DETERMINATION OF PHYTOTONIC EFFECT OF INSECTICIDES ON RICE CROP

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DECLARATION

I hereby declare that this thesis entitled "Determination of phytotonic effect of insecticides on rice crop" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Determination of phytotonic effect of insecticides on rice crop" is a record of research work done independently by Kum. GADE KRISHNA KUMARI, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

A large number of chemicals are being used for the control of crop pests. They are being primarily evaluated for their efficacy against the target pests and for their safety to man and the environment. But casual references about the stimulating effect of some of these chemicals on plant growth and yield are available in literature. The promotion of plant growth by the insecticides were brought to the notice of researchers with the report of Chapman and Allen (1948) that DDT accelearated the growth of tomato when applied on 14 day old seedlings. Subsequently a number of chemicals were reported to have such phytostimulatory effect on a variety of crops. Such chemicals are available in all classes of insecticides and in all types of formulations. They fall in groups with different modes of action and they influence different growth stages of crops (Venugopal and Litsinger, 1980).

Subsequent to the introduction of granular formulation the growth promoting activity of pesticides on crops got greater recognition particularly from field observations. In recent times carbofuran induced growth stimulation on cotton, tobacco, sorghum, corn and rice has been cited by various workers (Apple, 1971; Hardas et al., 1972; Daynard et al., 1975; Nayeem and Bapat, 1976; Sambandam and Venugopal, 1976; Saivaraj and Venugopal 1978; Venugopal and Litsinger, 1980). High yield responses observed in many experiments in the field of plant protection could not be explained by insect control alone. Follow up studies under pest free conditions were also conducted by scientists and the role of phytostimulations in the increased yield has now been recognised as a factor. This has to be exploited as a technology for achieving higher productivity of crops.

In the present study an attempt was made (1) to screen some of the common insecticides used for the control of rice pests in Kerala for their phytostimulatory effect (2) the effect of different dosages of pesticides applied in nursery and transplanted crop either alone or in combination on the yield and growth of the crop was ascertained (3) the commercial formulations of pesticides were applied in potted plants at the same dosages as in field for verifying the results obtained from field trials (4) in another set of pot trials the insecticides formulated from their technical grades were applied at the same dosages to ascertain the role of the adjuvants in commercial formulations in stimulating the growth and yield of crop (5) the persistence and bio-efficacy of the two types of formulations on rice were assessed using Nilaparvata lugens as test organism (6) since high dosages of pesticides were used in the experiment the terminal residues of the toxicant in the grains also was assessed through chemical and biological assays.

Review of literature

REVIEW OF LITERATURE

1.1 Growth stimulating action of insecticides on crops like cereals, pulses, cotton and vegetables have been briefly reviewed below. Information available on the persistent toxicity of the insecticides to the paddy pests and the residues in grain caused by pesticide applications also have been reviewed in brief.

1.1.1 Rice

Nagalingam (1968) studied the effect of dip treatment of paddy seedlings with various insecticides and observed that 0.003% methyldemeton, 0.025% phosphamidon and 0.4% phorate helped in recovering the seedling yellowing due to pest attack and he presumed this to be due to the stimulatory effect of the toxicant.

Ragupathy and Jayaraj (1974) found stimulated growth of rice in plots treated with fensulfothion @ 1.0 kg ai/ha than with 0.75 kg ai/ha of endrin.

FMC 35001, methylparathion, perthane, FMC 31768, diazinon and decamethrin applied as 0.04% sprays, in a green house study at IRRI, showed that tillering and plant height were higher in treated plants. In another study, aldicarb, carbofuran and FMC 31768 gave similar results (Anon., 1976a).

Application of carbofuran, isazophos, ethoprop and acephate at 1.5 kg ai/ha in irrigation water significantly increased the height of the plants (Heinrichs _et al._, 1978).

Carbaryl at low concentrations stimulated the germination of rice seeds and enhanced root and shoot growth of the seedlings (Tsai, 1978).

Higher concentration of plant nutrients like K, Mg, Ca, Mn, Co and Fe were seen in plants treated with carbofuran (Chelliah, 1979).

Quinalphos at 0.04% when applied thrice @ 10 day intervals reduced the infestation by _Dicladispa armigera_ and significantly increased tiller height, number and length of panicles and grain yield (Budhraja _et al._, 1980).

Casquijo _et al._ (1980) observed higher yields in plots treated with carbofuran.

Miah and Islam (1980) concluded that diazinon 3.0 kg ai/ha and bidrin 2.5 kg ai/ha at sowing increased the growth and yield of rice.

Saivaraj and Venugopal (1980) obtained enhanced growth and higher yield of rice treated with carbofuran and mephosfolan granules at 0.75 and 1 kg ai/ha respectively when applied 20, 40 and 60 days after planting.

Soil incorporation of carbofuran at 1 kg ai/ha (Venugopal and Litsinger, 1980), seed treatment at 10 g ai/kg seed (Litsinger et al. 1980) and 1.2 and 1.8 kg ai/ha at sowing and planting (Park, 1981) were reported to induce the growth of the plants and thus give higher yield. They also found that carbofuran directly stimulated total and productive tillers, grain and straw yields besides promoting early maturity. Further they observed soil incorporation as a better method of application than broadcasting.

Carbofuran at 0.5 kg ai/ha applied on 20 and 40 days after planting, over the water surface increased plant height leaf area, dry matter, productive tillers, filled grains and yield. In addition uptake and available 'N' was higher in treated plots (Balasubramaniyan and Morachan, 1981).

Sorghum

Hardas et al. (1972), Nayeem and Bapat (1976), Sambandam and Venugopal (1976) and Nayeem (1979) showed that carbofuran had hormonic effect on vegetative growth hastening flowering and other yield contributing characters of sorghum in addition to an effective control of shoot fly.

At 0.56 kg ai/ha disulfoton caused an increase in grain yield (Thompson and Harvey, 1980).

Maize

Apple (1971) observed positive effect of carbofuran application on growth and yield of the crop, applied @ 1-8 lb ai/acre at planting.

Zabel et al. (1974) found that soil application of gamma BHC, phorate and fenitrothion at 0.45, 1.0 and 2 kg ai/ha respectively at sowing time resulted in significant increase in the germination of seeds and in the yield of maize.

Increased growth and yield were reported by Daynard et al. (1975) while investigating the non-insecticidal influence of carbofuran and chlordane granules applied at sowing @ 0.6 to 5.6 and 2.2 kg ai/ha respectively.

Cotton

Azinphos methyl sprayed at 0.3 kg ai/ha on 14-21 day old plants increased the flower set (Haeckaylo and Scales, 1959) in cotton significantly.

Brown et al. (1962) obtained a significant increase in yield and boll production of cotton following DDT-toxaphene applications @ 2 and 1.016 at square formation stage.

Soil application of disulfoton and aldicarb at 1.75 and 2.75 kg ai/ha enhanced plant height and weight, laminar area in cotton (Swamiappan et al., 1976).

Field tests by Gawand *et al*. (1972) in Egypt revealed that organophosphorus compounds dyfonate, azinphosmethyl and phoxim increased yield, dry weight of seedling, length and fineness of the staple while the organochlorine insecticides chlordecone, endrin, gamma BHC increased the strength and length and fineness of the staple.

Sellammal *et al*. (1979) obtained significant difference in plant growth and boll production due to application of synthetic pyrethroids fenvalerate, permethrin, cypermethrin at 100 g ai/ha and 10 g ai/ha of decamethrin.

Aldicarb @ 1, 2 and 4 kg ai/ha as soil treatment was found to have a positive effect on the growth and yield of seed cotton. Increase in the height of plants, number of branches, number of bolls and yield of seed cotton was observed with an increase in dosage of pesticide (Yadav and Mallik, 1980).

Tobacco

Enhanced shoot growth and leaf yield of tobacco grown in disulfoton or carbofuran treated soil was attributed to a physiological response of the plants to the insecticides (Pless *et al*., 1972).

Pulses

Black gram

According to pareek and Gaus (1970) DDT application induced the growth of pulses.

Varma and Pant (1975) observed that a combination of phorate @ 1.5 kg ai/ha at sowing and endosulfan 0.07% applied as spray at pod formation gave, besides significant protection from pest attack, increased surface area of foliage, plant weight and number of pods.

Reports (Anon., 1976b) showed that phorate, solvirex, ekalux and dasanit enhanced the root length and weight of root and shoot in black gram.

Swaminathan and Prasad (1976) observed slightly increased shoot and root growth with carbofuran.

Green gram

Four doses of disulfoton i.e. 1.0, 1.5, 2.0 and 2.5 kg ai/ha applied in soil at the time of sowing proved very effective in increasing height of plants, number of leaves per plant, fresh and dry weight of plant, boldness and yield of grain (Chaudhary et al., 1981).

Beans

Allen (1947) observed that the action of DDT on bean plants closely resembled that of some plant hormones. He also reported that the effect of non-herbicidal concentration of 2, 4-D on the growth and development of bean plants were almost similar to response of beans to DDT treatment i.e. DDT acted as a growth promoting substance. Yield and quality of bean were increased by dimethoate and demeton-methyl sprayed @ 0.1, 1.2 and 0.66% at flowering (Judenko, 1971).

Horse bean and peas

Phorate, phosalone and disulfoton stimulated nodulation and growth of broad bean and pea besides giving good control of aphids, whitefly and mites (Adel-Salam et al., 1974).

Soyabean

Emulsion spray with methomyl and carbofuran at midbloom resulted in taller plants (Wheeler and Bass, 1971).

Beneficial effect on growth of soyabean was reported for systemic insecticides disulfoton, phorate, propoxner and carbofuran (Moody and Bailey, 1974a). They (1974b) also reported that furrow application of carbofuran, fensulfothion and a 1 : 1 mixture of fensulfothion and disulfoton at 1.82 lb ai/acre at sowing time increased the height of the lowest pods on the stem.

Cowpea

Visalakshi and Nair (1980) showed that phorate granules applied at the time of sowing of cowpea increased the height and total 'N' content of plants.

Phorate and disulfoton at 1.0 and 2 kg ai/ha, carbofuran at 0.5 and 1.0 kg ai/ha were found to increase plant height, number of branches, weight of shoot and root, length of tap root, number and dry weight of nodules and yield. The improvement in growth was attributed to the combined effect of pest control and stimulatory effect of the insecticides on plants (Nandakumar, 1981).

Vegetables

Bhendi

Krishnaswami (1954), Thirumalarao *et al.* (1964) and Navaneethan (1970) noted a stimulatory effect on the growth of bhendi due to DDT application.

Increased growth and yield of bhendi due to the application of disyston (Rawat and Sahu, 1973) and phorate granules (Saibhi *et al.*, 1975 and Murthy *et al.*, 1976) were observed.

Vigorous plant growth, early flowering, increased yields and higher soluble N, P, Ca and Mg were obtained from carbofuran treatment (Santhakumar *et al.*, 1975).

The influence of different insecticides on the ultimate yield of bhendi by their indirect effect on the growth of the plant was reported by Sharma (1979). Aldicarb and disulfoton at 2.0 kg ai/ha gave higher weight with more number of fruits.

Brinjal

DDT induced growth was noted on brinjal by Krishnaswami (1954) and Thirumala Rao *et al.* (1964).

Carbofuran granules at 6 kg ai/ha resulted in large size and greater number of fruits (Hussian and Nirula, 1975). Cytrolane, carbaryl, dimethoate and phorate at 1, 1.5, 2.0 kg ai/ha increased plant height and the number as well as weight of fruits (Kumaresan and Baskaran, 1975).

Tomato

DDT was the first insecticide reported to stimulate growth of tomato at a concentration of 0.008% applied 14 days after sowing (Chapman and Allen, 1948).

Reed (1964) observed increased fruit set and yield due to dieldrin application.

Hagley (1965) observed promoted root growth in tomato seedlings with 1.6 per cent emulsion of aldrin applied 21 days after sowing.

Potato

Schultz (1961) observed that phosphate triazine insecticide, guthion as 0.3% topical spray on red skinned potatoes increased yield above the levels that could be attributed to insect and disease control alone and this increase was attributed to a greater set of tubers.

Fruit trees

Studies on the effects of methyldemeton and dimethoate on some physiological processes in apple and plum revealed that these treatments increased the growth of shoots, leaf surface and chlorophyll content and the capacity to reduce water loss (Prints, 1968).

1.2 Persistent toxicity of insecticides to the different pests of rice

Soaking the roots of rice seedlings for 12-24 hours in 1000 ppm solution of carbofuran gave effective protection against whorl maggot *Hydrellia* sp. and BPH *N. lugens* (Stal), for 15 to 20 days after planting and *Nephotettix virescens* 40-50 days (Anon., 1971).

Thontadaraya and Prabhuswamy (1971) reported that phorate at 1.0 and 2 lb ai/acre persisted in rice plants for about 30 days after application of insecticide.

Carbofuran at 1.0 and 2.0 kg ai/ha gave 75-100% kill of adults of *Nephotettix virescens* 3 days after application like the other insecticides tested but remained effective for the longest period of 35 days (Kulshreshtha *et al.*, 1971).

Stem borer incidence was effectively controlled up to 20 days after transplanting with carbofuran applied at 0.2 kg ai/ha in the nursery (Anon., 1973).

Persistence was high in water, soil and rice plants during first 2 days when diazinon was applied at 30 kg/ha to water surface but declined sharply on 4th day and extremely low by 15th day (Takahashi and Masui, 1974).

Nagalingam ~~et al.~~ and Nair (1975) found that caterpillars fed on leaves collected from 10th day onwards after treatment with phorate showed complete mortality up to 14 days and by 15th day lost its effectiveness.

Carbofuran at 0.5 and 1 kg ai/ha applied 30 days after planting in the field gave maximum kill of 75-95% of BPH respectively during 1st week and decreased to 50% after two weeks of treatment (Mathai et al., 1976).

Rajukkannu et al. (1977) observed that phorate at 1.25 kg ai/ha degraded quickly but carbofuran at the same dose persisted in soil for more than 60 days.

Roots of rice seedling dipped in mud slurries containing 0.1% carbofuran gave 70 and 50% mortality of BPH nymphs when exposed on plants on 14 and 20 days after treatment respectively (Rao and Das, 1977).

Kono et al. (1978) found cartap with high insecticidal activity to persist in the seedling up to two weeks after treatment.

Mohandas et al. (1978) reported that water at field capacity level was conducive to a high level of insecticide absorption and for its prolonged persistence in the crop.

Carbofuran at 0.5 kg ai/ha in acidic rice soils dissipated to undetectable levels within 21 days after application but when applied within seven days after application of lime, considerable amount of insecticide persisted even after three weeks (Rajagopal _et al._, 1978).

Persistence of carbofuran (Rajukkannu, 1978 and 1981) and mephosfolan (Saivaraj _et al._, 1978) were more in field capacity level than in flooded conditions.

The uptake and persistence of carbofuran was higher than phorate when applied at 1.25 kg ai/ha with half life value in plants as 25-27 days and 13 days respectively (Rajukkanu _et al._, 1979).

Saivaraj _et al._ (1979) reported that mephosfolan applied at 0.75 kg ai/ha persisted for 30-40 days under flooded conditions.

Root zone application of carbofuran showed increased persistence than in paddy water broadcast application (Rajukkanu _et al._, 1980).

Koshiya _et al._ (1980) determined persistence and residual toxicity of some granular insecticides by applying them @ 1 kg ai/ha on standing water of the potted plants and found that carbofuran and isofenphos persisted for a longer period of time.

Among the granular formulations tested MIPC (Mipcin) gave 100% mortality of BPH up to 25 days after insecticide application. Carbofuran resulted in 100 per cent mortality only up to 6 days while with monocrotophos mortality of BPH decreased gradually from 3rd day after application (Venkataswamy and Kalode, 1980).

1.3 Residues of insecticides applied in paddy field occurring in grains at the time of harvest

Application of phorate at 2.0, 1.0 and 0.5 lb/acre in paddy fields at 50 to 60 days after planting caused residues of 4.0, 6.5 and 9.5 ppm respectively (Anon., 1971).

Rajukkannu *et al.* (1976) reported that phorate at 1.25 kg ai/ha applied to rice at 15 and 45 days after planting left residues of 0.07 and 0.08 ppm respectively in hulled grains, up to 0.15 ppm in straw and there was no detectable residue in bran. While soil application of carbofuran at the same dose resulted in 0.03 to 0.06 ppm of residues in grain it was not detectable in straw at harvest.

Carbofuran at 1.0 kg ai/ha applied twice showed 0.11 ppm residues in rice grain and the values were below the EPA tolerance limit up to five rounds of application (Anon., 1977).

Rajukkannu *et al.* (1977) found that soil application of carbofuran and phorate @ 1.25 kg ai/ha under flooded conditions in paddy fields showed 0.057 and 0.192 ppm residues in hulled grain and straw respectively.

Saivaraj and Venugopal (1977) reported that carbofuran at 0.75 and 1.0 kg ai/ha applied twice and thrice at 20 days interval commencing from 15 or 20 DAP left a residue of 0.04 and 0.11 to 0.18 ppm in grain and bran respectively for two rounds while for three rounds of application the residual levels were 0.1 to 0.15 for grain and 0.18 to 0.75 for bran. Mephosfolan at the same doses for two applications showed residues of 0.1 to 0.2 ppm in grain and 0.12 to 0.17 ppm in bran. But when applied thrice the residues amounted to 0.2 to 0.48 and 0.08 to 0.18 in grain and bran respectively.

Residue level of carbofuran in paddy grain and straw was 0.66 and 0.21 ppm respectively when applied at 1.25 kg ai/ha 20 days after transplanting while the residues of phorate at the same dose were 0.08 in grain and 0.15 ppm in straw (Rajukkannu and Krishnamoorthy, 1979).

Visalakshi *et al.* (1979) observed that carbofuran 0.5 kg ai/ha applied at boot leaf stage left non-detectable levels of the toxicant in grain and 0.35 to 0.47 ppm in straw and it was

0.62 to 0.81 and 1.0 to 1.44 ppm respectively for 1 kg ai/ha. For phorate at 1.25 kg ai/ha the residues were 0.24 to 0.34 in grain and straw but at 2.5 kg ai/ha the residues increased to 0.38 to 0.65 and 0.85 to 1.1 ppm respectively.

Materials and methods

MATERIALS AND METHODS

Field and pot trials were conducted at the College of Agriculture, Vellayani, to determine the phytotonic effect of four insecticides, carbofuran, phorate, monocrotophos and quinalphos on a short duration rice variety 'Triveni' during 1981-82.

2.1 Field trial to determine the phytotonic effect of insecticides

2.1.1 Raising the crop: The area selected was with facilities for controlled irrigation and drainage.

The cultivation practices recommended for short duration rice varieties in the Package of Practices of the Kerala Agricultural University (1982) were followed excluding plant protection measures.

Nursery plots of 1.2 x 1.2 m with 20 cm bunds and with separate irrigation and drainage channels were prepared. The sprouted seeds were sown.

In the main field, plots of 3.6 x 3.3 m were laid and the plots in a block were separated with bunds 30 cm wide and the blocks were separated with bunds of 70 cm width. Randomised block design was adopted for the lay out and each treatment was replicated thrice. Twenty one day old seedlings were transplanted in the main field with three seedlings per hill and in lines with a spacing of 15 x 10 cm. After transplanting controlled irrigation and drainage were done as and when required.

2.1.2 Treatment Following treatments were given in the three experiments laid out separately.

(a) Treatment in nursery 15 days after sowing only (DAS)

Carbofuran	0.5	and	4.0	kg ai/ha
Phorate	1.25	and	10.0	,,
Monocrotophos	0.25	and	2.0	,,
Quinalphos	0.25	and	2.0	,,
Control	No treatment			

(b) Treatment in main field 21 days after planting only (DAP)

Carbofuran	0.5	and	1.0	kg ai/ha
Phorate	1.25	and	2.5	,,
Monocrotophos	0.25	and	2.0	,,
Quinalphos	0.25	and	2.0	,,
Control	No treatment			

(c) Treatments in nursery 15 days after sowing (DAS) and in main field 21 day after planting (DAP)

Carbofuran	0.5	and	0.5	kg ai/ha
,,	0.5	and	1.0	,,
,,	4.0	and	0.5	,,
,,	4.0	and	1.0	,,

Phorate	1.25	and	1.25	kg ai/ha
,,	1.25	and	2.5	,,
,,	10.0	and	1.25	,,
,,	10.0	and	2.5	,,
Monocrotophos	0.25	and	0.25	kg ai/ha
,,	0.25	and	2.0	,,
,,	2.0	and	0.25	,,
,,	2.0	and	2.0	,,
Quinalphos	0.25	and	0.25	,,
,,	0.25	and	2.0	,,
,,	2.0	and	0.25	,,
,,	2.0	and	2.0	,,
Control	No treatment			

Prior to the insecticidal application the plots were completely drained out and were again irrigated two days after the treatment. The granular insecticides were mixed with equal weight of dry sand for uniform distribution. Spraying was done with a pneumatic knapsack sprayer using 500 l of spray fluid per hectare.

.3 Assessment of results

.1 Yield contributing characters

(a) Height of plant: Plant height was recorded at weekly intervals after the application of insecticides and the observation was continued up to the 12 days prior to harvest. The height recorded was the measure from the base of the stalk to the tip of the longest leaf or to that of the earhead whichever was higher. Four plants were marked as observational plants in each plot. Height of these plants and two other plants chosen at random during each observation was noted. From the data mean height per plant was calculated.

(b) Leaf area index : Leaf area was recorded at 15 day intervals after insecticidal application in main field. Four sample hills were selected for each observation. The maximum width (w) and length (l) of all the leaves of the middle tillers in each hill were noted and leaf area per tiller was worked out using the formula, leaf area (LA) = k x l x w, where k is an adjustment factor 0.75. Leaf area per hill was taken as total leaf area of middle tiller x total number of tillers. Leaf area index (LAI) was the sum of leaf area of 4 sample hills / area of land covered by four hills.

(c) Root length : Six plants from each plot were uprooted and the length of the longest root in each plant was recorded and the average was computed.

(d) Number of tillers / sq m : The tillers from observational plants were counted at 15 day intervals after application of insecticides and values per sq m were computed.

(e) Weight of shoot and root : The shoot and roots were separated and dried in an oven at 70-80°C till attaining constant weight. This was done in the field experiment alone 36 and 51 days after planting.

(f) Productive tillers / sq m : Number of productive tillers from the observational plants were counted before harvest and the value per sq m was computed.

(g) Weight of panicle : The average weight of panicle was determined by dividing the total weight from the clump by the number of tillers.

(h) 1000 grain weight : Thousand grains were counted from the winnowed and cleaned produce from each plot and were weighed.

2.1.3.2 Grain yield : The grain harvested from each plot was dried, cleaned, winnowed and weighed. From this, yield of grain per hectare was computed.

2.1.3.3 Pest infestation : The pest count was taken at 20, 28, 38 and 48 days after planting. The various parameters used for assessing incidence of different pests are given below.

(a) Leaf folder (*Cnaphalocrocis medinalis* Guen.)

The incidence was assessed in terms of the number of infested leaves. The total number of leaves (both damaged and undamaged) was recorded from six randomly selected hills and the percentage of damaged was calculated.

(b) Gall fly Orseolia oryzae (WM) Mani

One square metre plot was randomly fixed in each treatment plot by throwing a square metre frame. The number of infested hills, damaged tillers and total number of tillers in damaged hill were observed. Then the percentage incidence was evaluated as number of damaged hills in the sample x number of damaged tillers x 100 / total number of hills in the sample x total number of tillers in infested hills.

(c) Rice bug (*Leptocorisa acuta*)

Incidence was recorded by standard net sweeps. Three 180^{o} sweeps were made by diagonally crossing the plot. Mean of the sweeps was worked out and the same was recorded as the population of the pest per plot.

(d) Red spotted ear head bug (*Menida histrio*)

Net sweeps were made for recording the bug population. Mean of the catch in three sweeps per plot was worked out.

2.2 Determination of phytotonic effect of insecticides prepared from technical materials and those of commercial formulations on rice

2.2.1 Raising the crop

Medium sized flower pots (20 cm x 18 cm) were filled with soil collected from rice fields and 21 day old seedlings were planted @ 3 seedlings per pot. For the first experiment sprouted seeds were sown and the plants were later thinned to retain three numbers per pot. Adequate number of pots for treatments each with three replications were raised.

2.2.2 Treatment : The treatments given in the field experiment were given in the potted plants also. The emulsions prepared from emulsion concentrates and those prepared from technical grades of the insecticides, using benzene as solvent and triton 100x as emulsifier, were sprayed on the plants using an atomiser. Uniform quantity was sprayed in all treatments. The required quantities of granules were mixed with dry sand and uniformly distributed in the pots.

2.2.3 Assessment of results : Assessment of the growth and yield parameters was done as described under field trial.

2.3 Determination of persistent toxicity of different insecticides

This was done using third instar nymphs of brown plant hopper, *Nilaparvata lugens* (Stal) as test insect.

2.3.1 Raising the crop : The crop was raised in pots as described earlier. Adequate number of plants for all treatments each with three replications were maintained.

2.3.2 Treatment : Treatments were given as mentioned under 2.1.2 (b).

2.3.3 Exposure of test insects : Fifteen numbers of third instar nymphs of *Nilaparvata lugens* collected with an aspirator from a culture maintained in the laboratory were confined to the stem portions of the treated plants after removing the leaves and covering the same with a chimney. The open end of the chimney was covered with muslin cloth. Insects were thus released at the end of 1, 2, 3, 5 and 7 days after application of insecticides. The mortality was recorded 24 hours after the exposure, treating the morbid ones also as dead.

2.3.4 Assessment of persistent toxicity

The persistent toxicity of the insecticides to *N. lugens* was calculated in terms of PT indices following the methods of Pradhan (1967) where P is the period up to which the toxicity persisted and T is the average toxicity i.e. the sum of percentages of mortality / number of observations.

2.4 Estimation of residues of insecticides in paddy grains at harvest

2.4.1 Carbofuran

Carbofuran residue in paddy grains was estimated by colorimetric procedure described by Gupta and Dewan (1973).

Acid hydrolysis followed by solvent extraction

The principle of this method is to convert conjugated forms of carbofuran in grain sample into glucoside form using hot acid digestion.

Twenty five grammes each of grain samples were taken in 500 ml conical flasks and 250 ml of 0.25 N hydrochloric acid was added (Cook *et al.*, 1969). Using air condenser these were refluxed on water bath for an hour. The contents were then filtered through glass wool over cotton and using hot 0.25 N HCl, the volume was made up to 250 ml.

The hydrochloric acid extract was then transferred to 500 ml separating funnel. Fifty ml of dichloromethane and six drops of 4% sodium lauryl sulphate were added to the extract, shaken well for two minutes and then allowed to stand for some time. The dichloromethane layer was drawn out and filtered through anhydrous sodium sulphate so as to remove the water content if any. This procedure was repeated thrice for each sample and the filtered extract was made up to 100 ml and stored in refrigerator.

Acetonitrile-hydrocarbon partition technique

The method described by Jones and Riddick (1952) was used for the removal of fatty materials from the extract prepared above.

The extract from each sample (100 ml) was concentrated in a Kudorna Danish Evaporator. To this 50 ml acetonitrile was added and evaporation continued. Then the solution was transferred quantitatively into a 250 ml separating funnel and extracted twice with 30 ml each of hexane saturated with acetonitrile. Discarding the hexane layers, the acetonitrile portion was concentrated to about five ml and again taken in 250 ml separating funnel. To this 100 ml, 0.25 N hydrochloric acid was added and this aqueous phase extracted thrice with 50, 25 and 25 ml each of dichloromethane. These dichloromethane layers were passed through anhydrous sodium sulphate and volume made up to 100 ml.

Clean-up

Twenty ml aliquot of the dichloromethane extract was taken in a test tube, shaken well with activated charcoal and filtered through Whatman No. 1 filter paper. Using a manifold dry air evaporator, 10 ml of the filtrate was evaporated to dryness. Thirty ml methanol was used to rinse the sides of the test tube and seven ml freshly prepared coagulating solution was added to it. The content was allowed to stand for 10 minutes with occasional shaking and finally filtered through Whatman No. 42 filter paper.

Determination of residue

The filtrate was further processed by pipotting five ml samples each into a 25 ml stoppered test tubes and were placed in ice bath kept below 4°C. Two ml of 1.5 N methanolic KOH was added to the solution, mixed well and then allowed to stand for five minutes. One ml of cold chromogenic reagent (prepared by mixing thoroughly 25 ml of cold ethyl alcohol and 2 ml of glacial acetic acid with 25 mg of p-nitrobenzene diazonium fluoroborate for two minutes and filtered through Whatman No. 1 filter paper) was added, well shaken and placed in the ice bath for two minutes. Then the colour was read at 550 mμ wave length in a Spectronic-20 spectrophotometer.

Calculation of the residue

The quantity of the insecticide residue in the extract was calculated by refering to the regression equation worked out for different concentrations of carbofuran, against their optical densities $y = 0.0929x - 0.0452$.

4.2 Phorate, Monocrotophos and Quinalphos

The residues of these O P compounds were estimated by following the procedure of Getz and Watts (1964).

Twenty five gram each of grain samples were ground and taken in a 250 ml flask excepting quinalphos where grains as such were taken. To this 40 ml of chloroform was added and placed in a shaker for 30 minutes and filtered through anhydrous sodium sulphate. The extraction procedure was repeated thrice each with 25 ml lots of chloroform. These extracts were combined and concentrated to almost dryness.

Clean-up

Twentyfive ml chloroform was used to rinse the tubes and then passed through a two cm column containing four cm layer of anhydrous sodium sulphate and five gram adsorbant mixture over cotton. The aliquot was collected in 100 ml reagent bottles. The clean-up was continued thrice each with 25 ml chloroform and finally the aliquot was made up to 100 ml and stored in the refrigerator.

Estimation of residues

To 25 ml aliquot each taken in B_{19} test tubes a drop of propylene glycol was added and concentrated in Kuderna Danish evaporator.

To the concentrated aliquot 0.4 ml each of benzyl pyridine and cyclohexylamine solutions were added and the tubes were placed in oil bath for three minutes at 180°C fitted with air condenser. The tubes were then cooled in an ice bath for one minute; three ml ethyl acetate was added to each tube and the colour was read at 540 m/u in a Spectronic-20 spectrophotometer.

Calculations were done as mentioned earlier. Regression equations worked out were, for phorate $y = 0.156x - 0.0402$, for monocrotophos $y = 0.0305x - 0.0091$ and for quinalphos $y = 0.010x + 0.0707$.

2.4.3 Bio assay of insecticide residues in grains

The residues of all the four insecticides were estimated biologically using one day old adults of *Drosophila melanogaster*. The extracts for colorimetric assay were used for bio assay also. One ml each of the extract was taken in rimless bio assay tubes (20 cm x 2.5 cm) and they were gently rotated to spread the solution on the inner surface to get an uniform deposit. The test insects were released into the tubes and kept at 27 ± 1°C. The mortality was noted after 24 hours and was corrected for control mortality using Abbot's formula. The data were subjected to Probit analysis using the method of Finney (1964) and the regression equations worked out as follows :

carbofuran	$y = 0.00075x + 4.2491$
phorate	$y = 0.00597x + 3.6629$
monocrotophos	$y = 0.0096x + 3.8947$
quinalphos	$y = 1.633x + 1.774$

The residues in the sample extracts were determined from the regression equations based on mortality of the test insect.

Results

RESULTS

Effect of treating different growth stages of rice plants with various insecticides on the yield

The yield data relating to the various experiments are presented in Table 1, Appendix 1 and Fig. 1. All the treatments except monocrotophos 2.0 kg ai/ha and quinalphos 2.0 kg ai/ha gave yield significantly higher than that of control, when applied at 15 days after sowing. In the field trial using commercial formulations the maximum yield was obtained in plots treated with carbofuran @ 0.5 and 4.0 kg ai/ha, the difference between the two doses being statistically insignificant. The yields in those plots were 147.2 and 142.4 per cent of the yield in control. The two doses of phorate also gave high yields of 135.7 and 132.7 per cent of the yield in control, the difference between the yields of these plots being insignificant and also on par with the yield in plots treated with carbofuran @ 4.0 kg ai/ha. The lower doses of quinalphos and monocrotophos were also superior to control while the higher doses of those insecticides gave yields on par with control only. In the initial stages following the application of higher doses of monocrotophos and quinalphos the plants showed symptoms of toxicity though in later stages they recovered.

In the pot culture experiment also the yield in plants treated with quinalphos and monocrotophos @ 2 kg ai/ha was

Table 1. Effect of treating different growth stages of rice plants with various insecticides on the yield of the crop

Treatments			Percentage increase in yield over control when					
			treated at 15 DAS			treated at 21 DAP		
			In potted plants		In field	In potted plants		In field
			A	B	B	A	B	B
Carbofuran	0.5	kg ai/ha	135.89	137.88	147.20	145.50	139.70	119.80
,,	*4.0	,,	122.58	124.81	142.40	169.60	170.80	142.20
Phorate	1.25	,,	119.51	120.45	132.70	143.10	120.50	132.70
,,	*10.0	,,	128.56	130.56	135.70	168.90	153.40	134.40
Monocrotophos	0.25	,,	123.64	125.97	122.00	120.20	121.40	122.20
,,	2.0	,,	110.22	108.56	105.30	170.30	141.70	131.30
Quinalphos	0.25	,,	122.84	124.54	122.60	156.20	132.80	128.00
,,	2.0	,,	112.78	107.78	108.30	140.70	144.50	130.70
Control			100.00	100.00	100.00	100.00	100.00	100.00
C.D.			14.94	13.31	11.26	49.93	35.58	17.49

DAS : Days after sowing DAP : Days after planting

A : Formulated from technical grades B : Commercial formulations

* At 21 DAP carbofuran and phorate were applied at 1 and 2.5 kg ai/ha respectively

Fig. 1. Effect of treating different growth stages of rice plants with various insecticides on the yield of the crop

A - Treatment in nursery only (15 DAS)

		kg ai/ha
1	Carbofuran	0.5
2	,,	4.0
3	Phorate	1.25
4	,,	10.0
5	Monocrotophos	0.25
6	,,	2.0
7	Quinalphos	0.25
8	,,	2.0

B - Treatment in main field only (21 DAP)

		kg ai/ha
1	Carbofuran	0.5
2	,,	1.0
3	Phorate	1.25
4	,,	2.5
5	Monocrotophos	0.25
6	,,	2.0
7	Quinalphos	0.25
8	,,	2.0

C - Treatment in nursery (15 DAS) and mainfield (21 DAP) with

1	Carbofuran	0.5	kg ai/ha and	0.5	kg ai/ha	respectively
2	,,	0.5	,,	1.0	,,	,,
3	,,	4.0	,,	0.5	,,	,,
4	,,	4.0	,,	1.0	,,	,,
5	Phorate	1.25	,,	1.25	,,	,,
6	,,	1.25	,,	2.5	,,	,,
7	,,	10.0	,,	1.25	,,	,,
8	,,	10.0	,,	2.5	,,	,,
9	Monocrotophos	0.25	,,	0.25	,,	,,
10	,,	0.25	,,	2.0	,,	,,
11	,,	2.0	,,	0.25	,,	,,
12	,,	2.0	,,	2.0	,,	,,
13	Quinalphos	0.25	,,	0.25	,,	,,
14	,,	0.25	,,	2.0	,,	,,
15	,,	2.0	,,	0.25	,,	,,
16	,,	2.0	,,	2.0	,,	,,

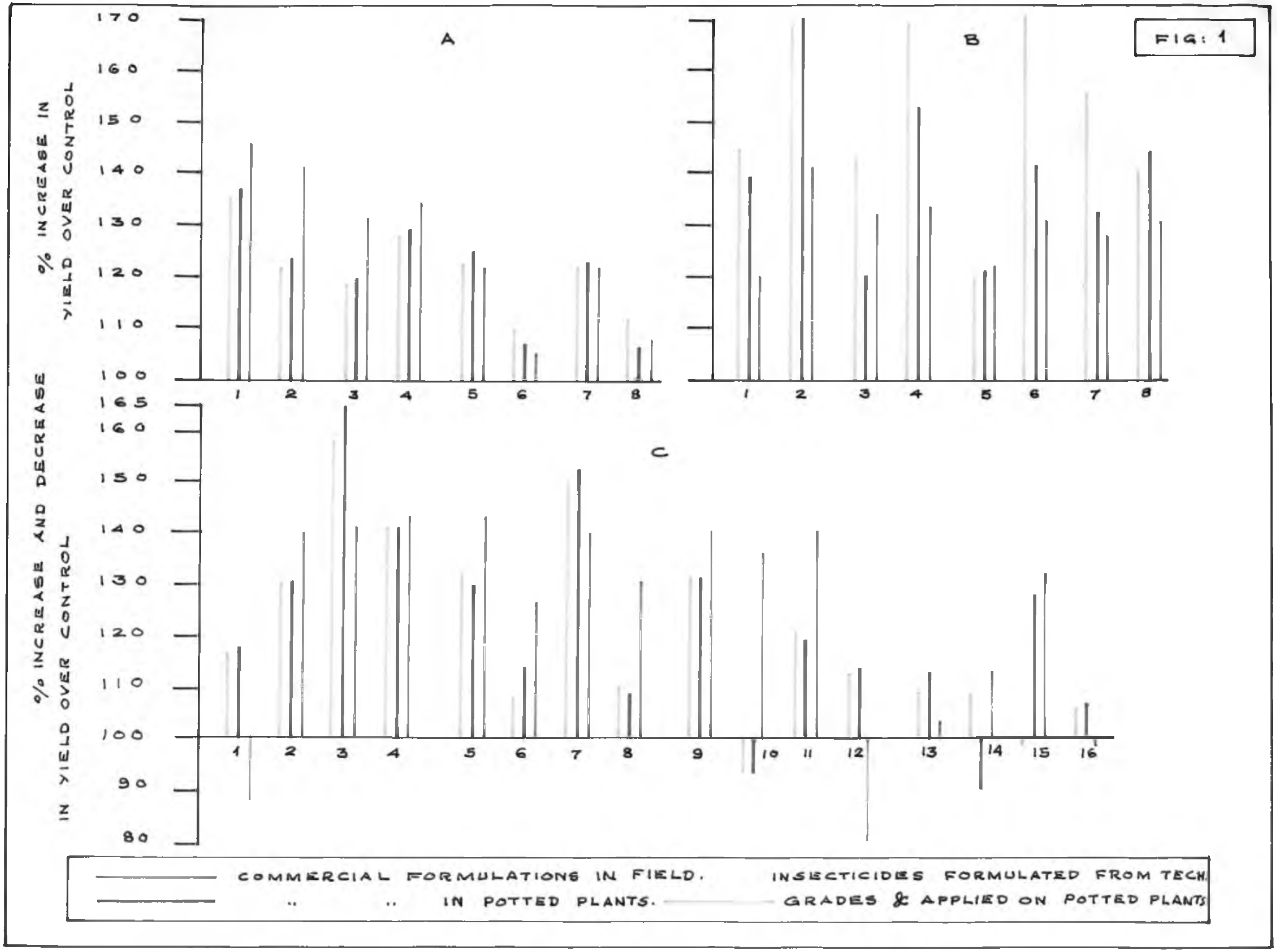


FIG: 1
A
B
C
% INCREASE IN YIELD OVER CONTROL
% INCREASE AND DECREASE IN YIELD OVER CONTROL
170
160
150
140
130
120
110
100
165
90
80
1 2 3 4 5 6 7 8
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
COMMERCIAL FORMULATIONS IN FIELD.
" " IN POTTED PLANTS.
INSECTICIDES FORMULATED FROM TECH. GRADES & APPLIED ON POTTED PLANTS

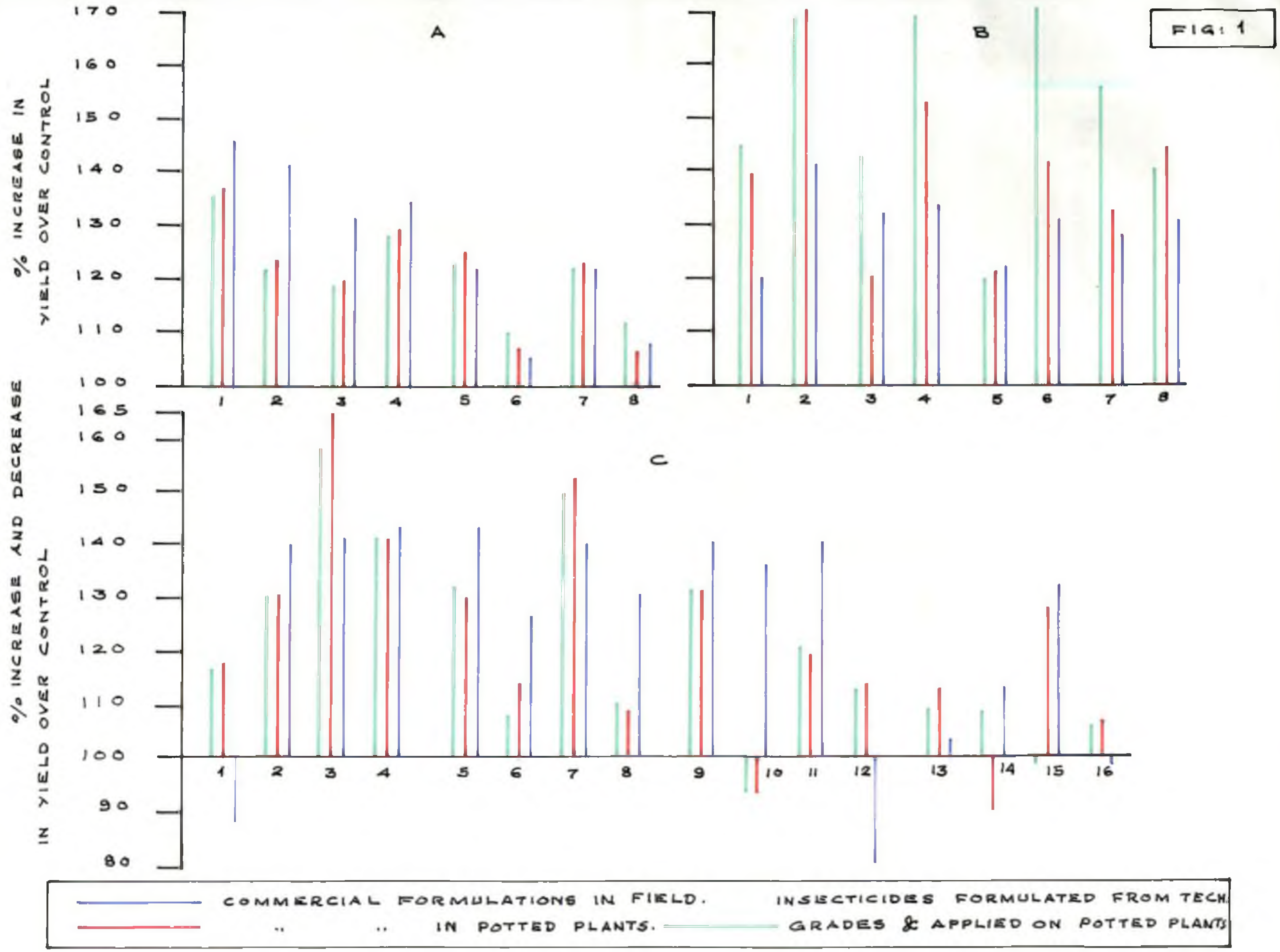

% INCREASE IN YIELD OVER CONTROL
% INCREASE AND DECREASE IN YIELD OVER CONTROL
A
B
C
COMMERCIAL FORMULATIONS IN FIELD.
" " IN POTTED PLANTS.
INSECTICIDES FORMULATED FROM TECH. GRADES & APPLIED ON POTTED PLANTS

FIG: 1

on par with that of control. The plants treated with phorate 1.25 kg ai/ha yielded higher than the control plants. The plants treated with carbofuran commercial formulation gave 137.9 per cent of the yield in control and it was followed by phorate 10 kg ai/ha, monocrotophos 0.25 kg ai/ha, carbofuran 4.0 kg ai/ha and quinalphos 0.25 kg ai/ha the yield in these treatments being 130.6, 126, 124.8 and 124.5 per cent of that of control. The yields in the treatments were not varying significantly. The increase in yield observed in plants treated with insecticides formulated from technical grades also showed the same trend as commercial formulations. Carbofuran 0.5 kg ai/ha was found to be the best and it was followed by phorate 10 kg ai/ha, monocrotophos 0.25 kg ai/ha, quinalphos 0.25 kg ai/ha and carbofuran 4.0 kg ai/ha, the yield in these treatments being in the range of 135.9 to 122.6 per cent of that of control and there being no significant difference among the treatments. Phorate 1.25 kg ai/ha was superior to control. The higher doses of monocrotophos and quinalphos showed slight phytotoxic symptoms and though the yields in the treatments were slightly higher than that of control they were on par statistically. The effect of the insecticides formulated from technical grades and corresponding doses of commercial formulations did not vary significantly.

In the second experiment in which the insecticidal treatment was given 21 days after planting in main field, all the treatments were found superior to control. Carbofuran 1 kg ai/ha gave the highest yield of 142 per cent of that of control and it was followed by phorate 2.5 kg ai/ha, phorate 0.25 kg ai/ha, monocrotophos 2.0 kg ai/ha, quinalphos 2 kg ai/ha, quinalphos 0.25 kg ai/ha, monocrotophos 0.25 kg ai/ha and carbofuran 0.5 kg ai/ha, the yield in the treatments being 134.4, 132.7, 131.3, 130.7, 128.0, 122.2 and 119.8 per cent of that of control. In the potted plants in which the commercial formulations were applied, the increase in yields due to the treatments were relatively higher than those obtained from corresponding treatments in the field. In pots it ranged from 170.8 to 120.2 per cent of that of control while in field the range was 142 to 119.8 per cent. The formulations prepared from technical grades and applied on potted plants performed on par with the commercial formulations. The formulations of monocrotophos prepared from technical grades ranked top in yield while in the case of the commercial formulations of the pesticide used in pot as well as field experiments yielded less than carbofuran and phorate.

The effect of treating nursery at 15 DAS and the main field at 21 DAP in different dose combinations shown in Table 2 revealed that quinalphos @ 2.0 and 0.25 kg ai/ha (in nursery and main

Table 1 Contd.
Effect of treating different growth stages of rice plants with various insecticides on the yield of the crop

Treatments				Percentage increase/decrease in yield over control when		
				treated at 15 DAS and 21 DAP		at
				In potted plants		In field
				A	B	B
Carbofuran	0.5 +	0.5	kg ai/ha	117.3	118.0	88.6
,,	0.5 +	1.0	,,	130.1	131.4	139.7
,,	4.0 +	0.5	,,	157.9	164.9	140.8
,,	4.0 +	1.0	,,	141.3	141.5	143.4
Phorate	1.25 +	1.25	,,	132.6	129.8	143.3
,,	1.25 +	2.5	,,	107.7	114.0	126.9
,,	10.0 +	1.25	,,	149.3	152.8	139.7
,,	10.0 +	2.5	,,	110.2	109.5	130.9
Monocrotophos	0.25 +	0.25	,,	131.8	132.1	140.2
,,	0.25 +	2.0	,,	94.8	92.8	135.7
,,	2.0 +	0.25	,,	121.3	120.1	140.5
,,	2.0 +	2.0	,,	113.4	114.4	79.8
Quinalphos	0.25 +	0.25	,,	109.6	113.3	102.9
,,	0.25 +	2.0	,,	109.7	89.4	113.0
,,	2.0 +	0.25	,,	98.6	127.9	132.0
,,	2.0 +	2.0	,,	106.6	107.2	98.0
Control				100.0	100.0	100.0
C.D.				13.53	13.97	22.34

DAS : Days after sowing　　DAP : Days after planting

A : Formulated from technical grades　　B : Commercial formulations field respectively), quinalphos 0.25 and 2.0 kg ai/ha, quinalphos 0.25 and 0.25 kg ai/ha, carbofuran 0.5 and 0.5 kg ai/ha and monocrotophos 0.25 and 2.0 kg ai/ha yielded on par with control. The yields in all other treatments were superior to control and on par among themselves, the increase over control being in the range of 126.9 to 143.4 per cent.

The commercial formulations and formulated technical grades applied in potted plants did not cause significant variations in yield. All the treatment combinations of quinalphos except 2.0 and 0.25 kg ai/ha (in nursery and main field), phorate 1.25 and 1.25 kg ai/ha as well as 10 and 1.25 kg ai/ha, monocrotophos 0.25 and 0.25 kg ai/ha as well as 2.0 and 0.25 kg ai/ha gave yields on par with that of control. Quinalphos at 2 and 2 kg ai/ha gave significantly higher yield than control as a commercial formulation while in the laboratory formulation from technical grade it came on par with control. Carbofuran and phorate applied in higher doses in nursery and lower doses in main field gave the highest yield, the difference between the two levels of insecticide treatment being statistically insignificant.

<u>Effect of treating rice crop with various insecticides on height of the plants</u>

Table 2 gives the data relating to the height of plants observed in various experiments and the details of statistical

Table 2. Effect of treating different growth insecticides on the mean height (cm)

Treatments			Plants treated at		
			7 DAP		
			A	B	C
Carbofuran	0.5	kg ai/ha	45.3	44.0	26.0
,,	4.0	,,	36.3	41.0	25.3
Phorate	1.25	,,	41.0	41.0	24.7
,,	10.0	,,	44.0	45.3	26.3
Monocrotophos	0.25	,,	42.0	40.0	25.4
,,	2.0	,,	38.3	37.3	25.2
Quinalphos	0.25	,,	38.7	42.3	23.5
,,	2.0	,,	36.3	40.7	22.7
Control			40.0	40.0	25.0
C.D.			5.67	5.67	1.34

DAS : Days after sowing

DAP : Days after planting

NS : Not significant

stages of rice plants with various

15 DAS and observed at								
14 DAP			21 DAP			28 DAP		
A	B	C	A	B	C	A	B	C
55.0	55.3	44.2	67.0	66.7	58.5	78.7	74.0	64.3
48.3	52.7	40.0	57.3	61.0	54.8	71.3	72.0	63.2
48.3	47.7	41.9	53.3	62.3	57.3	70.0	70.7	59.3
50.7	53.0	44.9	57.3	68.7	61.8	72.0	73.0	65.1
56.0	51.0	44.7	65.0	63.0	60.0	74.0	70.3	62.6
52.3	47.0	43.8	62.3	60.3	56.4	72.0	69.3	60.3
49.3	54.0	35.8	62.7	63.0	57.5	73.7	74.0	63.7
48.0	55.3	34.7	58.7	57.3	56.5	70.3	71.0	59.8
44.0	44.0	35.9	50.3	50.3	51.8	63.3	63.3	56.6
5.48	5.48	4.82	6.93	6.93	NS	NS	NS	NS

A : Insecticides formulated from technical grades and applied on potted plants

B : Commercial formulations applied on potted plants

C : Commercial formulations applied in the field

analysis of the data are given in Appendix 2. The effect of treatment in nursery as seen from the mean height of plants in various treatments at 7 DAP revealed that in field the lower doses of pesticides were more stimulatory than the higher doses except in the case of phorate where the mean height in plots treated with the insecticide at 10 kg ai/ha was superior to those treated @ 1.25 kg ai/ha. Higher dose of phorate, both the doses of carbofuran and monocrotophos resulted in taller plants, the differences among the treatments being insignificant. In plots treated with lower doses of phorate and both doses of quinalphos, the plants were shorter than those of control. At 14 days after planting plots treated with the lower dose of phorate also came on par with the other effective treatments, the mean height of plants being in the range 40 to 44.9 cm. The height of the quinalphos treated plants was lower than those of control but they were not significantly different. At 21 DAP the plants treated with the higher dose of phorate and lower doses of other insecticides were taller than those in the remaining treatments though the height of plants under the different treatments was not varying significantly. In treatments the mean height of plants ranged from 54.8 to 61.8 cm against the height of the control plant 51.8 cm. In the subsequent observations the height of plants in different treatments was not found varying significantly.

The commercial formulations tried in pot culture experiments showed that at 7 DAP plants treated with phorate, quinalphos and carbofuran were taller than those in control while monocrotophos at the two doses retained the plants on par with control. At 14 DAP quinalphos, which did not give significant effect on plant height in the field experiment retained a higher rank in the pot culture experiment. But at 21 DAP phorate 10 kg ai/ha, carbofuran 0.5 kg ai/ha, monocrotophos 0.25 kg ai/ha, quinalphos 0.25 kg ai/ha and phorate 1.25 kg ai/ha were found to give taller plants, the mean height of plants in these treatments being in the range of 68.7 to 62.3 cm and on par. The remaining treatments were also superior to control. The mean height of plants in pots treated with the commercial formulations of insecticides and the formulations prepared from technical grades did not vary significantly, the range being 45.3 to 36.3, 56 to 48 and 67 to 53 cm for technical grades on 7, 14 and 21 DAS while the ranges of heights for commercial formulations were 45.3 to 37.3, 55.3 to 47 and 68.7 to 57.3 cm respectively on the corresponding dates. In subsequent observations plants treated with the insecticides were seen taller than those in control but the data were not significantly varying. As seen in the field experiment the formulations prepared from technical grades of monocrotophos, carbofuran and phorate also were found to stimulate plant height more than quinalphos.

The second experiment in which the insecticides were applied at 21 days after transplanting in the field (Table 2) the plant height showed significant variation at 49 DAP and 56 DAP. In the first observation at 28 DAP the plant height in control was 58.3 cm while in treated plots it varied from 62.1 to 65 cm. But the variations were not statistically significant. At 35 DAP mean plant height in control plots was 66.5 cm while in treated plots it ranged from 68.6 to 73.6 cm and the variations were not statistically significant. At 42 DAP the control plants recorded a mean height of 75.1 cm while in treated plots the mean height ranged from 77.2 to 81.2 cm. But this data also did not vary significantly. At 49 DAP the data showed significant variations among treatments. Quinalphos at 2 kg ai/ha maintained the plant height on par with control while all other treatments were superior to control. Carbofuran 0.5 kg ai/ha gave the maximum plant height of 90.4 cm and it was followed by phorate 2.5 kg ai/ha, carbofuran 1 kg ai/ha, monocrotophos 0.25 kg ai/ha, phorate 1.25 kg ai/ha, monocrotophos 2.0 kg ai/ha, there being no significant variation among the treatments. The lower dose of quinalphos was on par with the above treatments except carbofuran 0.5 kg ai/ha which remained significantly superior to monocrotophos. At 56 DAP also the plant height in various plots showed significant differences. Treatments found superior on 49 DAP retained

Table 2. Contd.

Effect of treating different growth on the mean height (cm)

Treatments			Plants treated at 21 DAP					
			28 DAP			35 DAP		
			A	B	C	A	B	C
Carbofuran	0.5	kg ai/ha	63.0	64.3	65.0	67.0	68.3	73.6
,,	1.0	,,	65.3	67.0	64.0	72.0	71.3	70.4
Phorate	1.25	,,	61.3	61.0	62.0	66.7	67.0	69.5
,,	2.5	,,	64.0	65.3	64.6	70.0	70.7	70.8
Monocrotophos	0.25	,,	60.3	60.0	62.1	64.7	64.0	71.0
,,	2.0	,,	62.0	62.6	62.0	68.3	67.7	70.0
Quinalphos	0.25	,,	59.7	60.7	63.7	63.3	64.3	73.2
,,	2.0	,,	62.3	63.0	62.1	68.0	69.3	68.6
Control			58.0	58.0	58.3	62.7	62.7	66.5
C.D.			NS	NS	NS	4.67	4.67	NS

A : Insecticides formulated from technical grades and applied on potted plants

B : Commercial formulations applied on potted plants

C : Commercial formulations applied in the field

stages of rice plants with various insecticides

and observed at											
42 DAP			49 DAP			56 DAP			63 DAP		
A	B	C	A	B	C	A	B	C	A	B	C
70.0	74.0	81.2	78.7	79.7	90.4	79.6	81.6	91.6	81.0	83.3	-
76.0	78.0	78.6	82.3	81.7	88.8	84.3	84.3	89.1	85.0	86.0	-
73.6	73.0	78.9	79.3	79.6	87.6	80.7	80.3	87.8	81.3	81.0	-
75.3	75.0	78.9	81.0	81.0	88.9	82.7	83.0	89.7	83.3	84.0	-
71.0	70.0	76.7	75.7	75.0	87.8	77.6	76.3	88.3	79.0	78.7	-
73.7	73.0	75.9	78.3	78.0	87.5	79.3	79.3	88.1	80.0	80.3	-
70.0	70.0	82.3	74.0	75.3	86.3	76.3	77.0	86.9	77.0	78.0	-
72.3	73.0	77.2	76.7	77.7	83.1	78.3	79.0	83.7	78.7	79.7	-
67.0	67.0	75.1	72.0	72.0	81.7	72.3	72.3	82.3	75.0	75.0	
4.62	4.62	NS	4.57	4.57	3.96	4.64	4.64	4.04	4.44	4.44	-

DAP : Days after planting

NS : Not significant

the same superiority on 56 DAP also. The lower and higher doses of the pesticides did not induce the plant height with significant differences.

The commercial formulations applied in potted plants had caused significant variations in plant heights as observed at different periods after application. Unlike in field experiment carbofuran at the higher dose of 1 kg ai/ha produced the maximum plant height in pots though it was on par with the lower dose of 0.5 kg ai/ha in all the observations. At 35 DAP the plant height in pots treated with carbofuran showed the highest plant height of 71.3 cm and it was followed by phorate 2.5 kg ai/ha, quinalphos 2 kg ai/ha, carbofuran 0.5 kg ai/ha, monocrotophos 2 kg ai/ha and phorate 1.25 kg ai/ha, the mean plant height in these treatments ranged from 70.7 to 67.0 cm and they were on par. Quinalphos 0.25 kg ai/ha and monocrotophos 0.25 kg ai/ha were on par with control and also on par with the lower dose of phorate. In pots the higher doses of monocrotophos and quinalphos gave a higher stimulation of plant height while in field the lower doses of the toxicant were found more stimulatory. In general the two insecticides induced less on plant height when compared to carbofuran and phorate. In the two doses tried commercial formulations of the insecticides and the formulations made from technical grades of the same did not induce significant differences in the height of the plants.

In the third experiment the plants were treated in nursery and main field at different dose combinations. The data showed (Table 2) that the height of the plants observed at different occasions after treatment had significant variations in the case of field experiment. In all the observations the application of insecticides at the lower dose in nursery 15 DAS and followed by the same dose in the main field at 21 DAP gave the maximum plant height. It was followed by the higher doses in nursery and main field, lower dose in nursery and higher dose in main field. The different dose combinations of monocrotophos did not cause significant variations in plant height observed at various occasions. Up to the 42 DAP the combinations of dissimilar doses in nursery and main field failed to exert any stimulatory effect on plant height since the mean height of plants in those treatments were on par with the corresponding controls. At 49 DAP plant height in all treatments except monocrotophos @ 2 and 2 kg ai/ha and quinalphos @ 2.0 and 0.25 kg ai/ha were significantly higher than in control and at 56 DAP the latter treatment alone remained on par with control. Comparison of the best dose combinations of various insecticides showed that the insecticides included in the present experiment were equally effective in inducing plant height. The commercial formulations applied in pots caused significant variations in height in the first

Table 2. Contd.

Effect of treating different growth stages on the mean height (cm)

Treatments				Plants treated at 15 DAS					
				28 DAP			35 DAP		
				A	B	C	A	B	C
Carbofuran	0.5	+ 0.5	kg ai/ha	81.3	83.0	79.5	84.3	85.0	84.6
,,	0.5	+ 1.0	,,	70.0	74.0	70.4	78.0	80.0	75.7
,,	4.0	+ 0.5	,,	76.0	76.0	73.6	84.0	78.3	76.5
,,	4.0	+ 1.0	,,	78.3	80.0	76.3	82.3	83.0	82.5
Phorate	1.25	+ 1.25	,,	79.0	75.0	78.4	83.7	84.3	86.9
,,	1.25	+ 2.5	,,	73.6	75.0	69.7	79.7	82.3	73.6
,,	10.0	+ 1.25	,,	77.0	79.7	72.9	83.7	84.0	77.5
,,	10.0	+ 2.5	,,	73.7	73.3	76.3	83.0	83.3	82.2
Monocrotophos	0.25	+ 0.25	,,	75.0	74.3	79.1	82.7	81.0	84.8
,,	0.25	+ 2.0	,,	69.0	74.7	71.2	78.3	77.0	77.7
,,	2.0	+ 0.25	,,	67.7	70.0	71.4	75.3	75.3	77.2
,,	2.0	+ 2.0	,,	73.3	72.0	75.2	81.0	80.3	80.9
Quinalphos	0.25	+ 0.25	,,	73.0	74.0	79.4	83.7	81.7	84.0
,,	0.25	+ 2.0	,,	76.0	76.0	69.2	81.0	82.0	77.8
,,	2.0	+ 0.25	,,	75.3	75.0	68.7	79.7	80.0	73.3
,,	2.0	+ 2.0	,,	72.0	72.7	77.9	80.3	81.0	83.6
Control				68.7	68.7	69.4	76.2	76.2	75.4
C.D.				6.32	6.32	5.17	NS	NS	6.55

A : Insecticides formulated from technical grades and applied on potted plants

B : Commercial formulations applied on potted plants

C : Commercial formulations applied in the field

of rice plants with various insecticides

and 21 DAP and observed at											
42 DAP			49 DAP			56 DAP			63 DAP		
A	B	C	A	B	C	A	B	C	A	B	C
86.3	89.7	94.1	93.3	96.0	96.3	97.0	98.7	97.0	98.0	99.0	-
86.0	87.3	87.4	92.0	93.0	90.7	95.0	95.7	90.7	95.7	95.7	-
90.0	92.0	87.8	95.0	96.7	94.4	96.3	98.7	94.8	97.0	99.0	-
83.7	85.3	91.5	92.0	94.0	94.5	95.3	96.0	94.7	96.7	96.3	-
85.3	88.7	88.7	92.3	95.0	94.4	95.0	96.3	94.8	95.7	97.0	-
84.7	87.7	83.7	88.0	91.0	90.1	91.0	93.7	90.4	92.3	94.0	-
89.7	91.3	84.6	93.0	94.0	90.8	95.3	97.0	91.2	96.0	97.7	-
84.3	86.0	89.0	89.0	92.7	91.5	94.0	95.0	91.6	95.0	95.3	-
84.0	85.7	91.4	92.7	91.3	92.1	96.0	94.0	93.7	97.0	95.3	-
85.3	84.0	86.0	91.0	91.3	91.5	93.7	93.3	91.0	94.3	94.0	-
84.0	84.3	85.6	89.0	86.0	90.3	90.3	90.0	90.4	90.7	93.7	-
84.0	84.0	88.2	91.7	90.0	89.6	94.7	93.0	91.0	95.0	93.3	-
86.0	85.0	91.0	92.0	92.0	93.6	91.3	92.7	92.6	91.7	93.0	-
85.0	88.6	84.9	92.0	94.0	90.8	93.0	94.7	91.0	94.3	95.0	-
83.0	85.0	78.7	88.3	89.3	85.8	90.7	91.3	86.1	91.0	90.0	-
84.3	84.0	90.2	87.0	88.0	91.9	89.7	90.0	92.1	89.66	91.0	-
82.3	82.3	82.9	85.0	85.0	85.4	87.3	87.3	86.4	87.6	87.6	-
NS	NS	5.01	NS	NS	4.47	NS	NS	3.43	6.33	6.33	-

DAS : Days after sowing
DAP : Days after planting
NS : Not significant

observation made on 28 DAP only. Carbofuran applied in nursery and main field at 0.5 and 1 kg ai/ha, phorate @ 10 and 2.5 kg ai/ha, monocrotophos at 0.25 and 0.25 kg ai/ha, 2 and 0.25 kg ai/ha and 2 and 2 kg ai/ha, quinalphos at 0.25 and 0.25 kg ai/ha and @ 2.0 and 2.0 kg ai/ha were on par with control with reference to the mean plant heights observed. Between the corresponding doses of each insecticide used as commercial formulation and as material formulated from technical grades no significant differences could be observed with reference to their effect on plant height observed at different intervals after treatment. Height of plants observed in various treatments in pot culture experiments at 35, 42, 49 and 56 DAP did not show significant variations among the treatments.

<u>The effect of treating rice crop at various growth stages with various insecticides on the leaf area indices</u>

The data relating to this character are presented in Table 3 and results of statistical analysis are presented in Appendix 3. The application of the insecticides in the nursery at 15 DAS did not induce significant variations in the leaf area of the crop in the main field as observed at intervals of 8, 23, 38 and 53 days after planting. In the pot culture experiment the leaf area indices showed significant variations in the treatments at 38 and 53 days after planting. At 38 DAP

Table 3. Effect of treating different growth stages on the leaf area index (LAI)

Treatments			Plants treated 8 DAP		
			A	B	C
Carbofuran	0.5	kg ai/ha	0.63	0.85	2.79
,,	4.0	,,	0.55	0.74	2.48
Phorate	1.25	,,	0.68	0.69	2.52
,,	10.0	,,	0.74	0.78	3.59
Monocrotophos	0.25	,,	0.69	0.62	2.94
,,	2.0	,,	0.58	0.48	2.82
Quinalphos	0.25	,,	0.65	0.77	2.83
,,	2.0	,,	0.63	0.56	2.70
Control			0.52	0.52	2.43
C.D.			NS	NS	NS

A : Insecticides formulated from technical grades and applied on potted plants

B : Commercial formulations applied on potted plants

C : Commercial formulations applied in the field

of rice plants with various insecticides

at 15 DAS and observed at								
23 DAP			38 DAP			53 DAP		
A	B	C	A	B	C	A	B	C
2.22	2.34	3.41	3.73	3.60	3.13	3.52	3.87	3.07
1.76	2.06	3.55	3.04	3.42	2.66	3.32	3.55	2.38
2.08	2.47	3.12	2.49	2.86	2.59	3.01	3.53	2.50
2.73	2.98	3.38	3.46	3.60	3.14	4.20	4.13	2.77
2.93	3.14	3.42	4.35	4.17	3.29	3.65	3.42	3.26
2.54	2.85	3.38	4.14	4.05	3.00	3.43	3.18	2.13
2.34	2.15	3.46	2.54	2.89	3.22	4.02	4.87	3.27
2.17	1.92	3.13	2.11	2.58	2.74	2.56	2.78	2.30
1.87	1.87	3.11	2.21	2.21	2.75	3.13	3.15	2.07
NS	NS	NS	0.22	0.22	NS	0.94	0.94	NS

DAS : Days after sowing
DAP : Days after planting
NS : Not significant

the leaf area index in plants treated with monocrotophos at the two doses were coming top, the differences between them being insignificant. It was followed by carbofuran 0.5 kg ai/ha, phorate 10.0 kg ai/ha and carbofuran 4.0 kg ai/ha, the differences among the treatments being insignificant. The two levels of quinalphos and the lower level of phorate were significantly inferior to the other treatments though they were superior to control. At 53 DAP the relative ranking of the pesticides on the basis of the LAI was in the following descending order quinalphos 0.25 kg ai/ha, phorate 10 kg ai/ha, carbofuran 0.5 kg ai/ha, carbofuran 4.0 kg ai/ha, phorate 1.25 kg ai/ha, monocrotophos 0.25 kg ai/ha. The plants treated with commercial formulations and laboratory formulated technical materials did not show any significant differences in LAI. The leaf area indices of plots treated with various insecticides at 21 DAP also failed to show statistically significant variations. In pot culture experiment the commercial formulations caused significant variations at 36 and 51 DAP. In the first observation highest LAI was seen in plots treated with monocrotophos 2.0 kg ai/ha and it was followed in the descending order by carbofuran 1.0 kg ai/ha, monocrotophos 0.25 kg ai/ha, carbofuran 0.5 kg ai/ha, phorate 2.5 kg ai/ha and quinalphos 2.0 kg ai/ha. In the second observation the highest LAI was in plots treated with quinalphos 2.0 kg ai/ha and it was followed by monocrotophos

Table 3. Contd.

Effect of treating different growth stages of rice plants with various insecticides on the leaf area index (LAI) of the crop

Treatments			Plants treated at 21 DAP and observed at					
			36 DAP			51 DAP		
			A	B	C	A	B	C
Carbofuran	0.5	kg ai/ha	3.01	4.09	3.04	2.32	2.89	2.55
,,	1.0	,,	3.59	4.26	3.63	2.36	3.05	3.78
Phorate	1.25	,,	3.06	3.38	3.49	1.91	2.74	2.70
,,	2.5	,,	3.26	3.56	3.77	1.93	2.88	3.22
Monocrotophos	0.25	,,	2.68	4.14	2.97	1.99	3.13	2.85
,,	2.0	,,	3.28	4.99	3.18	2.92	3.02	3.07
Quinalphos	0.25	,,	3.18	2.99	3.13	2.05	2.48	2.95
,,	2.0	,,	4.01	3.55	3.67	2.39	3.13	3.05
Control			2.85	2.85	3.17	1.79	1.79	2.81
C.D.			0.65	0.68	NS	0.56	0.56	NS

DAP : Days after planting NS : Not significant

A : Insecticides formulated from technical grades and applied on potted plants

B : Commercial formulations applied on potted plants

C : Commercial formulations applied in the field

0.25 kg ai/ha, carbofuran 1.0 kg ai/ha, monocrotophos 2.0 kg ai/ha, carbofuran 0.5 kg ai/ha, phorate 2.5 and 1.25 kg ai/ha and quinalphos 0.25 kg ai/ha.

Data relating to the application of insecticides in various dose combinations are presented in Table 3 and Appendix 3. In the field trial the leaf area indices in various treatments did not vary significantly. But the data relating to the commercial formulations of pesticides in potted plants varied significantly in the observations taken at 36 and 51 DAP. At 36 DAP the LAI was least in the treatment of carbofuran 0.5 kg ai/ha in nursery followed by 1 kg ai/ha in main field. The LAI in other dose combinations of carbofuran did not show significant variations. But the highest index was in pots treated with carbofuran @ 4 kg ai/ha followed by 0.5 kg ai/ha. At 51 DAP also the highest LAI was in 4.0 and 0.5 kg ai/ha and it was followed by 4.0 and 1 kg ai/ha, 0.5 and 1.0 kg ai/ha and 0.5 and 0.5 kg ai/ha, the last three being on par. Various combinations of doses of phorate did not cause significant variations in LAI of plants at 36 and 51 days after planting. The combination of lowest doses of 0.25 and 0.25 kg ai/ha of monocrotophos alone caused a LAI higher than that of control plants at 36 and 51 DAP. The leaf area index in pots treated with various dose combinations of quinalphos were

Table 3. Contd.
Effect of treating different growth stages of rice plants with various insecticides on the leaf area index (LAI) of the crop

Treatments				Plants treated at 15 DAS and 21 DAP and observed at					
				36 DAP			51 DAP		
				A	B	C	A	B	C
Carbofuran	0.5 + 0.5	kg ai/ha		6.45	6.50	3.96	4.70	5.16	3.51
,,	0.5 + 1.0	,,		3.83	5.96	4.43	3.07	5.20	3.90
,,	4.0 + 0.5	,,		4.66	7.43	5.16	4.28	6.70	3.98
,,	4.0 + 1.0	,,		6.93	6.97	5.39	5.70	5.50	3.81
Phorate	1.25 + 1.25	,,		6.19	6.24	4.25	4.84	4.86	3.67
,,	1.25 + 2.5	,,		5.04	6.20	3.87	3.56	4.72	3.20
,,	10.0 + 1.25	,,		5.25	6.48	3.99	3.70	4.85	3.30
,,	10.0 + 2.5	,,		5.97	6.14	3.77	4.03	4.70	3.55
Monocrotophos	0.25 + 0.25	,,		5.86	4.82	5.29	5.22	4.60	4.09
,,	0.25 + 2.0	,,		4.88	5.45	3.92	4.53	2.62	3.34
,,	2.0 + 0.25	,,		5.02	3.64	4.01	5.87	3.32	3.48
,,	2.0 + 2.0	,,		4.76	4.22	4.19	3.73	3.36	3.54
Quinalphos	0.25 + 0.25	,,		4.92	5.52	5.78	4.70	4.72	4.66
,,	0.25 + 2.0	,,		4.20	5.42	4.07	3.38	4.30	3.37
,,	2.0 + 0.25	,,		4.40	5.60	4.13	3.52	4.43	3.57
,,	2.0 + 2.0	,,		4.30	5.00	4.73	4.55	4.66	3.73
Control				3.62	3.62	3.55	3.29	3.29	3.30
C.D.				1.09	1.09	NS	1.02	1.02	NS

DAS : Days after sowing. DAP : Days after planting. NS : Not significant
A : Insecticides formulated from technical grades and applied on potted plants.
B : Commercial formulations applied on potted plants.
C : Commercial formulations applied in the field.

significantly higher than that of control at 36 and 51 DAP and they were on par among themselves. The LAI in pots treated with most of the combinations of doses of commercial formulations of pesticides did not vary significantly from the corresponding doses of the insecticides formulated in the laboratory using technical grades of the toxicant. However, LAI was highest in carbofuran 4.0 and 1.0 kg ai/ha (technical grades) both at 36 and 51 DAP. Phorate at all combinations caused significant difference at 36 DAP while the variation was not much at 51 DAP. All the combinations of doses of monocrotophos at 36 DAP and except 2.0 and 2.0 kg ai/ha at 51 DAP resulted in greater leaf area index. LAI in pots treated with technical grades of quinalphos did not vary significantly.

Effect of treatments on the shoot and root weights of rice

Data relating to this are presented in Table 4 and Appendix 4. When nursery alone was treated with insecticides in field the highest shoot weight was seen in plots treated with monocrotophos 0.25 kg ai/ha at 36 DAP which was also on par with the same insecticide at 2.0 kg ai/ha. The latter was on par with control. Other treatments were inferior to control. Shoot weight at 51 DAP showed that all treatments were giving higher shoot weight than control. Phorate 10.0 kg ai/ha gave the maximum shoot weight followed by carbofuran 0.5 kg ai/ha. The latter was on par with the remaining treatments.

Table 4. Effect of treating different growth stages of rice plants with commercial formulations of various insecticides, on the shoot and root weight of crop

Treatments			Treated at 15 DAS				Treated at 21 DAP			
			Shoot weight observed at		Root weight observed at		Shoot weight observed at		Root weight observed at	
			36DAP	51DAP	36DAP	51DAP	36DAP	51DAP	36DAP	51DAP
Carbofuran	0.5	kg ai/ha	4.80	6.78	3.41	1.55	4.76	6.29	2.87	3.06
,,	*4.0	,,	4.07	5.98	2.18	1.38	6.50	6.96	3.82	4.01
Phorate	1.25	,,	3.83	6.47	1.58	1.38	4.77	5.91	2.37	2.87
,,	*10.0	,,	4.80	8.53	2.73	1.62	5.11	6.75	2.73	3.18
Monocrotophos	0.25	,,	5.61	6.65	3.83	1.84	4.84	5.22	2.24	3.13
,,	2.0	,,	5.23	6.25	3.55	1.73	5.03	6.25	2.48	3.18
Quinalphos	0.25	,,	4.66	6.68	2.05	2.08	4.79	6.75	2.43	3.00
,,	2.0	,,	4.50	6.03	1.95	1.50	5.28	7.16	2.84	3.08
Control			4.93	5.10	2.95	1.02	4.59	5.70	2.24	2.87
C.D.			0.64	1.16	0.50	0.396	NS	0.935	0.794	NS

* At 21 DAP carbofuran and phorate were applied at 1.0 and 2.5 kg ai/ha respectively

DAS : Days after sowing DAP : Days after planting

NS : Not significant

The application of pesticides in the main field alone at 21 DAP also resulted in significant increase in the shoot weight of plants in various treatments. Monocrotophos 0.25 kg ai/ha and phorate 1.25 kg ai/ha, monocrotophos 2.0 kg ai/ha and carbofuran 0.5 kg ai/ha were on par with control while the remaining treatments were superior to control.

The treatment in nursery and main field also resulted in significant variations in shoot weight. At 36 DAP quinalphos 0.25 and 0.25 kg ai/ha, carbofuran 4.0 and 1.0 kg ai/ha in nursery and main field were superior to other combinations of the doses of the insecticide they being on par also. In the case of phorate, 10 and 1.25 kg ai/ha was the best combination the remaining dose combinations being on par and inferior. In the case of monocrotophos also the higher dose in nursery and lower dose in the main field was seen more stimulating. In the case of quinalphos lower doses in nursery and main field or the higher dose in nursery followed by lower dose in main field gave high shoot weight. Taking the best combinations of treatment for comparison of the four insecticides they were found equally effective in stimulating shoot growth of the plants.

The dose combinations of various insecticides found superior for inducing shoot weight were found producing higher quantities of roots also (Table 4).

Table 4. Contd.

Effect of treating different growth stages of rice plants with commercial formulations of various insecticides, on the shoot and root weight of crop

Treatments	Treated at 15 DAS and 21 DAP			
	Shoot wt. observed at		Root wt. observed at	
	36 DAP	51 DAP	36 DAP	51 DAP
Carbofuran 0.5 + 0.5 kg ai/ha	5.74	7.68	1.90	2.59
,, 0.5 + 1.0 ,,	6.22	9.48	2.29	2.79
,, 4.0 + 0.5 ,,	6.27	10.68	2.47	3.86
,, 4.0 + 1.0 ,,	8.24	11.67	4.47	4.81
Phorate 1.25 + 1.25 ,,	6.15	9.47	3.42	4.02
,, 1.25 + 2.5 ,,	5.09	8.47	2.55	3.92
,, 10.0 + 1.25 ,,	7.93	9.55	2.74	4.05
,, 10.0 + 2.5 ,,	5.77	6.70	2.99	3.14
Monocrotophos 0.25 + 0.25 ,,	6.62	8.40	2.25	3.42
,, 0.25 + 2.0 ,,	6.40	7.93	2.46	3.03
,, 2.0 + 0.25 ,,	7.15	10.04	3.83	4.21
,, 2.0 + 2.0 ,,	5.58	7.58	2.01	2.96
Quinalphos 0.25 + 0.25 ,,	8.32	9.61	5.07	3.65
,, 0.25 + 2.0 ,,	5.54	7.47	1.84	2.93
,, 2.0 + 0.25 ,,	7.19	10.34	2.88	3.09
,, 2.0 + 2.0 ,,	5.74	7.79	2.76	3.43
Control	5.18	7.47	2.16	2.67
C.D.	0.979	1.71	0.686	0.668

DAS : Days after sowing DAP : Days after planting

<u>Effect of insecticide application on the number of productive tillers</u>

The results presented in Table 5 and Appendix 5 showed that the application of pesticides at different levels in the nursery alone did not cause significant variations in the number of productive tillers. When applied 21 DAP the data from field experiment did not show significant variations. In pot culture studies all the treatments were found superior to control and they were all on par.

The various dose combinations of pesticides applied in nursery and main field (Table 5) showed that the number of tillers were significantly varying in the field. The higher doses of insecticides in the nursery followed by their lower doses in the main field produced the maximum number of productive tillers in the treatments but these were also on par with the treatments having the combinations minimum doses in the nursery and main field except in the case of carbofuran. In the case of carbofuran, combinations other than the lower doses in nursery and main field were equally effective. The pot culture studies in which the commercial formulations were tried also showed the same trend of relative performance of dose combinations of various insecticides as seen in field. No significant variations could be seen between the commercial

Table 5. Effect of treating different growth stages of rice plants with various insecticides on the productive tillers of the crop

Treatments			Treated at 15 DAS			Treated at 21 DAP		
			In potted plants		In field	In potted plants		In field
			A	B	B	A	B	B
Carbofuran	0.5	kg ai/ha	8.7	8.6	492.0	7.3	7.3	413.2
,,	*4.0	,,	7.0	7.3	461.4	8.0	8.0	424.3
Phorate	1.25	,,	7.7	7.6	469.0	6.7	7.3	390.8
,,	*10.0	,,	8.3	8.3	483.5	7.6	8.0	407.6
Monocrotophos	0.25	,,	8.0	7.7	483.8	7.0	7.0	357.3
,,	2.0	,,	7.7	7.3	461.4	7.6	7.7	413.2
Quinalphos	0.25	,,	7.7	7.6	476.4	7.3	7.0	368.5
,,	2.0	,,	7.0	7.0	446.4	7.7	7.3	374.1
Control			6.3	6.3	448.0	5.3	5.3	379.7
C.D.			NS	NS	NS	1.25	1.25	NS

A : Formulated from technical grades

B : Commercial formulations

DAS : Days after sowing

DAP : Days after planting

NS : Not significant

* At 21 DAP carbofuran and phorate were applied at 1.0 and 2.5 kg ai/ha respectively.

Table 5. Contd.

Effect of treating different growth stages of rice plants with various insecticides on the productive tillers of the crop

Treatments			Treated 15 DAS and 21 DAP		
			In potted plants		In field
			A	B	B
Carbofuran	0.5 + 0.5	kg ai/ha	10.7	9.7	390.8
,,	0.5 + 1.0	,,	12.0	12.0	407.6
,,	4.0 + 0.5	,,	13.0	13.3	469.0
,,	4.0 + 1.0	,,	13.0	12.0	435.5
Phorate	1.25 + 1.25	,,	12.3	11.0	424.3
,,	1.25 + 2.5	,,	10.7	11.7	435.5
,,	10.0 + 1.25	,,	12.7	12.3	452.3
,,	10.0 + 2.5	,,	10.3	9.7	402.0
Monocrotophos	0.25 + 0.25	,,	10.7	10.0	413.2
,,	0.25 + 2.0	,,	9.3	9.3	435.5
,,	2.0 + 0.25	,,	12.0	12.0	441.3
,,	2.0 + 2.0	,,	9.3	9.3	407.6
Quinalphos	0.25 + 0.25	,,	10.3	10.3	418.8
,,	0.25 + 2.0	,,	10.0	9.3	446.7
,,	2.0 + 0.25	,,	11.0	11.3	463.4
,,	2.0 + 2.0	,,	9.7	9.0	379.7
Control			7.7	7.7	358.5
C.D.			1.364	1.364	60.18

A : Formulated from technical grades

B : Commercial formulations

DAS : Days after sowing

DAP : Days after planting

formulations of insecticides tried and the laboratory formulated technical grades of pesticides.

<u>Effect of applying various insecticides on the panicle weight of rice</u>

The results presented in Table 6 show that the application of pesticides in the nursery alone did not significantly affect the weight of panicles in different treatments (Appendix 6). When applied 21 days after planting the data from the field experiment showed significant variation among the treatments. Carbofuran 1.0 kg ai/ha, phorate 2.5 kg ai/ha, quinalphos 2.0 kg ai/ha were found to be on par and superior and these were followed by carbofuran 0.5 kg ai/ha, the mean weights in remaining treatments were on par with that of control. The data obtained from pot culture studies did not show significant variations.

Combination of nursery and main field treatments (Table 6) also influenced the panicle weight varyingly in different treatments. Carbofuran @ 4.0 and 0.5 kg ai/ha in nursery and main field gave the highest mean panicle weight and it was closely followed by carbofuran 4.0 and 1 kg ai/ha, phorate 10 and 1.25 as well as 1.25 and 2.5 kg ai/ha, carbofuran 0.5 and 1 kg ai/ha, monocrotophos 2 and 0.25 kg ai/ha and phorate 1.25 and 1.25 kg ai/ha were also effective in giving

Table 6. Effect of treating different growth stages of rice plant with various insecticides on the panicle weight (gm) of the crop

Treatments			Treated 15 DAS			Treated 21 DAP		
			In potted plants		In field	In potted plants		In field
			A	B	B	A	B	B
Carbofuran	0.5	kg ai/ha	1.60	1.70	1.97	1.79	1.90	1.89
,,	*4.0	,,	1.38	1.49	1.61	2.00	2.12	2.09
Phorate	1.25	,,	1.35	1.33	1.75	1.71	1.83	1.70
,,	*10.0	,,	1.55	1.51	1.81	1.92	1.98	1.99
Monocrotophos	0.25	,,	1.51	1.58	1.77	1.56	1.46	1.64
,,	2.0	,,	1.47	1.31	1.66	1.97	1.89	1.83
Quinalphos	0.25	,,	1.40	1.10	1.53	1.77	1.67	1.64
,,	2.0	,,	1.37	1.41	1.42	1.81	1.84	1.90
Control			1.16	1.16	1.45	1.24	1.24	1.66
C.D.			NS	NS	NS	NS	NS	0.239

* At 21 DAP carbofuran and phorate were applied at 1.0 and 2.5 kg ai/ha respectively

A : Formulated from technical grades

B : Commercial formulations

DAS : Days after sowing

DAP : Days after planting

NS : Not significant

Table 6. Contd.

Effect of treating different growth stages of rice plant with various insecticides on the panicle weight (gm) of the crop

Treatments		Treated 15 DAS and 21 DAP		
		In potted plants		In field
		A	B	B
Carbofuran	0.5 + 0.5 kg ai/ha	1.76	1.93	1.67
,,	0.5 + 1.0 ,,	1.98	2.10	2.08
,,	4.0 + 0.5 ,,	1.84	1.97	1.88
,,	4.0 + 1.0 ,,	2.19	2.23	2.19
Phorate	1.25 + 1.25 ,,	2.19	2.01	1.83
,,	1.25 + 2.5 ,,	1.74	1.92	1.73
,,	10.0 + 1.25 ,,	1.62	1.64	1.91
,,	10.0 + 2.5 ,,	2.13	2.14	2.05
Monocrotophos	0.25 + 0.25 ,,	2.26	1.99	1.62
,,	0.25 + 2.0 ,,	1.87	1.79	1.51
,,	2.0 + 0.25 ,,	1.67	1.66	1.76
,,	2.0 + 2.0 ,,	1.71	1.91	1.84
Quinalphos	0.25 + 0.25 ,,	1.72	1.89	1.62
,,	0.25 + 2.0 ,,	1.64	1.77	1.59
,,	2.0 + 0.25 ,,	1.61	1.61	1.60
,,	2.0 + 2.0 ,,	1.68	1.94	1.67
Control		1.67	1.67	1.54
C.D.		0.367	0.367	0.285

A : Formulated from technical grades

B : Commercial formulations

DAS : Days after sowing. DAP : Days after planting higher panicle weight. Remaining treatments were all on par with control. The pot culture experiment using commercial formulations also showed that the higher doses of carbofuran and phorate in nursery followed by lower doses in main field gave the higher mean panicle weight at harvest. Between the technical and commercial formulations there was no significant differences in their effect on panicle weight.

<u>Correlation between the yield and yield contributing characters under various treatments</u> (Table 7)

In the field experiment in which commercial formulations of pesticides were applied 15 DAS, the plant height, shoot weight and panicle weight were seen significantly correlated with yield. In the pot culture studies using commercial formulations, plant height, leaf area index, number of tillers, productive tillers, panicle weight and 1000 grain weight were seen positively correlated with yield. In pot culture studies using formulations made in laboratory from technical grades of toxicants plant height, productive tillers, panicle weight and 1000 grain weight were seen significantly correlated with yield.

Commercial formulations of pesticides when applied in the field 21 DAP, root length and 1000 grain weight were seen correlated with yield. In pot culture studies with commercial

Table 7. Correlation between yield and yield contributing characters in rice crop treated with various insecticides

		Plant height		Leaf area index	Root length	No. of tiller	Productive tillers	Shoot weight	Root weight	Grain weight	Panicle weight
<u>Treatments in nursery</u>		<u>7 DAP</u>	<u>14 DAP</u>								
Technical grades		0.495**	0.638**	0.370	-	0.306	0.652**	-	-	0.678**	0.540**
Commercial formulations	A	0.279	0.570**	0.439*	-	0.419*	0.639**	-	-	0.501**	0.310
	B	0.388*	0.406*	0.158	0.018	0.274	0.055	0.460*	0.141	0.329	0.459*
<u>Treatments in main field</u>		<u>49 DAP</u>	<u>56 DAP</u>								
Technical grades		0.464*	0.620**	0.381	-	0.382*	0.582**	-	-	0.361	0.410*
Commercial formulations	A	0.503**	0.709**	0.537**	-	0.525**	0.707**	-	-	0.501**	0.734**
	B	0.375	0.294	0.213	0.396*	0.255	0.096	0.286	0.256	0.439*	0.363
<u>Treatments in nursery and in main field</u>		<u>56 DAP</u>									
Technical grades		0.404**		0.243	-	0.448**	0.667**	-	-	0.468**	0.579**
Commercial formulations	A	0.425**		0.604**	-	0.565**	0.724**	-	-	0.576**	0.619**
	B	-0.038		-0.213	0.428**	0.317*	0.351*	0.429**	0.453**	0.272	0.463**

A : Commercial formulations applied in pots

B : Commercial formulations applied in field

DAP : Days after planting

** Significant at 5% and 1% level in field

* Significant at 5% level

formulations, plant height, leaf area index, number of tillers, productive tillers, panicle weight and 1000 grain weight were seen positively correlated with yield while with technical grades of pesticides plant height, number of tillers, productive tillers and panicle weight were found to be correlated with yield.

In the field trial with combinations of nursery and main field treatments using commercial formulations of pesticides root length, number of tillers, productive tillers, shoot and root weights, panicle weight, were seen significantly correlated with yield. In pot culture studies plant height, number of tillers, productive tillers, panicle weight and 1000 grain weight were seen correlated with yield both in case of technical grades and commercial formulations of pesticides.

Incidence of pests on rice treated with various insecticides

The data relating to this are presented in Table 8 and Appendix 7. In plots treated with insecticides in nursery alone, the incidence of silver shoot in treated plots was found significantly lower than in control. But the incidence in untreated plot was 0.4 per cent and in treatments ranged from 0.12 to 0.27 per cent only. The percentage of leaf roller infested leaves showed significant variations at 18 DAP. In this case also the incidence in treated plots was lower than

Table 8. Incidence of pests on rice plants treated with various insecticides at different periods after treatment

Treatments	Treated 15 DAS					
	Mean percentage of silver shoots observed at		Mean percentage of leaf roller infested leaves observed at		Mean number of rice bug/3 sweeps observed at	
	28 DAP	38 DAP	18 DAP	28 DAP	38 DAP	48 DAP
Carbofuran						
0.5 kg ai/ha	0.76(4.95)	0.14(2.11)	0.78(5.00)	0.05(1.03)	0.00(1.00)	2.66(1.95)
,, 4.0 ,,	0.57(4.25)	0.16(2.21)	1.07(5.93)	0.02(0.44)	0.66(1.24)	1.66(1.58)
Phorate						
1.25 ,,	0.86(5.25)	0.21(2.63)	0.79(5.02)	0.09(1.39)	0.66(1.24)	1.00(1.33)
,, 10.0 ,,	0.71(4.73)	0.20(2.50)	0.83(5.23)	0.03(0.98)	0.66(1.24)	2.00(1.73)
Monocrotophos						
0.25 ,,	0.67(4.61)	0.27(2.90)	0.88(5.38)	0.08(1.31)	1.00(1.33)	3.30(2.01)
,, 2.0 ,,	0.55(4.19)	0.21(2.65)	0.85(5.29)	0.05(1.03)	0.66(1.24)	1.30(1.48)
Quinalphos						
0.25 ,,	0.41(3.59)	0.17(2.29)	0.77(5.03)	0.13(1.69)	0.00(1.00)	3.00(1.89)
,, 2.0 ,,	0.55(4.21)	0.12(2.01)	0.73(4.81)	0.11(1.55)	0.30(1.13)	2.00(1.72)
Control	1.38(6.65)	0.40(3.62)	1.67(7.38)	0.18(2.35)	1.30(1.47)	3.66(2.16)
C.D.	NS	0.729	1.07	NS	NS	NS

DAS : Days after sowing

DAP : Days after planting (Figures within parentheses are transformed values)

NS : Not significant

Table 8. Contd.

Incidence of pests on rice plants treated with various insecticides at different periods after treatment

Treatments			Treated 21 DAP			
			Mean percentage of silver shoots observed at		Mean percentage of leaf roller infested leaves observed at	Mean number of rice bug/3 sweeps observed at
			28 DAP	38 DAP	28 DAP	48 DAP
Carbofuran	0.5	kg ai/ha	0.81(5.05)	0.43(3.74)	1.00(5.73)	0.33(1.14)
,,	1.0	,,	0.52(4.12)	0.29(3.08)	1.17(6.19)	0.00(1.00)
Phorate	1.25	,,	0.62(4.47)	0.38(3.48)	1.03(5.76)	0.66(1.28)
,,	2.5	,,	0.53(4.06)	0.22(2.68)	0.89(5.42)	0.00(1.00)
Monocrotophos	0.25	,,	0.56(4.19)	0.42(3.66)	0.89(5.39)	0.33(1.14)
,,	2.0	,,	0.43(3.74)	0.28(2.97)	0.69(4.71)	0.00(1.00)
Quinalphos	0.25	,,	0.88(5.10)	0.24(2.79)	0.90(5.35)	0.33(1.14)
,,	2.0	,,	0.41(3.64)	0.17(2.33)	0.90(5.45)	0.33(1.14)
Control			0.93(5.48)	0.72(4.68)	1.69(7.47)	0.66(1.28)
C.D.			NS	NS	NS	NS

(Figures within parentheses are transformed values)

DAP : Days after planting.   NS : Not significant.

Table 8. Contd.

Incidence of pests on rice plants treated with various insecticides at different periods after treatment

Treatments	Treated 15 DAS and 21 DAP					
	Mean percentage of silver shoots observed at		Mean % of leaf roller infested leaves observed at	Mean No. of red spotted earhead bug/3 sweeps observed at	Mean No. of rice bug/3 sweeps observed at	
kg ai/ha	28 DAP	38 DAP	20 DAP	20 DAP	38 DAP	48 DAP
Carbofuran						
0.5 + 0.5	0.42(3.51)	0.82(5.17)	1.02(5.73)	1.33(1.47)	1.66(1.63)	3.33(2.06)
,, 0.5 + 1.0	0.60(4.13)	0.00(0.00)	1.06(5.85)	0.66(1.24)	1.66(1.61)	1.66(1.48)
,, 4.0 + 0.5	0.88(3.05)	0.43(3.67)	1.10(5.98)	0.33(1.14)	1.66(1.61)	1.33(1.41)
,, 4.0 + 1.0	0.29(3.05)	0.27(2.94)	0.79(5.11)	1.00(1.38)	1.66(1.61)	2.66(1.82)
Phorate						
1.25 + 1.25	0.46(3.79)	0.65(4.31)	0.98(5.69)	1.33(1.52)	2.33(1.82)	2.66(1.79)
,, 1.25 + 2.5	0.33(3.28)	0.07(1.25)	1.23(6.32)	0.33(1.14)	2.00(1.72)	1.33(1.47)
,, 10.0 + 1.25	0.35(3.37)	0.38(3.50)	1.03(5.76)	0.66(1.24)	1.33(1.47)	1.00(1.38)
,, 10.0 + 2.5	0.33(3.30)	0.41(3.63)	1.04(5.76)	1.00(1.41)	2.00(1.72)	3.33(2.02)
Monocrotophos						
0.25 + 0.25	0.66(4.47)	0.67(4.57)	1.18(6.18)	1.00(1.33)	0.33(1.14)	2.66(1.91)
,, 0.25 + 2.0	0.67(4.45)	0.22(2.69)	1.07(5.87)	0.00(1.00)	1.66(1.48)	1.00(1.33)
,, 2.0 + 0.25	0.44(3.70)	0.27(2.91)	0.09(5.95)	1.00(1.33)	0.33(1.14)	0.33(1.14)
,, 2.0 + 2.0	0.39(3.56)	0.50(3.73)	0.97(5.64)	1.00(1.33)	1.00(1.47)	1.66(1.58)
Quinalphos						
0.25 + 0.25	0.59(4.39)	0.40(3.67)	0.88(5.38)	1.66(1.58)	2.33(1.76)	2.00(1.69)
,, 0.25 + 2.0	0.37(3.50)	0.12(2.02)	1.19(6.20)	1.33(1.49)	0.33(1.14)	1.33(1.47)
,, 2.0 + 0.25	0.33(3.26)	0.25(2.83)	0.93(5.50)	0.33(1.14)	1.00(1.38)	1.00(1.38)
,, 2.0 + 2.0	0.34(3.29)	0.28(2.96)	0.84(5.25)	1.00(1.33)	0.66(1.24)	2.33(1.73)
Control	1.09(6.03)	0.95(5.57)	1.42(6.84)	1.66(1.58)	2.33(1.79)	3.66(2.15)
C.D.	NS	1.39	NS	NS	NS	NS

(Figures within parentheses are transformed values)

DAS : Days after sowing. DAP : Days after planting. NS : Not significant.

that of control there being no significant variation among the treatments. The level of incidence was very low ranging from 0.73 to 1.67 per cent only. Rice bug also occurred in the field but the population ranged from 1 to 3.66 per three standard sweeps and the data did not vary significantly.

Plots treated with insecticides at 21 DAP also had the gall fly incidence (0.41 to 0.93%), leaf roller (0.9 to 1.69% infested leaves) at 28 DAP and rice bug (0 to 0.66 bugs/3 sweeps) at 48 DAP. The data did not show significant variations. In plots treated with insecticides at 15 DAS in nursery and 21 DAP in main field also, the pest incidence occurred to a mild level. The silver shoot incidence ranged from 0.29 to 1.09 at 28 DAP and 0 to 0.95 at 38 DAP. The percentage of leaf roller infested leaves ranged from 0.79 to 1.42 at 20 DAP. Red spotted bug (0 to 1.66 numbers/3 sweeps) at 20 DAP and rice bug (0.33 to 2.33 and 0.33 to 3.66 numbers/3 sweeps) at 38 and 48 DAP respectively also were found in the observations

<u>Persistent toxicity of insecticides applied on rice at 21 DAP as commercial formulations and as formulations prepared from technical grades</u>

The data are presented in Table 9 and in Figs. 2 and 3. The mortality observed one day after the application did not

Table 9. Persistent toxicity of different insecticides applied on rice plants at 21 DAP to the brown plant hopper *Nilaparvata lugens* (Stal.)

Treatments			Corrected per cent mortality of BPH exposed on treated plants at different intervals after spraying (days)					P	T	PT
			1	2	3	5	7			
Carbofuran 0.5 kg ai/ha		A	17.78	22.22	33.33	28.89	-	5	25.55	127.75
		B	13.33	22.22	40.00	64.44	15.55	7	30.09	217.69
1.0	,,	A	24.44	31.11	46.67	33.33	11.11	7	29.33	205.31
		B	33.33	63.00	78.76	83.00	31.11	7	57.84	404.89
Phorate 1.25	,,	A	8.89	24.44	33.00	15.56	6.67	7	17.70	123.90
		B	11.00	24.00	35.00	46.66	13.33	7	25.99	181.90
2.5	,,	A	26.67	37.78	51.11	20.00	13.33	7	29.77	208.39
		B	24.44	31.11	46.77	60.00	22.22	7	36.88	258.17
Monocrotophos 0.25 kg ai/ha		A	31.11	24.44	11.11	-	-	3	22.22	66.66
		B	33.33	66.66	40.00	23.00	-	5	40.74	203.70
2.0	,,	A	37.78	28.89	20.00	6.66	-	5	23.34	116.70
		B	53.33	73.33	33.30	26.66	16.66	7	40.64	284.51
Quinalphos 0.25	,,	A	26.67	34.11	17.66	4.44	-	5	20.75	103.75
		B	26.66	35.00	15.50	6.65	-	5	20.93	104.63
2.0	,,	A	40.00	53.33	26.66	11.11	-	5	30.27	151.34
		B	31.00	44.44	22.20	13.11	11.11	7	24.34	170.38

A : Insecticides formulated from technical grades
B : Insecticides used as commercial formulations
DAP : Days after planting

P : Period
T : Average toxicity
PT: Index based on persistent toxicity

Fig. 2. Per cent mortality of brown plant hopper exposed to rice plants, treated with commercial formulations and laboratory formulated technical grades of pesticides, at different intervals after spraying

Carbofuran

A	Formulated from technical grades		0.5	kg ai/ha
B_1	,,	,,	1.0	,,
B	Commercial formulation		0.5	,,
A_1	,,		1.0	,,

Phorate

A	Formulated from technical grades		1.25	,,
B_1	,,	,,	2.5	,,
B	Commercial formulation		1.25	,,
A_1	,,		2.5	,,

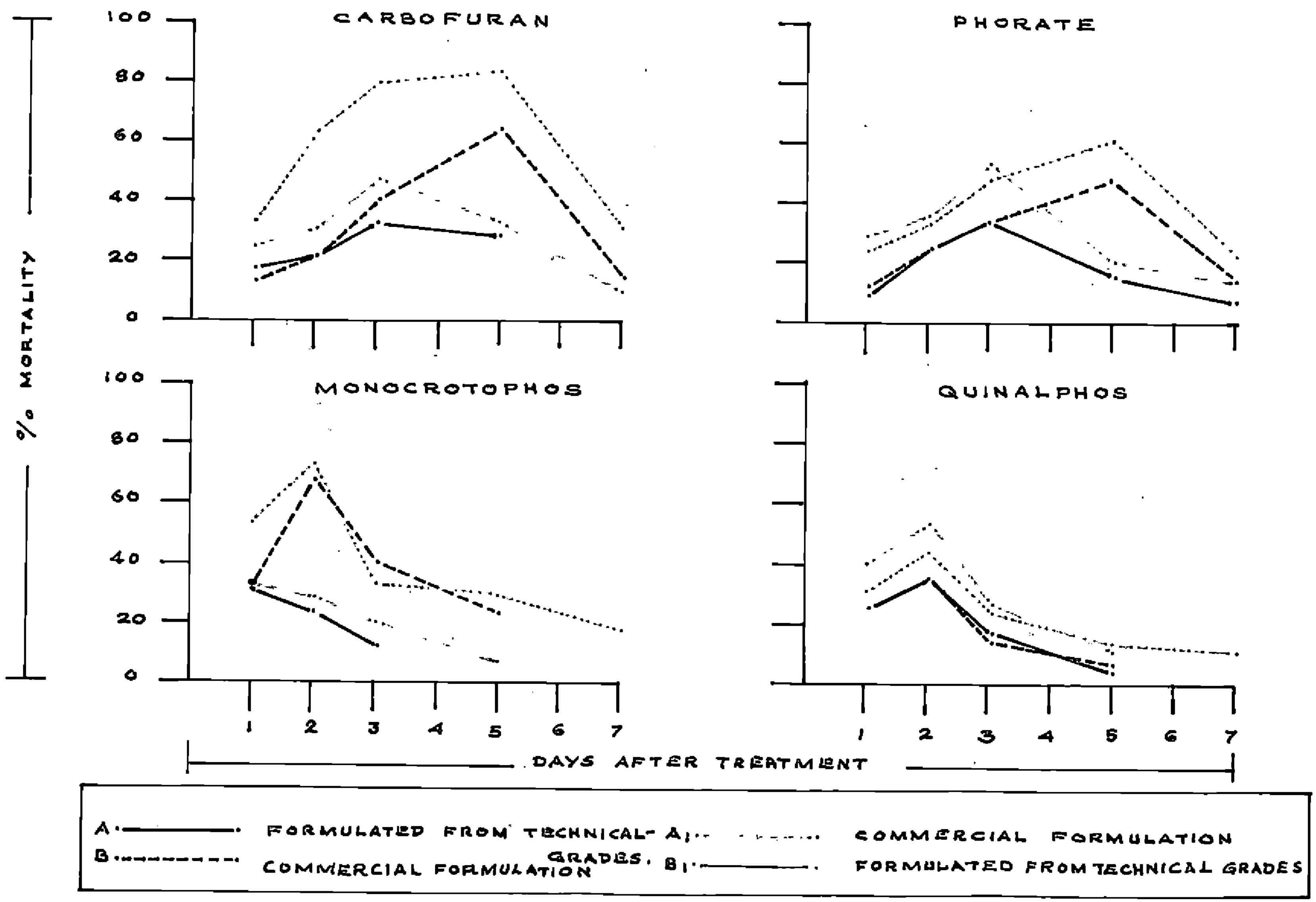
Monocrotophos

A	Formulated from technical grades		0.25	,,
B_1	,,	,,	2.0	,,
B	Commercial formulation		0.25	,,
A_1	,,		2.0	,,

Quinalphos

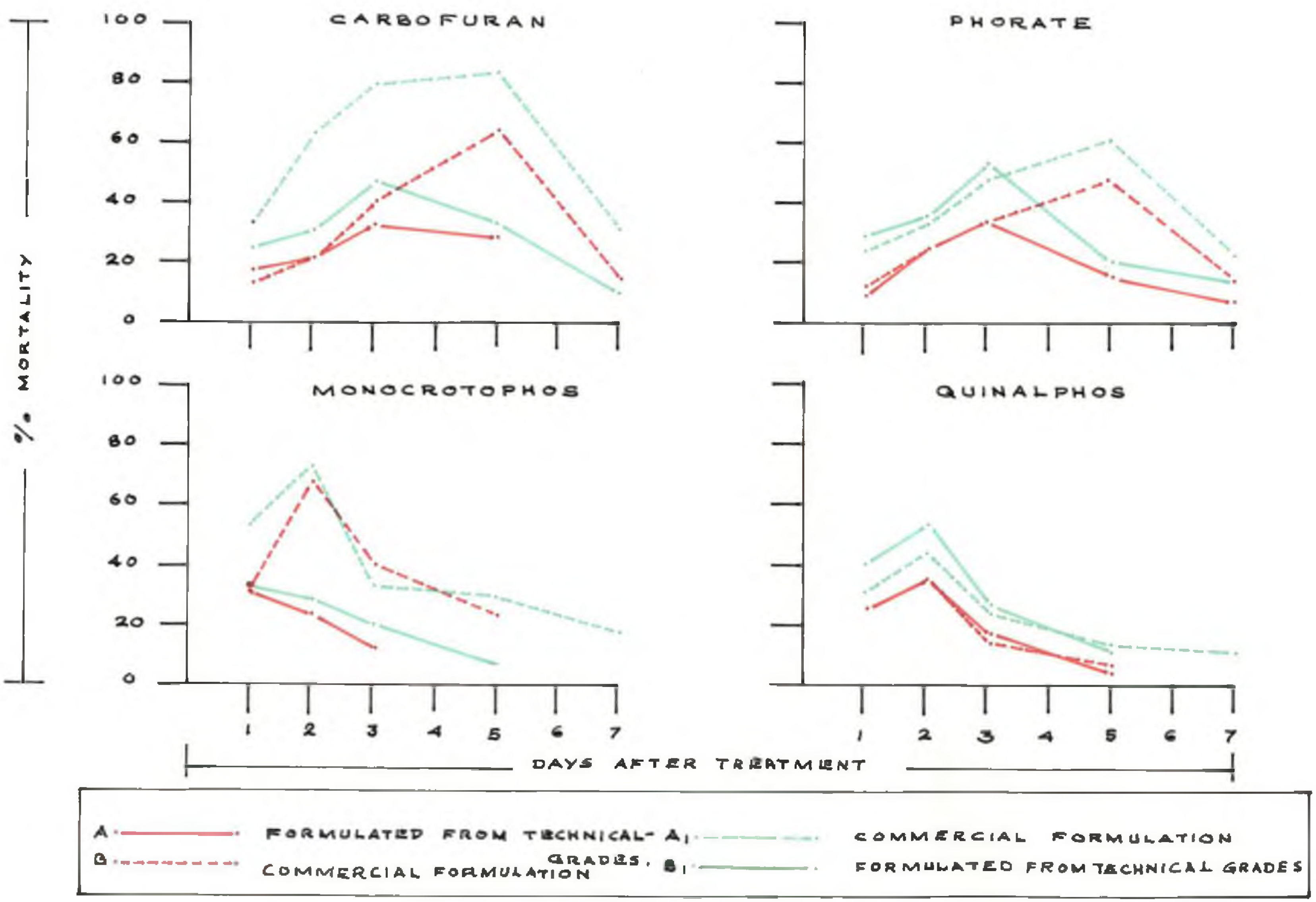
A	Formulated from technical grades		0.25	,,
B_1	,,	,,	2.0	,,
B	Commercial formulation		0.25	,,
A_1	,,		2.0	,,

FIG: 2



CARBOFURAN
PHORATE
MONOCROTOPHOS
QUINALPHOS
% MORTALITY
100
80
60
40
20
0
1 2 3 4 5 6 7
DAYS AFTER TREATMENT
A — FORMULATED FROM TECHNICAL GRADES.
B - - - - COMMERCIAL FORMULATION
A1 .... COMMERCIAL FORMULATION
B1 —·—·— FORMULATED FROM TECHNICAL GRADES

FIG: 2



% MORTALITY
CARBOFURAN
PHORATE
MONOCROTOPHOS
QUINALPHOS
100
80
60
40
20
0
1 2 3 4 5 6 7
DAYS AFTER TREATMENT
A : FORMULATED FROM TECHNICAL-GRADES.
B : COMMERCIAL FORMULATION
A1 : COMMERCIAL FORMULATION
B1 : FORMULATED FROM TECHNICAL GRADES

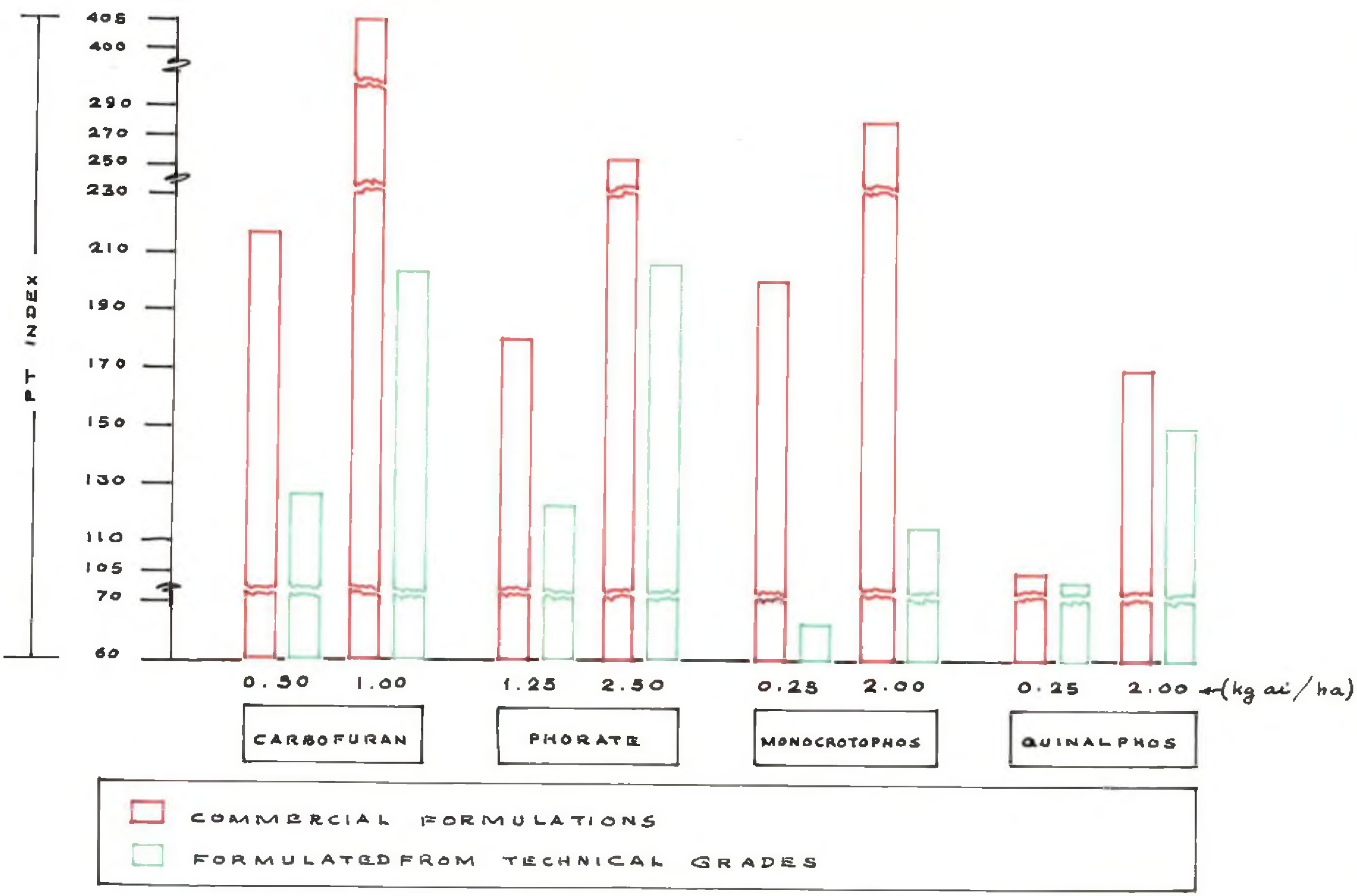
reveal significant difference between the commercial formulations and laboratory formulated technical grades of the insecticides except in the case of monocrotophos @ 2.0 kg ai/ha when the commercial formulation showed a higher toxicity. On the second day commercial formulations of carbofuran 1 kg ai/ha and monocrotophos 0.25 and 2 kg ai/ha were found superior to the corresponding formulations from technical grades. This difference was seen in all the subsequent observations also. On the fifth and seventh days the mortalities on plants treated with laboratory formulated phorate 1.25 and 2.5 kg ai/ha and carbofuran 0.5 kg ai/ha declined drastically while those on granule treated plants remained high.

Laboratory formulated carbofuran and phorate showed highest toxicity on 3rd day while monocrotophos and quinalphos showed maximum toxicity on the 1st day and 2nd day respectively. The granular formulations had highest toxicity on the 5th day while the commercial formulations of monocrotophos and quinalphos showed peak toxicity on the second day.

The PT index of commercial formulation of monocrotophos 0.25 kg ai/ha was 205 per cent of the formulation made from technical grade while in the case of monocrotophos 2 kg ai/ha, carbofuran 1 kg ai/ha, carbofuran 0.5 kg ai/ha, phorate 1.25 kg ai/ha, phorate 2.5 kg ai/ha, quinalphos 2 kg ai/ha and quinalphos 0.25 kg ai/ha the corresponding per cent increases were 143.79, 97.21, 70.00, 46.81, 12.58 and 0.82 respectively.

Fig. 3. Persistent toxicity of insecticides applied on rice at 21 DAP as commercial formulations and formulations prepared from technical grades.

FIG: 3


PT INDEX
405
400
290
270
250
230
210
190
170
150
130
110
105
70
60
0.50
1.00
1.25
2.50
0.25
2.00
0.25
2.00
(kg ai/ha)
CARBOFURAN
PHORATE
MONOCROTOPHOS
QUINALPHOS
COMMERCIAL FORMULATIONS
FORMULATED FROM TECHNICAL GRADES

Residues of insecticides in the grains harvested from plots treated at 21 DAP

All the treatments except phorate @ 2.5 kg ai/ha left non-detectable levels of residues (0.017 ppm) when applied at 21 DAP.

Residues of insecticides in the grains harvested from plots treated at 15 DAS in nursery and 21 DAP in the main field

The treatment with carbofuran and phorate alone left residues in the grains at detectable levels at harvest (Table 10). But the residues were also below the tolerance limit. The residues observed in chemical assay were slightly higher than those obtained from bioassay. Monocrotophos and quinalphos did not cause detectable levels of insecticide residue in grains.

Table 10. Residues of different insecticides in the paddy grains harvested from plants treated at different growth stages of the crop

Treatments	kg ai/ha	Residue (ppm) of insecticides in grains collected from			
		Plants treated at 21 DAP		Plants treated at 15 DAS and 21 DAP	
		Bio-assay	Chemical assay	Bio-assay	Chemical assay
Carbofuran	0.5	0.00035	ND	-	-
,,	1.0	0.00039	ND	-	-
,,	0.5 + 0.5			0.0002	ND
,,	0.5 + 1.0			0.0008	ND
,,	4.0 + 0.5			0.001	0.016
,,	4.0 + 1.0			0.001	0.007
Phorate	1.25	ND	ND	-	-
,,	2.5	ND	0.017	-	-
,,	1.25 + 1.25			0.013	0.029
,,	1.25 + 2.5			0.023	0.083
,,	10.0 + 1.25			0.012	0.080
,,	10.0 + 2.5			0.061	0.103
Monocrotophos	0.25	ND	ND	-	-
,,	2.0	ND	ND	-	-
,,	0.25 + 0.25			ND	ND
,,	0.25 + 2.0			ND	ND
,,	2.0 + 0.25			ND	ND
,,	2.0 + 2.0			ND	ND
Quinalphos	0.25	ND	ND	-	-
,,	2.0	ND	ND	-	-
,,	0.25 + 0.25			ND	ND
,,	0.25 + 2.0			ND	ND
,,	2.0 + 0.25			ND	ND
,,	2.0 + 2.0			ND	ND

DAS : Days after sowing DAP : Days after planting

ND : Non-detectable

Discussion

DISCUSSION

The data relating to the yield obtained from the field and pot trials have shown the existence of a phytotonic effect of the various insecticides applied on rice crop. Even a single application at 15 DAS in the nursery boosted the yield of rice significantly except in the higher doses of 2 kg ai/ha of quinalphos and monocrotophos. At this high dose the plants showed phytotoxic symptoms also. Among the four insecticides tested in nursery carbofuran had the highest boosting effect on yield and it was closely followed by phorate. The lower dosages of monocrotophos and quinalphos also were found to be on par with the lower dose of phorate. The difference in yield increase caused by the dosages of 0.5 and 4.0 kg ai/ha of carbofuran was not significant thus indicating that the plants did not show a linear response to the dosage levels of the toxicant. Soil incorporation of carbofuran, at the time of sowing and at the rate of 1.2 kg ai/ha (Park, 1981) gave higher yield. Miah and Islam (1980) observed a phytotonic effect for diazinon and bidrin applied in the nursery at a high dose of 3 and 2.5 kg ai/ha. Present studies indicated that such high dosages of pesticides cannot probably be utilised by the plant in the nursery. From the two levels of pesticides tried in the experiment the optimum dosage could not be found conclusively. But the required dose appears to be very close to the minimum level tried. In the case of phorate also the two levels 1.25 and 10 kg ai/ha caused almost similar levels of yield increase. The higher dosage of 10 kg ai/ha did not cause any phytotoxic symptom. But the lack of proportionate increase in phytotonic effect for the higher level of insecticide indicated the wastage of using high dosages in the nursery. In the case of quinalphos and monocrotophos the lower dosages of 0.25 kg ai/ha had a phytotonic effect. The optimum dosages for these insecticides could not be fixed from the present study since the second dose of 2 kg ai/ha had distinct phytotoxic effect. Probably the optimum may fall inbetween the two dosage levels tried. Detailed studies on the phytotonic effect of phorate, quinalphos and monocrotophos have not been reported earlier.

The results from pot culture studies using the commercial formulations of pesticides endorsed the findings in the field experiment. In comparing the data obtained from the above pot culture study with those collected from similar experiments in which insecticides formulated from their technical grades were used were broadly similar thus indicating that the phytotonic effect noted in commercial formulations was not due to the stimulation by any of the adjuvants used in the same. The actual toxicant might have had the phytotonic effect.

In the second experiment in which the insecticides were applied in the main field at 21 DAP also, a clear boosting of yield was observed. Carbofuran 1.0 kg ai/ha gave the highest increase in yield. Phorate at 1.25 kg ai/ha was found to be as good as 2.5 kg ai/ha. Unlike in the nursery monocrotophos and quinalphos at the higher dose of 2 kg ai/ha were found to be superior to their lower doses and they were on par with the best treatment of carbofuran 1.0 kg ai/ha. Plots treated with carbofuran at 0.5 kg ai/ha yielded least among the treatments showing that the dosage of the chemical found adequate for giving highest phytotonic effect to the rice plants in nursery was not sufficient for main field treatment at 21 DAP. But Balasubramoniyan and Morachan (1981) reported significant increase in rice yield with carbofuran at 0.5 kg ai/ha. Other studies have also shown yield increase due to the application of carbofuran in the main field at the early tillering phase of rice (Chelliah, 1979; Casquijo et al., 1980; Saivaraj and Venugopal, 1980).

Budhraja et al. (1980) observed an increase in the yield of rice treated with quinalphos at 0.04 per cent but the same was reported simultaneous with an effective control of <u>Dicladispa armigera</u> in the field. So the effect cannot positively be attributed to phytotonic effect. Information on the phytotonic effect of the remaining insecticides resulting in significant yield increase in rice have not been reported earlier.

Pot culture studies also gave higher yield due to the various treatments. In general the observations were in agreement with the conclusions drawn from the field experiment. The formulations made from technical grades did not differ from the commercial formulations in causing the yield increase thus eliminating the possible role of adjuvants in commercial formulations as the cause for phytotonic effect resulting in higher yield at harvest.

In the third experiment the insecticides were applied once in the nursery at 15 DAS and it was followed by another application in the main field at 21 DAP. The data showed that the increase in yield was more or less the same as obtained by treating the crop at one stage, either in the nursery or in the main field. The increase in yield obtained in the third experiment ranged from 102.9 to 143.4 per cent of control while the corresponding percentages in nursery treatment alone were from 105.3 to 147.2 and for the treatment in main field alone were from 119.8 to 142.2.

Probably the plants once stimulated may not remain susceptible to further stimulation by the pesticides at subsequent growth stages.

The different dose combinations of pesticides did not in general cause significant variations in yield increase. Combinations of lower doses in the nursery and main field were found inferior for carbofuran. But combinations of higher doses in nursery and main field were found injurious in the case of quinalphos and monocrotophos. The latter case may be the result of the phytotoxic effect of the toxicants in nursery treatment.

The effects of insecticidal treatment on various yield contributing characters were studied in the present investigations. In the nursery treatment the lower doses of pesticides had a higher stimulatory effect than the higher doses on plant height except in the case of phorate in which the higher dose was found to be more effective. In general, carbofuran 0.5 kg ai/ha, monocrotophos 0.25 and 2 kg ai/ha and phorate 10 kg ai/ha gave a significantly higher level of plant height compared to control. The effect of application gave significant difference in the plant height at 7 and 21 DAP i.e. second and third week after treatment. In subsequent observations the height of plants in various treatments were on par and also on par with control.

In the case of pot culture experiment observation at 21 DAP showed that all the treatments were significantly superior to control. Among the treatments carbofuran 0.5 kg ai/ha and phorate 10.0 kg ai/ha gave relatively higher levels of plant height. The laboratory formulated materials and commercial formulations did not reveal any significant differences in stimulating the plant height.

In the main field treatment at 21 DAP the height of plants showed significant variations at 49 and 56 DAP i.e. fourth and fifth week after treatment. Carbofuran 0.5 kg ai/ha gave the maximum plant height and it was followed by phorate 2.5 kg ai/ha, carbofuran 1.0 kg ai/ha, monocrotophos 0.25 kg ai/ha, phorate 1.25 kg ai/ha and monocrotophos 2 kg ai/ha there being no significant variations among the treatments. The lower dose of quinalphos also was on par with the above treatments except carbofuran 0.5 kg ai/ha. Thus all the insecticides tried in the experiment were found to stimulate the plant height significantly.

The potted plants treated with commercial formulations of pesticides showed significant variations in plant height in all the observations. In general the plant height was found favourably influenced by all the treatments except monocrotophos and quinalphos at 0.25 kg ai/ha. Even these insecticides were found effective at the higher dose of 2.0 kg ai/ha. As in previous experiments here also the commercial and laboratory formulated pesticides did not show significant variations in effect. The inducing effect of insecticidal application in main field on the growth of rice has been reported earlier also (Ragupathy and Jayaraj, 1974; Anon., 1976a; Saivaraj and Venugopal, 1980; Venugopal and Litsinger, 1980; Park, 1981).

In the third experiment insecticides were applied in the nursery and main field at different dose combinations. In all the observations the application of insecticides at the lower dose in nursery at 15 DAS followed by the lower doses in main field at 21 DAP were found to cause greater plant heights. This was followed by the dose combinations of higher rates in nursery as well as main field and lower dose in nursery followed by higher dose in main field. Though the observations up to the third week after application of pesticides revealed that the combinations of dissimilar doses in the nursery and main field retained the plant heights in the treatments on par with control, at 49 DAP all treatments except monocrotophos 2.0 and 2.0 kg ai/ha and quinalphos 2.0 and 0.25 kg ai/ha and at 56 DAP all except quinalphos 2.0 and 0.25 kg ai/ha were found on par and significantly superior to control. The variation in plant height in pot trials was significantly varying during the first week after application alone and in all subsequent observations the plant height in treatments were seen on par with that of control. There are no previous studies on the phytotonic effect of various dose combinations of pesticides in nursery and main field on rice.

The application of pesticides in the nursery, in the main field and in both did not influence the leaf area indices of the crop significantly as observed at 8, 23, 38 and 53 DAP. But in the pot culture studies leaf area indices varied with the different treatments. At 38 DAP the two doses of monocrotophos gave the highest LAI while carbofuran and the higher dose of phorate came next in ranking. But at 53 DAP quinalphos ranked first and it was followed by phorate and carbofuran. The relative ranking of the pesticides with reference to the LAI in the pots treated with various insecticides at 21 DAP also did not show consistent results in consecutive observations.

In the various combinations of doses in nursery and main field stages in pots the treatment with carbofuran at 4 kg ai/ha followed by 0.5 kg ai/ha gave the highest LAI.

The other three combinations were less effective. The various dose combinations of phorate and quinalphos did not cause significant variations in LAI among the treatments though they were superior to control. In the case of monocrotophos the dose combination of 0.25 and 0.25 kg ai/ha alone produced a LAI higher than that of control.

Regarding shoot weight observed at 36 DAP monocrotophos lower dose alone was found significantly superior to control. At 51 DAP shoot weight in all treatments were higher than that of control. But the maximum shoot weight was in plots treated with phorate 10 kg ai/ha and it was closely followed by carbofuran 0.5 kg ai/ha and the latter was on par with all the remaining treatments. When applied at 21 DAP quinalphos 0.25 and 2 kg ai/ha, carbofuran 1 kg ai/ha and phorate 2.5 kg ai/ha caused shoot weight significantly higher than that of control. The treatment in nursery and main field in different dosage combinations showed that for higher root and shoot weight quinalphos at 0.25 and 0.25 kg ai/ha was best and for carbofuran 4 and 1.0 kg ai/ha was better. In the case of monocrotophos and phorate higher dose in nursery and lower dose in main field was found superior.

The number of tillers were not significantly influenced by treating the nursery at 15 DAS or the main field at 21 DAP. In pot culture studies all treatments were found to produce higher numbers of productive tillers than in control but there was no significant variation among the treatments.

The experiment using various dosage combinations of pesticides showed that the application of higher doses in the nursery followed by the lower doses in main field and even the lower doses of pesticides in both growth stages of the crop induced a significantly higher number of productive tillers.

In the field experiment application of carbofuran, phorate and quinalphos at higher rates at 21 DAP caused a significant increase in the mean panicle weight while other treatments were on par with control. The treatment in nursery alone did not influence the panicle weight. Various dose combinations of carbofuran (except the lower doses in nursery and main field) higher dose of phorate in nursery followed by lower dose in main field or vice versa, monocrotophos higher dose in nursery followed by the lower dose in main field and lower doses of phorate in nursery and main field caused significantly higher panicle weight in the treatments when compared to control.

Relative ranking of the different treatments based on the various yield contributing characters did not show any remarkable agreement with the ranking based on the percentage increase of yield over that of control. But significant correlations were seen between the yield and yield contributing characters observed in experiments. In the field experiment in which the nursery alone was treated with pesticides the increase in yield was seen significantly correlated with plant height, shoot weight, panicle weight and yield increase caused by the main field treatments alone at 21 DAP was correlated with root length and 1000 grain weight. When nursery and main field were treated the yield was seen correlated significantly with root length, number of tillers, productive tillers, shoot and root weights and panicle weight.

In pot trials with commercial formulation the yield increase showed positive correlation with more number of yield contributing characters viz. plant height, leaf area index, number of tillers, panicle weight and 1000 grain weight. In the case of formulated technical grades of pesticides positive correlation could be obtained between yield and plant height, productive tillers, panicle weight, 1000 grain weight, number of tillers, when treated at 15 DAS and 21 DAP. In the treatment with different dosage combinations of pesticides in nursery and main field positive correlations were seen with the yield and yield contributing characters as observed in the plots treated at 21 DAP alone.

Data provided in Table 8 showed that the pests noted during the first crop season in which the experiment was carried out were shoall fly, leaf roller, red spotted ear head bug and rice bug. But the incidence recorded from various experimental plots revealed the very low population levels of the pests and also that the control of the pests through insecticidal treatment would not have brought any appreciable improvement of yield compared to the yield in control plots. Moreover the treatment with pesticides did not cause significant variation in the occurrence of pest population in various treatments. Obviously the higher levels of yield recorded in treated plots could have been caused by the phytotonic effect of the different pesticides used.

The persistent toxicity of commercial formulations of monocrotophos to brown plant hopper was much higher than its laboratory formulated technical grade when tried at the rates of 2 and 0.25 kg ai/ha. In this respect monocrotophos was followed by carbofuran 1.0 kg ai/ha, 0.5 kg ai/ha and phorate

2.5 kg ai/ha, 1.25 kg ai/ha. In the case of quinalphos there was no significant difference in the toxicity of the two types of formulations. The toxicity of the granular formulations to BPH reached its peak on the fifth day and it declined to zero level in another 2 to 5 days whereas the laboratory formulated technical grades of these pesticides showed the highest toxicity on the second day after application and later declined to zero level in five days. Regarding monocrotophos and quinalphos the peak toxicity to BPH was noted on the second day of application of the commercial formulation and on the first day of application for the laboratory formulated technical grades. The toxicity declined to zero level on seventh day after treatment. Thus the results showed that the laboratory formulated technical grades of pesticides might have been absorbed into the plant as effectively or even faster than the commercial formulations.

The lack of variations in the phytotonic effect of the two types of insecticidal formulations indicated that the component responsible for the stimulation should have been the toxicant and not any of the adjuvants added to the commercial preparations. Another interesting observation was that even the granular formulations claimed to be a slow releasing one, lost their toxicity between the seventh and tenth day and the laboratory formulated technical grades also retained its toxicity up to that period though the mortality percentage was somewhat low. Such bio-assay studies evaluating the toxicity of different types of formulations were not reported earlier though the persistent toxicity of commercial formulations have already been studied in Kerala (Nagalingam et al., 1975; Mathai et al., 1976; Rao and Das, 1977; Mohandas et al., 1978).

Residue data presented in Table 10 showed that the application of even the higher doses of pesticides at 21 DAP did not leave residues above tolerance limit in grain. In the case of monocrotophos and quinalphos the residues were not even detectable. The values obtained from bioassay was a little less than the corresponding values from chemical assay. This might be due to the mode of action os pesticides tested which were more systemic than contact in nature; the assay was based on their contact action on *Drosophila melanogaster*.

Summary

SUMMARY

The phytotonic effect of carbofuran, phorate, monocrotophos and quinalphos at different growth stages of rice were assessed through a series of field experiments and pot trials.

When applied in the nursery at 15 DAS carbofuran 0.5 kg ai/ha, phorate 1.25 kg ai/ha, monocrotophos 0.25 kg ai/ha and quinalphos 0.25 kg ai/ha caused a significant increase in the yield. The insecticides applied in potted plants at the same dosages and as commercial formulations gave yields broadly comparable to those obtained from field experiment. Data obtained from the pot trial in which laboratory formulated technical grades of pesticides were used showed that the stimulating effect of the above formulations and of the commercial formulations on the yield did not vary significantly This indicated that the component of the commercial formulation exerting a favourable influence on yield might have been the toxicant itself and not the unknown adjuvants available in the same.

In the second experiment in which the insecticides were applied at 21 DAP carbofuran 1 kg ai/ha gave the maximum yield and it was followed by phorate 1.25 kg ai/ha which was also on par with its higher dose of 2.5 kg ai/ha. Monocrotophos and quinalphos were found effective at the higher doses

of 2.0 kg ai/ha. No phytotoxic symptoms were observed for these insecticides. The data obtained from pot trials with the same treatments were in agreement with the field data. The formulations from the technical grades of pesticides did not differ from commercial formulations in effect.

In the third experiment the nursery at 15 DAS and the main field at 21 DAP were treated with varying dose combinations of the above four insecticides. The yield increase obtained from the treatment was on par with the increase obtained by treating the nursery stage at 15 DAS alone or the main field at 21 DAP alone. This indicated that the plants probably failed to respond to the repeated application of the pesticides.

The effect of insecticidal treatments on various yield contributing characters were assessed. In the nursery stage of the crop the lower doses of pesticides had higher stimulatory effect than the high doses in general. Carbofuran 0.5 kg ai/ha, monocrotophos 0.25 kg ai/ha and phorate 10 kg ai/ha were found superior in stimulating plant height. The significant variations in plant height could be observed during the second and third week after treatment only. In the pot culture studies also carbofuran 0.5 kg ai/ha and phorate 10 kg ai/ha were found significantly superior to other treatments.

In the main field treatment at 21 DAP the plant height varied significantly at fourth and fifth week after treatment only. All the treatments except quinalphos at 2 kg ai/ha gave significant increase in plant height. In the pot trial with these treatments the lower doses of monocrotophos and quinalphos at 0.25 kg ai/ha were found less effective.

The third experiment revealed that treating the nursery at 15 DAS with the lower doses of pesticides and the main field at 21 DAP with the same pesticides at lower doses gave the maximum stimulation of plant height. In the case of pot trial, plant height in treatments and control did not vary significantly.

The application of pesticides in the nursery, main field as well as in both the stages did not significantly influence the leaf area indices of the crop as observed at 8, 23, 38 and 53 DAP in field. In the pot trial though the leaf area indices varied significantly the relative ranking of pesticides with reference to the criterion did not show consistent results in the observations at different intervals.

The shoot weight and root weight did not show significant variations consistent with the treatments or with percentage increase in yield caused by the treatments.

The treatment in nursery alone did not influence the panicle weight. The higher doses of carbofuran, quinalphos and phorate caused a significant increase in the mean panicle weight when the treatments were given at 21 DAP. Among the various dose combinations tried the lower doses of carbofuran in nursery and main field, higher dose of phorate in nursery followed by lower dose in main field and vice versa, monocrotophos higher dose in nursery followed by lower dose in main field and phorate lower dose in nursery followed by the lower dose in main field caused significantly higher panicle weight.

In general the relative ranking of pesticides based on percentage increase in yield and on the basis of variations in different growth contributing characters did not show any remarkable agreement.

However the correlation studies showed that the yield obtained in different experiments were seen significantly correlated with many yield contributing characters.

When nursery alone was treated the yield was significantly correlated with plant height, shoot height and panicle weight.

In the treatment of the main field at 21 DAP the yield was positively correlated with root length and 1000 grain weight only.

When nursery and main field were treated there was positive correlation between the yield and root length, number of tillers, productive tillers, shoot and root weight as well as panicle weight.

In pot trials significant correlation could be seen between yield and more number of yield contributing characters viz. plant height, leaf area index, number of tillers, panicle weight and 1000 grain weight.

The pest incidence observed in the plots during the crop period was very low. Hence the increase in yield caused by the treatment has to be attributed to the phytotonic effect and not to the prevention of insect injury due to the control of the pests.

The studies on the persistent toxicity of the pesticides to brown plant hopper showed that the difference in the persistence of commercial formulations and laboratory formulated technical grades of pesticides was maximum in monocrotophos and it was followed by carbofuran and phorate. In the case of quinalphos the two types of formulations did not vary significantly. The granular formulations claimed to be slow releasers persisted only up to seven days as in the laboratory formulated material.

The application of carbofuran at 4 kg ai/ha in nursery (15 DAS) and 1 kg ai/ha in the main field (21 DAP), phorate 10 and 2.5 kg ai/ha, monocrotophos 2 and 2 kg ai/ha and quinalphos 2 and 2 kg ai/ha respectively did not leave residues above tolerance limit in harvested grains as assessed by chemical and biological assays.

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* Original not seen

Appendices

APPENDIX 1

Treatments		Yield from plants					
		Treated at 15 DAS			Treated at 21 DAP		
		In potted plants g/pot		In field kg/ha	In potted plants g/pot		In field kg/ha
		A	B	B	A	B	B
Carbofuran	0.5 kg ai/ha	19.3	19.61	4309	13.61	12.98	3998
,,	*4.0 ,,	17.42	17.80	4165	15.87	15.93	4750
Phorate	1.25 ,,	17.00	17.08	3883	13.21	11.35	4437
,,	*10.0 ,,	18.28	18.59	3974	15.73	14.38	4506
Monocrotophos	0.25 ,,	17.58	17.93	3570	11.19	11.26	4095
,,	2.0 ,,	15.70	15.43	3078	15.94	13.25	4371
Quinalphos	0.25 ,,	17.44	17.73	3576	14.23	12.31	4299
,,	2.0 ,,	16.01	15.27	3166	12.00	13.35	4380
Control		14.25	14.25	2934	9.56	9.56	3408

APPENDIX 1 Contd.

Treatments	Treated 15 DAS and 21 DAP		
	In potted plants g / pot		In field kg/ha
	A	B	B
Carbofuran			
0.5 + 0.5 kg ai/ha	19.11	19.26	2447
,, 0.5 + 1.0 ,,	21.19	21.40	3855.3
,, 4.0 + 0.5 ,,	25.74	26.86	3881.3
,, 4.0 + 1.0 ,,	23.04	23.05	3954
Phorate			
1.25 + 1.25 ,,	21.60	21.15	3750
,, 1.25 + 2.5 ,,	17.54	18.59	3505
,, 10.0 + 1.25 ,,	24.30	24.87	3855
,, 10.0 + 2.5 ,,	17.93	17.82	3602
Monocrotophos			
0.25 + 0.25 ,,	21.47	21.5	3869.6
,, 0.25 + 2.0 ,,	15.44	15.14	3741.7
,, 2.0 + 0.25 ,,	19.74	19.56	3873.7
,, 2.0 + 2.0 ,,	18.47	18.64	2204.7
Quinalphos			
0.25 + 0.25 ,,	17.86	18.44	2835.3
,, 0.25 + 2.0 ,,	17.87	14.45	3117.7
,, 2.0 + 0.25 ,,	16.06	20.84	3644.7
,, 2.0 + 2.0 ,,	17.38	17.46	2709
Control	16.29	16.29	2760

APPENDIX 1 Contd.

Results of statistical analysis of the data in Table 1.

Source	df	Mean squares		Mean squares	
Treatment	8	337.47**	446.5**	1924.04*	1273.9*
Error	18	75.83	60.16	747.17	430.1

Source	df	Mean squares	
Block	2	896.76	3407.34
Treatment	8	851.0**	432.84**
Error	16	42.37	107.5

Source	df	Mean squares	
Treatment	16	999.65**	1208.07**
Error	34	66.66	71.01

Source	df	Mean squares
Block	2	358.3
Treatment	16	1375.57**
Error	32	180.76

* Significant at 5% level

** Significant at 1% level

APPENDIX 2

Results of statistical analysis of the data in Table 2.

Source	df	Mean squares			
		7 DAP	14 DAP	21 DAP	28 DAP
Treatment	16	24.38*	32.12**	70.5**	28.89
Error	34	11.67	10.9	17.41	24.63

Source	df	Mean squares			
		7 DAP	14 DAP	21 DAP	28 DAP
Block	2	0.228	1.357	49.02	32.83
Treatment	8	4.052**	52.778**	25.02	23.49
Error	16	0.601	7.762	23.65	27.58

Source	df	Mean squares					
		28 DAP	35 DAP	42 DAP	49 DAP	56 DAP	63 DAP
Treatment	16	16.6*	24.04**	23.49**	25.04**	29.7**	25.9**
Error	34	7.71	7.92	7.73	7.57	7.8	7.14

* Significant at 5% level

** Significant at 1% level

APPENDIX 2 Contd.

Source	df	Mean squares				
		28 DAP	35 DAP	42 DAP	49 DAP	56 DAP
Block	2	1.23	2.24	7.78	4.48	12.46
Treatment	16	11.72	13.94	17.85	23.65**	25.36**
Error	32	12.94	6.9	7.58	5.24	5.44

Source	df	Mean squares					
		28 DAP	35 DAP	42 DAP	49 DAP	56 DAP	63 DAP
Treatment	32	37.61**	21.73	18.06	23.43	22.21	22.51*
Error	66	15.59	14.64	12.76	14.59	15.57	13.05

Source	df	Mean squares				
		28 DAP	35 DAP	42 DAP	49 DAP	56 DAP
Block	2	3.69	10.02	2.66	4.19	5.82
Treatment	16	47.24**	55.07**	43.61**	24.29**	23.69**
Error	32	9.66	15.48	9.08	7.21	4.26

* Significant at 5% level

** Significant at 1% level

APPENDIX 3

Results of statistical analysis of the data in Table 3

Source	df	Mean squares			
		8 DAP	23 DAP	38 DAP	53 DAP
Treatment	16	0.035*	0.510	1.547**	0.910**
Error	34	0.016	0.302	0.307	0.325

Source	df	Mean squares			
		8 DAP	23 DAP	38 DAP	53 DAP
Block	2	0.025	0.147	2.346	2.438
Treatment	8	0.365	0.083	0.210	0.666
Error	16	0.285	1.019	0.640	0.510

Source	df	Mean squares	
Treatment	16	1.10**	0.67**
Error	34	0.15	0.11

* Significant at 5% level

** Significant at 1% level

APPENDIX 3 Contd.

Source	df	Mean squares	
		36 DAP	51 DAP
Block	2	0.739	0.783
Treatment	8	0.247	0.377
Error	16	0.383	0.365

Source	df	Mean squares	
		36 DAP	51 DAP
Treatment	32	3.323**	2.399**
Error	66	0.468	0.406

Source	df	Mean squares	
		36 DAP	51 DAP
Block	2	0.34	1.71
Treatment	16	1.26	0.40
Error	32	0.73	0.32

** Significant at 1% level

APPENDIX 4

Results of statistical analysis of the data in Table 4.

Source	df	Mean squares		Mean squares	
		36 DAP	51 DAP	36 DAP	51 DAP
Block	2	0.160	1.593	0.168	0.01
Treatment	8	0.897**	2.530	1.905**	0.278**
Error	16	0.138	0.445	0.083	0.052

Source	df	Mean squares		Mean squares	
		36 DAP	51 DAP	36 DAP	51 DAP
Block	2	0.698	1.890	0.248	0.004
Treatment	8	0.989	1.219**	0.731*	0.350
Error	16	0.544	0.292	0.210	0.292

Source	df	Mean squares		Mean squares	
		36 DAP	51 DAP	36 DAP	51 DAP
Block	2	2.268	14.156	0.205	0.092
Treatment	16	3.116**	5.719**	2.445**	1.12**
Error	32	0.346	1.052	0.17	0.16

* Significant at 5% level

** Significant at 1% level

APPENDIX 5

Results of statistical analysis of the data in Table 5

Source	df	Mean squares	
Treatment	16	1.186	1.23*
Error	34	0.84	0.57

Source	df	Mean squares	
Block	2	27667.9	3439.5
Treatment	8	778.58	1654.8
Error	16	5839.6	1311.9

Source	df	Mean squares
Treatment	32	5.835**
Error	66	0.727

Source	df	Mean squares
Block	2	2691.8
Treatment	16	2637.6*
Error	32	1308.4

* Significant at 5% level

** Significant at 1% level

APPENDIX 6

Results of statistical analysis of the data in Table 6

Source	df	Mean squares	
Treatment	16	0.07	0.141
Error	34	0.058	0.075

Source	df	Mean squares	
Block	2	0.049	0.006
Treatment	8	0.098	0.081**
Error	16	0.054	0.019

Source	df	Mean squares
Treatment	32	0.122**
Error	66	0.051

Source	df	Mean squares
Block	2	0.069
Treatment	16	0.120**
Error	32	0.029

** Significant at 1% level

APPENDIX 7

Results of statistical analysis of the data in Table 8

Source	df	Mean squares					
		28 DAP	38 DAP	20 DAP	28 DAP	38 DAP	48 DAP
Block	2	0.464	0.062	0.815	2.18	0.172	0.164
Treatment	8	2.292	0.740	1.874	0.85	0.069	0.215
Error	16	1.01	0.177	0.383	0.94	0.132	0.247

Source	df	Mean squares			
		28 DAP	38 DAP	20 DAP	48 DAP
Block	2	0.544	0.608	0.312	0.025
Treatment	8	1.248	1.497	1.757	0.034
Error	16	1.371	0.473	0.567	0.039

Source	df	Mean squares					
		28 DAP	38 DAP	20 DAP	20 DAP	38 DAP	48 DAP
Block	2	0.418	0.329	2.592	0.824	1.525	0.181
Treatment	16	1.969	5.55**	0.522	0.085	0.162	0.25
Error	32	1.027	0.701	0.486	0.11	0.116	0.315

** Significant at 1% level

DETERMINATION OF PHYTOTONIC EFFECT OF INSECTICIDES ON RICE CROP

BY
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ABSTRACT OF THE THESIS
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ABSTRACT

The phytotonic effect of the commercial formulations of four insecticides viz. carbofuran, phorate, monocrotophos and quinalphos at different growth stages of rice was assessed through field experiments. The role of adjuvants in the formulations in causing the phytotonic effect was studied in pot culture studies.

When applied at 15 DAS alone carbofuran @ 0.5 kg ai/ha, phorate 1.25 kg ai/ha and monocrotophos and quinalphos at 0.25 kg ai/ha increased the yield significantly over control. Monocrotophos and quinalphos at 2 kg ai/ha were found phytotoxic. The higher doses of 4 kg ai/ha of carbofuran and 10 kg ai/ha of phorate were on par with the lower doses of the insecticides. This revealed the lower doses were the maximum levels to which the plants in nursery could respond to the toxicants.

When applied in main field at 21 DAP carbofuran at 1 kg ai/ha gave the maximum yield and it was followed by phorate 1.25 kg ai/ha which was on par 2.5 kg ai/ha of the toxicant. In the case of monocrotophos and quinalphos 2 kg ai/ha were found to be on par with phorate.

In the third experiment plants were treated with the above insecticides at different dose combinations once in

the nursery at 15 DAS and a second time in the main field at 21 DAP. The results showed that the treatments could not increase the yield more than the treatments made in the nursery alone or in the main field alone.

The above data indicated that the crop can be stimulated at nursery or in the main field for increasing the yield. The repeated application of pesticide may not enhance the yield. The dose requirement for optimum phytotonic effect may be low varying with insecticides and the stages of the crop at which applied. The dose ranges tried in the experiment were not adequate to fix the optimum levels.

The data from the pot culture studies showed that the yield increase caused by the various doses of insecticides due to their phytotonic effect were slightly higher than those obtained in the corresponding field experiments; they had an over-all agreement.

The yield obtained from the potted plants treated with commercial formulations of pesticides and those treated with corresponding doses formulated from the technical grades did not show significant variations. This indicated that the phytotonic effect observed could be attributed to the toxicant and not to the unknown adjuvants in commercial formulations.

The data on the yield contributing characters in various experiments were collected. The analysis of the data showed that the ranking of the treatments on the basis of yield increase did not strictly agree with the ranking based on the stimulating effect on various yield contributing characters. But significant positive correlations could be obtained between the yield contributing characters and the yield recorded in the different experiments. The correlation was more conspicuous in pot culture studies.

The data on the incidence of pest during the crop period revealed the negligible extent of possible damage that was prevented by the application of pesticides and thus contributing the increase in yield.

The technical materials formulated and applied on the crop were seen absorbed into the plant as effectively as commercial formulations as revealed by their persistent toxicity to brown plant hopper.

The high doses of pesticides used in the experiments did not leave residues of pesticides in grains at harvest above the tolerance limit.