At bootleaf stage the highest deposit was observed in plots sprayed with 550 l/ha of the solution and it was significantly higher than the deposit in all other treatments. The deposits in other treatments came in the following descending order: 600, 500, 450, 650 and 700 l/ha.

At heading stage the maximum deposit was seen in plots sprayed with 550 l/ha of the solution. It was also on par with the deposit in plots sprayed with 600 l/ha of the suspension. The latter came on par with the volumes of 500, 650 and 700 l/ha. The least deposit was in plots treated with 450 l/ha of the stain solution.

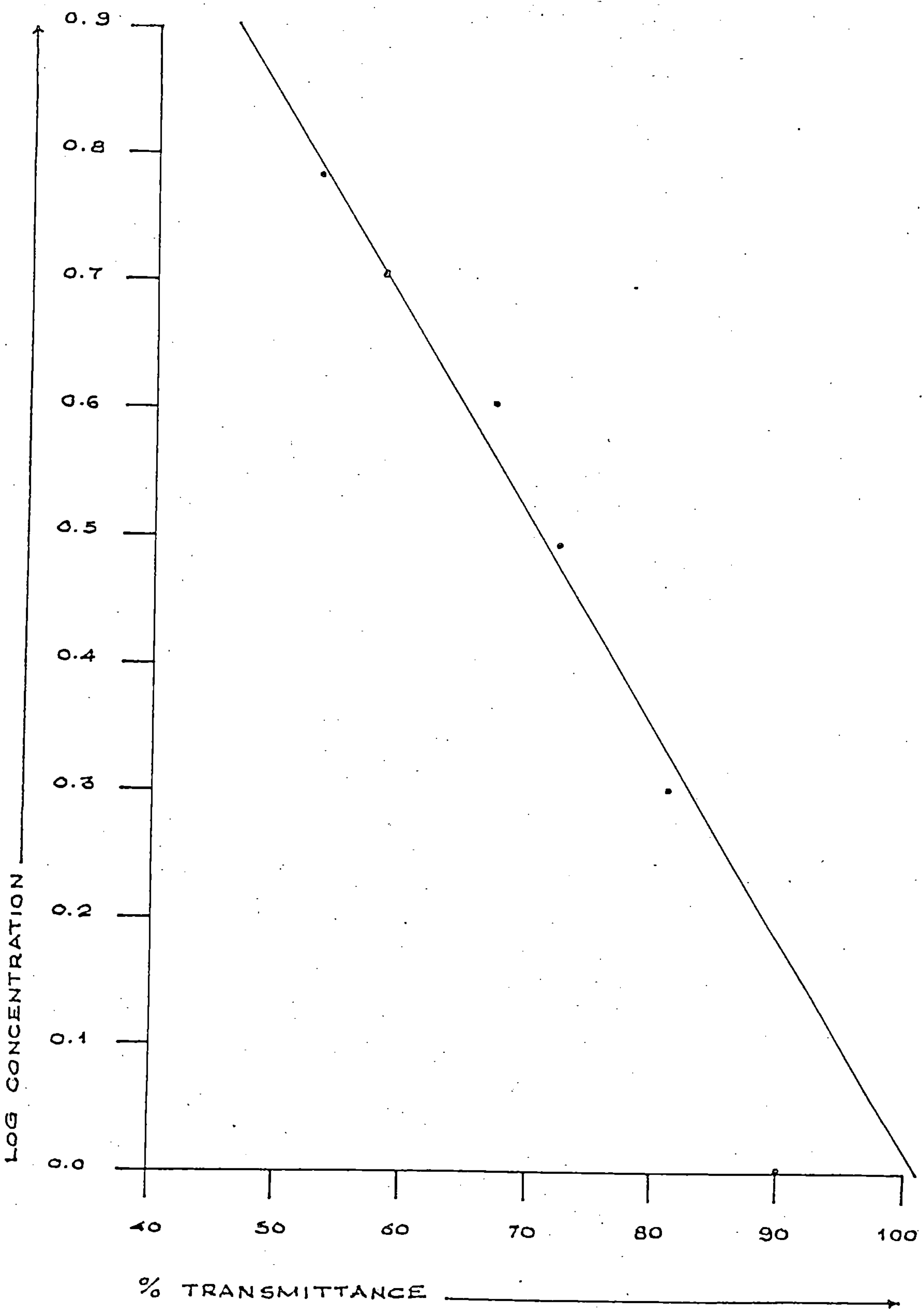
The mean leaf area indices in various plots showed that there was no significant variations in the extent of leaf area in various treatments at each growth stage of the crop.

Table 8. Deposit of stains on paddy leaves sprayed with varying volumes of 10% solution of safranin

Volumes of spray fluid used (l/ha)	Conc. of stain (%) in the solution obtained by dissolving the deposit on 5 hills in 1 litre of water in samples collected from treatment plots at			Leaf area indices at		
	Tillering	Bootleaf	Heading	Tillering	Bootleaf	Heading
300	0.03986	-	-	2.21	-	-
350	0.05453	-	-	2.80	-	-
400	0.04958	-	-	2.90	-	-
450	0.03827	0.08939	0.04566	2.71	3.95	4.25
500	0.02918	0.10942	0.08032	2.66	4.00	4.40
550	0.02918	0.13649	0.10035	2.60	3.85	4.10
600	-	0.11004	0.09153	-	3.95	4.10
650	-	0.08237	0.07593	-	4.10	4.20
700	-	0.07392	0.06467	-	4.00	4.40
C.D. at 5% level	0.0038	0.0145	0.00976	NS	NS	NS

NS : Not significant

Fig. 8. Standard curve for estimating the concentration of safranin in solutions washed out from leaf samples.



0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
LOG CONCENTRATION
40
50
60
70
80
90
100
% TRANSMITTANCE

FIGURE 9

Fig. 9. Effect of spraying varying volumes of safranin which cause spray deposits on rice at different growth stages.

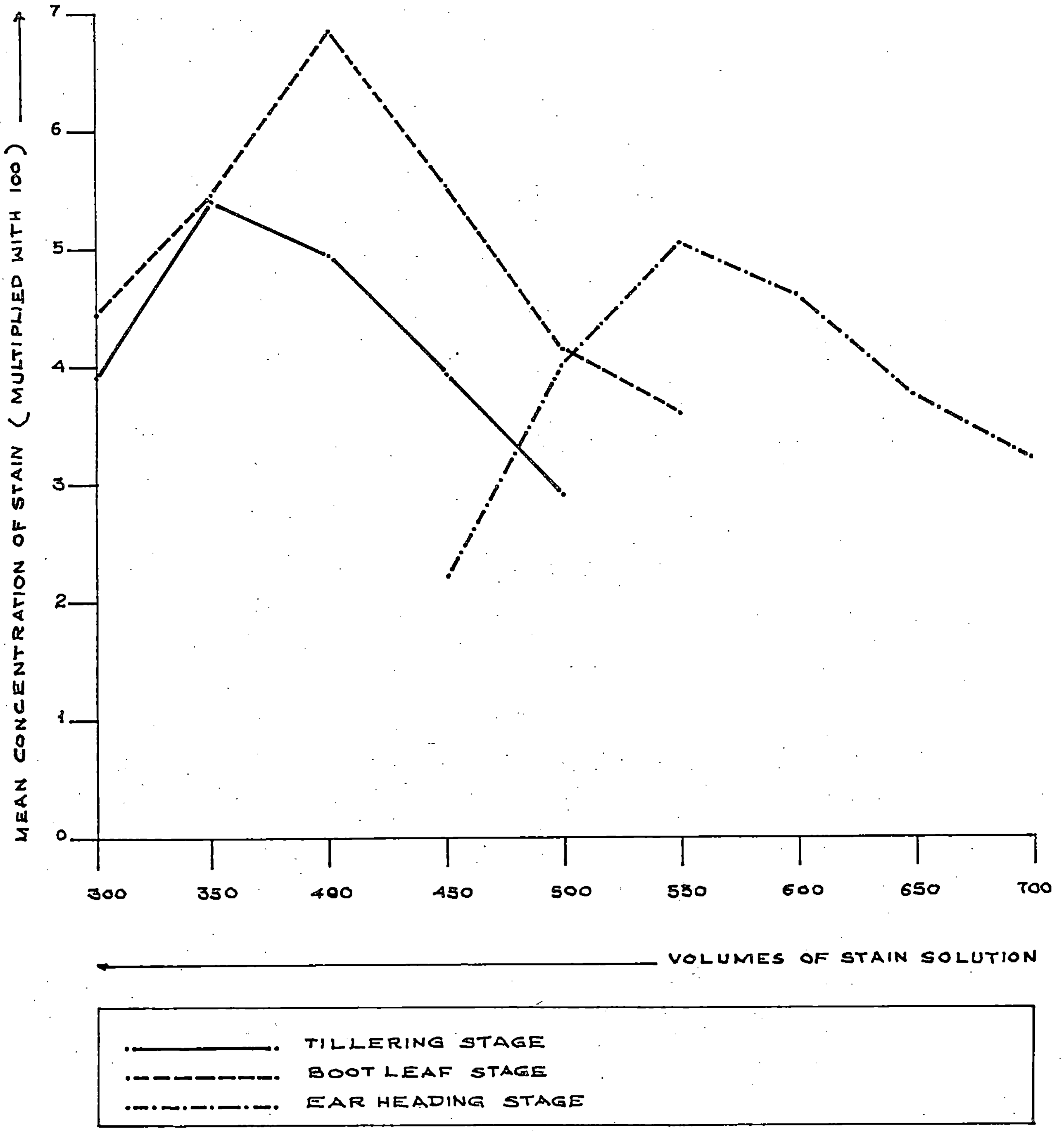

MEAN CONCENTRATION OF STAIN (MULTIPLIED WITH 100)
0
1
2
3
4
5
6
7
300
350
400
450
500
550
600
650
700
VOLUMES OF STAIN SOLUTION
TILLERING STAGE
BOOT LEAF STAGE
EAR HEADING STAGE

FIGURE. 8.

DISCUSSION

DISCUSSION

Bioefficacy of pesticides applied in a situation will depend not only on the toxicity of pesticides but also on the distribution of the toxicants and coverage of target areas (Bindra and Singh, 1971). Improper and excessive use of these chemicals in an agro-ecosystem will adversely affect the bioefficacy. Besides it will contaminate the human environment and result in the residue hazards through agricultural commodities. The distribution of the pesticides in a situation will be influenced significantly by the volume of spray fluid used for treatment. Inadequate quantities of the spray fluid will result in uneven distribution of the chemical in the situation and excessive quantity will result in run-off losses and consequent reduction in bio-efficacy and environmental contamination. Theoritically in an ideal condition the volume of spray fluid used for treating a specific target area should be one that does not reach the run off level but sufficient to give full coverage on the surface area to be treated. Obviously in fixing the optimum quantity needed for the treatment of a crop the growth stage will be a deciding factor since the surface to be covered in the treatment (the foliage) increases with the growth of the plant. These aspects have received the attention of researchers from very early days (Evans and Martin, 1935; Hensill and Tihenko, 1939) but specific recommendations on the volume of spray fluid required, supported by research data, are still lacking.

Rice is a crop in which insecticides are now being used extensively and intensively in Kerala. The pesticide input has increased several fold in recent years subsequent to the introduction of high yielding varieties and the emergence of devastating pests like brown plant hopper and diseases like sheath blight, grassy stunt, tungro disease, etc. Attempts to fix optimum volumes of spray fluid for the different growth stages of the crop were made previously. Patel (1960) recommended a range of 40 to 80 gallons of spray fluid for treating one ha of paddy using a high volume sprayer. Heinrichs (1978) recommended the spraying of 333, 500 and 500 l/ha for the control of brown plant hopper infesting the crop at 15, 35 and 60 days after planting. Based on the carbaryl deposit formed on leaf surface treated with 0.2 per cent carbaryl suspension Mathew (1982) recommended 200, 300, 400 and 500 l/ha of the suspension as the optimum volumes for treating the crop at 30, 45, 60 and 75 days after sowing. He also observed that the levels of control obtained with varying volumes of spray fluid used against C. medinalis and N. depunctalis were in general agreement with the levels of deposits observed on leaf surface for the corresponding volumes.

The current recommendations for insecticide use in field are largely emphasising the quantity of insecticide to be used per unit area and the quantity of carrier material to be used in formulating the pesticides for field application is seldom stressed. In this context the present investigations were taken up with a view to assessing the necessity, if any, for recommending on insecticide for field use in terms of the quantity of the toxicant per unit area (kg/ha) or in terms of the optimum volume of the spray fluid prepared at a dilution known to be toxic to the pest involved and at a fixed volume. This aspect was studied with reference to a series of pests and diseases which occurred during the different growth stages of the crop in two cropping seasons.

The results of the first experiment (Table 1) showed that the maximum reduction of N. depunctalis population, which occurred three weeks after transplanting, was in plots treated with 350 l/ha of HCH 0.2 per cent suspension, as observed at 2 and 4 days after treatment The extent of leaf damage observed at 7 DAT also showed the same effect.

In the experiment 1 B where the recommended dose of 1.2.5 kg ai/h was applied using varying volumes of water as carrier the highest re duction in pest population and leaf damage were observed in plots treated with 350 l/ha of spray fluid. Though the quantity of the insecticide applied in different treatments remained the same the efficacy varied in relation to the volume of water used in the formulation.

The lower level of 300 l/ha of spray fluid and higher levels of 400, 450, 500 and 550 l/ha of spray fluid were found on par among themselves and also with control.

The results of the experiment in which the treatments were evaluated against C. medinalis (at tillering stage of the crop) showed that the maximum reduction in leaf damage observed 1 WAT was in plots treated with 400 l/ha of the 0.05 per cent emulsion of quinalphos. But in the data collected two weeks after treatment 350 l/ha also came on par with 400 l/ha. The experiment 2B where the dose of quinalphos in different treatments was maintained at the recommended level of 0.25 kg ai/ha plots sprayed with 400 l/ha of the spray fluid showed the minimum damage of leaf at 1 WAT and at 2 WAT the data in 400 l/ha came on par with that of 350 l/ha. On the basis of the leaf damage observed at the end of 2 weeks after treatment 350 l/ha of spray fluid could be considered as optimum for controlling leaf roller incidence at tillering stage of the crop.

The incidence of brown leaf spot of rice was also seen controlled effectively with 350 l/ha of 0.4 per cent suspension of Dithane M 45 (Table 6 and Figure 6). While the quantity of chemical was maintained at the recommended level of 2 kg/ha also the maximum reduction in the disease was recorded in plots treated with 350 l/ha of the suspension.

Thus in general for the control of pest and diseases occurring in the tillering stage of rice 350 l/ha of the spray fluid may have to be recommended for maximising the bioefficacy of the pesticides.

In the bootleaf stage of the crop control of C. medinalis using varying volumes of quinalphos 0.05 per cent emulsion ranging from 450 to 700 l/ha tried and from the extent of leaf damage observed at 1 and 2 weeks after treatment all the treatments were found on par and superior to control. In the observation recorded at 3 WAT though all treatments were on par plots treated with 550 and 600 l/ha of the spray fluid were significantly less damaged than control.

When the insecticide at the fixed dose of 0.25 kg ai/ha was applied in varying volumes of water 550 and 600 l/ha came on par in reducing the leaf damage and they were significantly superior to control as observed at 1, 2, and 3 weeks after treatment. Thus the results, in general indicated that 550 l/ha may be chosen as the optimum spray volume for controlling C. medinalis incidence at bootleaf stage of the crop.

When quinalphos 0.05 per cent was applied for the control of rice stem borer S. incertulas at bootleaf stage of the crop in varying volumes 550 l/ha of the emulsion caused the maximum reduction in white earhead incidence. When the fixed dose of 0.25 kg ai/ha was tried in varying volumes 550 l/ha and 600 l/ha were found on par and better than the remaining treatments. Obviously the minimum level of emulsion to be recommended for the control of the pest at bootleaf stage appeared to be 550 l/ha.

With reference to the control of sheath blight on rice which occurred at the bootleaf stage, the optimum volume of Bavistin 0.1% was 500 l/ha. When the fungicide was applied at the fixed dose of 0.5 kg/ha the least incidence was noted in plots treated with 550 l/ha of the spray fluid. The data on the control of sheath rot incidence also showed that 550 l/ha of spray fluid was the optimum volume to be used for the maximising the bioefficacy of treatments.

An overall assessment of the control of pests and diseases which occurred during the booting stage of the crop indicated that 550 to 600 l/ha of the spray fluid should be used for ensuring the maximum bioefficacy of treatments.

Only pest which occurred in the heading stage of the crop was the rice bug L. acuta. When methyl parathion 0.05 per cent emulsion was sprayed in varying volumes, 550 and 600 l/ha were found to give better reduction of population as observed one day after treatment. With reference to the persistent effect of the pesticide in four subsequent observations also the same trend was seen. When the insecticide was applied at a constant dose of 0.25 kg ai/ha and using varying volumes of water as carrier treatments with 550 and 600 l/ha of spray fluid gave better control. For treating the crop at the heading stage 550 l/ha of spray fluid may be recommended as optimum.

The results shown in Table 8 revealed that the deposits of safranin formed on the foliage of rice sprayed with varying volumes of a fixed concentration of the stain varied significantly. The maximum deposits of the stain at tillering, bootleaf and heading stages of the crop were 350, 550 and 550 l/ha respectively.

These volumes were in strict agreement with the optimum volumes of pesticide emulsions / suspensions observed for the control of pests and diseases occurring in different growth stages of the crop

Considering the overall results from the experiments it can be concluded that for controlling the various pests and diseases occurring at tillering, bootleaf and heading stages of the crop the optimum volumes of spray fluid to be used should be 350, 550, and 550 l/ha respectively when a properly calibrated sprayer was used for the treatment. The results further showed that even when adequate quantities of pesticides per unit area was ensured it was essential to use the optimum volume of water in formulating the pesticides for ensuring adequate bioefficacy.

The results indicated that the bioefficacy of the pesticides is to a large extent depending on the proper distribution of the toxicants and coverage of the target site in spraying. Suboptimal levels of spray fluids will obviously cause uneven spread and coverage of the target site while the excess fluid applied on the target will result in run off and consequent endodrift (Himel, 1974) especially on the foliage crops.

Using optimum levels of spray fluid at tillering stages of rice will result in significant saving of the insecticide used (300 l of 0.2% HCH suspension contains 0.7 kg ai and 350 l of 0.05% quinalphos emulsions will contain 0.175 kg ai of toxicant against the recommended doses of 1.25 kg ai/ha and 0.25 kg ai/ha respectively). For treating the crop at bootleaf and heading stages at optimum volumes of 550 l/ha of insecticide emulsion at a suitable concentration, quantity of pesticides slightly higher than the normal recommended dose will be required per unit area i.e. 0.275 kg ai/ha of quinalphos or methyl parathion as against the recommended dose of 0.25 kg ai/ha.

The optimum volumes of spray fluids now recommended on the basis of bioefficacy against various pests and diseases occurring at the different growth stages of rice are in agreement with the earlier recommendations based on deposit assessment made by Mathew (1982) and those recommended for controlling brown plant hopper by Aquino and Heinrichs (1978). The desirability of recommending fixed quantity of pesticides per unit area without specifying the volume of spray fluid to be used was tested and the results showed that the practice did not ensure maximum level of pest control possible with the quantities of pesticides used. This conclusion is contradicting many of the earlier findings (Moore, 1958; Hickely, 1960; Aquino and Heinrichs, 1978) but remains adequately established.

As observed by earlier workers (Mathews, 1971; Mathew <u>et al</u>., 1984) the spray fluid requirement in a crop will also depend on leaf area indices and the latter will be influenced by the variety of the crop grown, fertility of the soil and the agronomic practices followed. Hence the optimum volume arrived through the present investigations may only be a broad generalisation. Since the leaf area indices are likely to be influenced by many factors in the agro-ecosystem and is likely to vary the recommendations for a fixed volume of pesticide formulation per unit area for a growth stage may not prove precise.

Since the practice of recommending a fixed quantity of insecticide per unit area is not rational and since using a fixed volume of formulation at fixed dosage for a particular growth stage of crop may only be approximate by virtue of the possible variations in leaf area the recommendation of 'spraying the crop with an insecticide formulation of desired concentration ensuring adequate coverage of the target site by stopping the spraying process just before the onset of run-off' will be more effective.

SUMMARY

SUMMARY

A series of field experiments were conducted in the Instructional Farm attached to the College of Agriculture, Vellayani, during 1984-'85 with a view to (1) fixing the optimum volume of spray fluid needed for controlling the rice pests occurring at different growth stages of the crop and (2) assessing the desirability of recommending fixed quantity of insecticide per unit area without specifying the quantity of carrier to be used. The experiments were conducted in bulk crop area planted and maintained as per package of practices recommended by Kerala Agricultural University (1982), by peg marking required number of plots as and when sufficient pest population was noted. Randomised block design was adopted for the experiments.

In the first experiment the efficacy of varying volumes of HCH 0.2 per cent suspension (300, 350, 400, 450, 500 and 550 l/ha) for controlling N. depunctalis was assessed and 350 l/ha was found to be the optimum quantity for controlling the pest which occurred at the tillering phase of the crop. In a parallel experiment the insecticide was applied at the rate of 1.25 kg ai/ha by in varying volumes of water as in previous experiment. The results showed that even when fixed dose was used the quantity of water used influenced the bioefficacy of the toxicant and 350 l/ha was the optimum for reducing the larval population and leaf damage.

For the control of leaf roller of paddy C. medinalis, which occurred during the tillering phase of the crop, 0.05 per cent quinalphos emulsion was sprayed in volumes ranging from 300 to 550 l/ha. The extent of leaf damage observed one week after treatment showed 400 l/ha as the best treatment while the damage at 2 WAT showed that 350 l/ha was also on par with 400 l/ha for the control of the pest. The experiment in which the insecticide was used at constant dose of 0.25 kg ai/ha but in varying volumes of water also endorsed the above results.

The extent of control of brown leaf spot disease which occurred in the tillering phase of the crop with varying volumes of 0.4 per cent Dithane M 45 suspension was studied and for the control of the disease 350 l/ha was found to be the optimum volume of spray fluid to be used. Even when the fixed dose of 2 kg/ha was sprayed the reduction in disease varied with the volume of water used in the formulations and 350 l/ha was found to be the optimum.

The overall conclusion from the above experiments was that for the control of various pests and diseases occurring at tillering stage of rice 350 l/ha of the spray fluid would be the optimum. The above volume maximise the bioefficacy of the pesticides, when the treatment was done with a toxic concentration of the pesticide in the spray fluid or even when the recommended fixed dose of toxicant per unit area was used.

The experiments conducted at the bootleaf stage of the crop, for the control of leaf roller *C. medinalis*, using varying volumes ranging from 450 to 700 l/ha of 0.05 per cent emulsion of quinalphos showed that all the treatments were on par among themselves and with control during 1 and 2 WAT. But during the third week plots treated with 550 and 600 l/ha of spray fluids showed significantly lower level of leaf damage than in control. When the insecticide was sprayed at a constant dose of 0.25 kg ai/ha volumes of 550 and 600 l/ha were found significantly superior to control. The results indicated that 550 l/ha of spray fluid may be chosen as the optimum volume for treating the crop at bootleaf stage for controlling *C. medinalis*.

The incidence of white earhead in plots treated with varying volumes of quinalphos 0.05 per cent emulsion showed that 550 l/ha of the spray fluid was the optimum quantity for controlling the incidence of stem borer *S. incertulas* at bootleaf stage of the crop. With the fixed dose of 0.25 kg ai/ha of the insecticide also the above volume was found preferable for maximising the effect.

The experiment conducted for the control of sheath blight and sheath rot of rice by spraying the crop at bootleaf stage also revealed that 550 l/ha of the spray fluid was the optimum quantity to be used. The trend was the same when the treatments were done with fixed concentration of the pesticide in spray fluid or with varying concentration of spray fluid to give a fixed dose per unit area.

The results of the above experiments indicate that for controlling the pests and diseases occurring at bootleaf stage of rice the optimum volume of spray fluid to be used may be fixed as 550 l/ha.

In the heading stage of the crop the incidence of rice bug L. acuta was observed. When methyl parathion 0.05 per cent emulsion was sprayed in volumes ranging from 450 to 700 l/ha, 550 and 600 l/ha gave the maximum reduction of population one day after treatment. The persistent effect of treatment, as observed in the reduction of population with reference to the pretreatment count, in four subsequent observations also showed that 550 l/ha was in general the optimum volume of spray fluid required for best results. When the insecticide was applied at a fixed dose of 0.25 kg ai/ha, but with varying volumes of water, plots treated with 550 l/ha of spray fluid showed higher reduction of rice bug population.

In a separate series of experiments the deposition of sprayed chemical on rice plants at different growth stages of the crop and with varying volumes of spray fluid was studied using safranin as tracer. Maximum deposits of the stain at tillering, bootleaf and heading stages of the crop were with 350, 550 and 550 l/ha of spray fluid respectively. The volumes were corresponding to the optimum volumes of spray fluids recommended for the control of various pests and diseases occurring at the three different growth stages of the crop.

The results obtained from the different experiments conducted in the present investigations showed that the bio-efficacy of pesticides sprayed on rice is considerably influenced by the volume of the spray fluid used. For controlling the various pests and diseases occurring at tillering, bootleaf and heading stages of the crop the optimum volumes of spray fluid to be used were 350, 550 and 500 l/ha respectively for maximising the bioefficacy of the toxicants. It was further observed that even when the pesticides were applied at fixed dose per unit area the bioefficacy varied with the variations in the volume of spray formulations used.

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APPENDIX

APPENDIX I.

Pretreatment observations relating to the various experiments

Volumes of spray fluid used (l/ha)	Mean number of caseworm larvae in 1 m^2 area of the plot (vide. Tab. 1)		Mean percent damage (vide. Tab. 2)		Mean percent of damage at tillering stage (vide. Tab. 3)		Mean number of *L. acuta* in 1 m^2 area of the plot (vide. Tab. 5)		Percentage of leaf spot observed in 1 m^2 area at tillering stage (vide. Tab. 6)	
	B	A	B	A	B	A	B	A	B	A
300	9.76	11.30	3.53	3.39	11.02	13.05	-	-	90.00	46.66
350	7.33	10.00	3.95	3.62	9.15	12.14	-	-	100.00	30.60
400	10.00	10.30	3.31	3.75	8.64	10.12	-	-	86.66	46.66
450	7.00	10.33	3.46	3.25	7.45	10.13	14.00	28.66	96.66	60.00
500	7.67	11.66	3.78	3.51	15.00	16.41	11.66	26.33	100.00	46.66
550	10.67	10.33	4.01	3.90	14.95	14.38	15.33	32.00	100.00	70.00
600	-	-	-	-	-	-	17.00	26.33	-	-
650	-	-	-	-	-	-	17.66	23.00	-	-
700	-	-	-	-	-	-	17.33	34.66	-	-
Control	10.00	12.00	4.30	4.61	11.58	11.03	18.66	31.33	-	-

B : Plots treated with the pesticide in fixed dose

A : Plots treated with the pesticide in varying doses

ABSTRACT

EFFECT OF VARYING VOLUMES OF PESTICIDE SPRAY FLUID ON THE CONTROL OF RICE PESTS

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ABSTRACT OF A THESIS
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ABSTRACT

A series of field experiments were conducted in the Instructional Farm attached to the College of Agriculture, Vellayani, during 1984-'85 for evaluating the bioefficacy of pesticide suspensions/emulsions sprayed in varying volumes at different growth stages of rice crop for the control of various pests and diseases keeping the concentrations of the toxicants in the spray fluid at the recommended levels. A parallel series of experiments were conducted with similar volumes of spray fluids which were in different concentrations for maintaining the doses in all treatments at constant recommended level. The experiments were conducted in an area under bulk planting of rice (planted and maintained as per the package of practices recommended by the Kerala Agricultural University) by peg marking adequate number of plots at locations where pest incidence occurred in sufficient intensity. Randomised block design was adopted in all the experiments.

At tillering phase of the crop the incidence of case worm, N. depunctalis, leaf roller C. medinalis and brown leaf spot disease were observed. Against N. depunctalis HCH suspension 0.2 per cent was used in varying volumes in one experiment and the same at a fixed dose of 1.25 kg ai/ha and in varying volumes a parallel experiment. For the control of C. medinalis quinalphos 0.05 per cent emulsion was tried in varying volumes and the fixed dose of 0.25 kg ai/ha was also used in varying volumes.

The treatment for the disease was with Dithane M 45 at a concentration of 0.4 per cent and at a dose of 2.0 kg/ha in similar range of volumes. The volumes of spray fluid used were 300, 350, 400, 450, 500 and 550 l/ha and for each treatment there were three replications. Plots sprayed with water alone were retained as controls.

The results were assessed in terms of the reduction/increase in the populations of the pest or on the intensity of the damage caused by the pest, observed at different intervals after spraying. Results of the experiment showed that 350 l/ha was the optimum volume of spray fluid for the control of the pests and diseases occurring at tillering phase of the crop. In the second series of experiments where the recommended doses of toxicants per unit area were used in varying volumes of water the bioefficacy of the pesticides varied with the volumes of spray fluid used per unit area. At the tillering phase of the crop a formulation with 350 l/ha of water gave the maximum effect.

At bootleaf stage the crop was infested by the leaf roller C. medinalis and the stem borer S. incertulas. Quinalphos 0.05 per cent emulsion was sprayed in varying volumes ranging from 450 to 700 l/ha. In both the experiments 550 l/ha of the spray fluid was found as the optimum volume with reference to the reduction in the extent of damage caused by the pests. Even when the quantity of pesticide applied per hectare was maintained at the fixed level of 0.25 kg ai the efficacy was varying with the volume of spray fluid used. The volume of 550 l/ha was found to be the optimum for the control of both the pests.

In the bootleaf stage the incidence of sheath blight and sheath rot were observed and for controlling the disease Bavistin 0.1% suspension was sprayed at varying volumes ranging from 450 to 700 l/ha. In another experiment the pesticide was applied in the same range of volumes but maintaining the dose at the fixed rate of 0.5 kg/ha in all treatments. From the results 550 l/ha could be fixed as the optimum volume for maximising the bioefficacy of the pesticide against the two diseases.

The overall assessment of the data obtained from the experiments conducted at the bootleaf stage of the crop revealed that 550 l/ha of the spray fluid should be used for the control of the pests and diseases occurring at the stage and that the recommendation of a fixed quantity of pesticide per unit area will not be adequate unless it is used in 550 l/ha of water.

Only pest which occurred during the heading stage of the crop was the rice bug L. acuta. When methyl parathion 0.05% emulsion was applied at varying volumes ranging from 450 to 700 l/ha, 550 l/ha gave the highest initial reduction in population and maintained the effect up to the fifth day after treatment. Even when the quantity of insecticide was kept at a fixed dose of 0.25 kg ai/ha the volume of water to be used was found to be 550 l/ha for maximising the bioefficacy of treatment.

In a separate series of experiments the influence of varying volumes of spray fluid on the coverage and deposit formation on different growth stages of the crop was ascertained using safranin as tracer. The data showed that the volume required for maximum deposition at tillering, bootleaf and heading stages of the crop were 350, 550 and 550 l/ha respectively. These volumes were corresponding with the volumes of pesticide formulations required for maximising the bioefficacy against the pests at different growth stages of the crop.