EVALUATION OF CARBARYL, ENDOSULFAN AND MONOCROTOPHOS ON ARHAR AND SOYBEAN IN RELATION TO PHYTOTOXICITY, INCIDENCE OF MAJOR PESTS AND YIELD

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By

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CERTIFICATE-I

This is to certify that the thesis entitled, "EVALUATION OF CARBARYL, ENDOSULFAN AND MONOCROTOPHOS ON ARHAR AND SOYBEAN IN RELATION TO PHYTOTOXICITY, INCIDENCE OF MAJOR PESTS AND YIELD" submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURE of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bona fide research work carried out by Shri ALOK KUMAR AWASTHY under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

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This is to certify that the thesis entitled "EVALUATION OF CARBARYL, ENDOSULFAN AND MONOCROTOPHOS ON ARHAR AND SOYBEAN IN RELATION TO PHYTOTOXICITY, INCIDENCE OF MAJOR PESTS AND YIELD" submitted by Shri ALOK KUMAR AWASTHY to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirements for the degree of M.Sc. (Agr.) in the Department of Entomology, has been approved by the Students Advisory Committee and External Examiner(s) after an oral examination on the same.

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(Alok Kumar Awasthi)

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CHAPTER - 1

INTRODUCTION

Pulses enjoy a unique position in the human diet as they are potentially rich source of proteins. Among the pulses, soybean (*Glycine max* (L.) Merrill) and Arhar (*Cajanus cajan* (L.) Mill.), both are the important grain legumes, members of the pea family, grown widely in India. Both are very nutritious and almost as important as rest of pulses put together. Both are the important pulse crops of our country and play an important role in our agricultural economy. Major pegion-pea producing countries are India, Uganda, Burma and Dominican Republic while major soybean producing countries are U.S.A., China, Brazil and Indonesia.

All the agricultural crops are grown generally for their food value. Therefore, a great importance is attached to their proper cultivation and protection from pests and diseases, against which they have very limited tolerance. As a result, an intensive chemical spray programme is usually followed to control the harmful organisms.

One of the limitations of chemical application is phytotoxicity which may nullify, the control schedule. Pesticidal chemicals, when used on agricultural crops, should be evaluated for their effectiveness on the target organisms as well as for visible symptoms of injury, if any, to the host plant. Their possible effects on the vital physiological processes, and subsequent influence on ultimate yield and quality is generally not much emphasized. Potential damage to these processes may already have been inflicted even before visible symptoms of injury.

Photosynthesis i.e. carbon assimilation, the ability of green plants to fix atmospheric carbon dioxide into carbohydrates by using energy from sunlight, is the principal process which directly influence plant productivity. It is of great importance whether the pesticides which are effective in controlling plant pests without impairing the net photosynthate production can improve plant growth and increase the crop yield or it suppresses the development and adversly effect the fruit production i.e., the crop yield.

The chlorophyll concentration is of considerable importance to any crop plant, which itself is an efficient convertor of energy into photosynthates through the C-4 path way. The photosynthetic activity is more pronounced during the vegetative phase of the crop growth contributing to total dry matter production. Phytotoxic chemicals are compounds that cause death or injury to crop plants.

The phytotoxicity of any pesticide to crop, results into reduced yield, stunted growth, production of neorotic spots, yellowing, chlorosis, burning of leaves and at times even complete death of crop plant. The agricultural chemicals are capable of altering the physical and chemical composition of crop plants by influencing their physiology (Pritam Singh, 1970). Such alteraction in their composition is of critical importance to the plant productivity. In pulses the photosynthetic activity decline at the time of pod development (Sinha, 1973,1974). At this time phytotoxicity cause the drop of developing pod or the formation of not fully matured pods due to lack of sufficient supply of photosynthates. This will results in the reduction of pod setting and ultimately in yield of pulses.

The carbaryl, which is an important carbamate insecticide, commonly known as "sevin" was discovered by 'Lambrech' in 1953 and was introduced as an insecticide in 1965 by Union Carbide (U.S.A.). Although it is known to be a powerful insecticide for the control of many insect-pests species. It has been reported to be phytotoxic to certain crop plants. Chari and Patel (1970) reported for the first time such a phytotoxic effect of carbaryl in Arhar (Cajanus cajan). In later years, although several workers reported phytotoxic effect of carbaryl on arhar and soybean [Koehlar add Rachie (1972), Shrivastava (1973), Gangrade (1974), Kapoor et al. (1975), Balasubramanian et al.(1976), Anonymous (1978), Bergman and Pedige (1978), Anonymous (1979, 1980, 1981), Vaishampayan et al. (1982) and Odak (1983)] detailed studied are still lacking on its exact effect on pod setting, grain size and yield potential of the treated plants.

Preliminary trials were conducted at Jabalpur during 1982 on soybean and Arhar both (Vaishampayan et al. 1982). The present investigations were undertaken to observe in detail, the various aspects of phytotoxicity and confirm the results of earlier trials.

The present investigations were carried out with following specific objectives:

1. To study the phytotoxic effect of carbaryl dust as well as spray formulations, compared with endosulfan and monocrotophos sprays as standard and control on foliage as well as on pod setting and its subsequent effect on yield potential of plant.

2. To study the effect of the above insecticidal treatments on the major insects and the grain yield of soybean and Arhar.

CHAPTER - 2

REVIEW OF LITERATURE

The available literature relevant to the present studies has been reviewed under the following heads:

2.1 General phytotoxicity.

2.2 Specific to carbaryl.

2.2.1 General

2.2.2 Soybean

2.2.3 Arhar

2.3 Incidence of major insect-pests.

2.3.1 Soybean

2.3.2 Arhar

2.4 Chemical control of major insect-pests.

2.4.1 Soybean

2.4.2 Arhar

2.1 General phytotoxicity

Phytotoxic effect of pesticides, when applied to crop plants in field, is known to the entomologists since long. The earliest report is that of Hervey and Schroeder (1946) who reported DDT 3% dust to cause severe stunting of the Ohio-31 variety of cucumber.

Carrunth and Howe (1948) noted no phytotoxicity on table queen while on 'butter nut' and 'blue bubbard' chlorosis was produced resulting in 50% kill of the plants due to the application of 3% DDT, 1% gamma BHC and 2% chlorinated camphore dust.

Chapman and Allen (1948) observed chlorosis, necrosis, stunting and decreased yield of cucurbits treated with DDT and other chlorinated hydrocarbons.

Alban and Brown (1950) described the susceptibility of some of the cucurbits to DDT injury.

Banerjee and Chaterjee (1955) reported that DDT 1% spray does not cause any injury to the cucurbitaceous crops, while 4% and 5% BHC dust injured only <u>Lagneria vulgaris</u> which showed leaf burn.

Taiwania (1955) observed that DDT dust at 5% and 10% and BHC 0.5% and 1% caused chlorosis and affected the internal structures of watermelon leaves.

MacCollum (1956) studied effects and correction of DDT phytotoxicity to cucurbits and found that DDT injury is primarily associated with its ortho para and para para isomers.

Mukerjee and Wadhi (1956) studied the phytotoxicity of toxaphene, DDT, dieldrin, lindane and aldrin to some of the cucurbits.

Champ (1966) reported that DDT 1% spray (EC) killed or severely damaged the plant, while in form of dispersible powder it cause some marginal scorching and yellowing to cucurbit leaves.

Sood et al. (1972) observed that dimethoate was slightly phytotoxic to bottle gourd, cucumber and round gourd.

2.2 Specific to carbaryl

2.2.1 General

Lichtenstein et al. (1962) reported reduction in the rate of respiration of root tips was caused by carbaryl in peas and cucumber.

Ullah and Nadejde (1977) reported ultra low volume formulation containing 35% carbaryl (carbavur 3) to be effective for a long time against the aphid, but phytotoxic to cotton.

Tsai (1979) contrary to phytotoxic effect observed carbaryl at low concentration (10^{-6}n) to stimulate the germination of rice seeds and enhance both root and shoot growth.

2.2.2 Soybean

Gangrade (1974) reported that carbaryl (sevin) is a very powerful insecticide for the control of many insects of soybean but it caused phytotoxicity.

Kapoor *et al*. (1975) reported that 0.2% carbaryl was phytotoxic to soybean.

Bergman and Pedigo (1978) reported that carbaryl (sevin) at 2 lb toxicant/acre has caused leaf-scorch on the plants of soybean.

Vaishampayan *et al*. (1982) reported that carbaryl 0.2%, 0.4% sprays and carbaryl 10% dust treatments at both vegetative and flowering cum podding stages in soybean showed some phytotoxic effect but there had no significant effect on its yield potential.

2.2.3 Arhar

Chari and Patel (1970) reported phytotoxic action of carbaryl on pegion pea (*Cajanus cajan*).

Koehlar and Rachie (1972) reported severe phytotoxic effects of carbaryl on pegion pea.

Shrivastava (1973) reported that carbaryl proved some-what phytotoxic on pegion pea.

Balasubramanian *et al*. (1976) conducted two field experiments with 10 treatments to judge their effectiveness for the control of *Heliothis armigera* (Hb.), *Melanagromyza obtusa* (Mallock.) and *Exelaltis atmosa* (Wism) on red gram in Tamilnadu. He reported that although carbaryl both at 0.1% and 0.25% registered less pod borer damage, they did not give good yields in these trials.

At Coimbatore, different formulations of carbaryl showed phytotoxicity on pegion pea crop and adversly affected the yield (Anonymous, 1979).

Phytotoxicity on pegion-pea, due to use of carbaryl formulations in the form of yellowing and dropping of leaves was reported from Bangalore (Anonymous, 1980).

At Jabalpur, carbaryl treatment, though proved effective against borers, showed phytotoxic symptoms with yellowing of leaves, flower dropping and early maturity which lead to reduction in the number of pods borne by each plant of arhar. It adversely affected the yield also (Anonymous, 1981).

Vaishampayan *et al*. (1982) reported that carbaryl 0.2%, 0.4% spray and 10% dust treatments at both vegetative and flowering cum podding stages in arhar showed some phytotoxic effect but the yield in carbaryl treated crop (w.p. and dust both) was comparatively lower than monocrotophos treated plots (although non-significant).

Odak (1983) reported that the application of carbaryl 5% dustb showed phytotoxic symptoms on pegion pea crop and adversely affected the yield also.

2.3 Incidence of major insect-pests:

2.3.1 Arthropod pests of soybean:

Fletcher (1914) noted the larvae of *Lamprosema indicata* F. through out the plains of South India.

Fletcher (1920) reported that the leaf miner *Stomopteryx subsecivella* zeller. is a specific pest of soybean, which appeared in epidemic form in Maharashtra.

Plank (1946) reported that the leaf roller *Lamprosema indicata* F. was largely responsible for loss of 50% to 75% leaf area in fieldsof seminole variety of soybean in 1944 in Puerto Rico.

Vander-Iaan (1953) reported that the injury caused by *Stomopteryx subsecivella* zeller was observed in different varieties of soybean in Jawa and Sumatra, larva feeds on a short blister like mine in the leaf for about 18 days, after which it emerged and webbed several leaflets together, forming a shelter in which it completed its development.

Gangrade (1971) reported that the mean population of Heliothis armigera ranged from 0.26 to 1.42 per 100 plants in the rabi season and 3.50 to 8.25 per 100 plants in the kharif season. The leaf folder, Lamprosema indicata F. appeared in August and continued upto the end of September and also in November-February in case of humid winter. About 4 to 5 larvae per 100 plants in kharif season were reported. Larvae have a habit of folding soybean leaves from the tip inwards or alongwith mid-rib.

Singh (1969) reported tobacco caterpillar, Spodoptera littoralis as a serious pest of soybean in the Himalayan area. The larvae of this pest defoliate the crop in September.

Singh and Chibber (1969) recorded that the semi looper Plusia orichalcea Fbr. is a polyphagous looper and devours voraciously the foliage and other soft vegetative parts of soybean. Besides soybean, it caused extensive damage to cauliflower, cabbage and other crops. The pest is widely distributed in India.

Gangrade (1976) reported that the leaf miner, Stomopteryx subsecivella zeller is a specific pest of soybean, which appeared in epidemic form at Jabalpur during September 1971. The larvae of leaf miner mined the leaves under the epidermis resulting in scorched or crinkiling symptoms.

Bhattacharjee (1977) reported that two species of leaf roller, Lamprosema dimenalis Gns. and L. indicata F. sporadically caused considerable damage to crop of soybean in India. It appears that the outbreak occurs only sporadically because the pests are held in check by natural enemies.

2.3.2 Pod Borer Complex of Arhar:

Fletcher (1917) described Exelastis atmosa as a common insect attacking tur crop, causing more damage to tur than others.

Ahmad (1937) reported that 59% and 86% of pegion pea pods were damaged by the pod fly, Agromyza obtusa in Delhi and Pusa (Bihar), respectively.

Ayyar (1940) described the caterpillar of Exelastis atmosa as a typical borer cutting through the pod and feeding on the seeds internally.

Shrivastava (1972) recorded 29.1 percent pod, 20.8 percent grain damage and 45.7 percent loss in weight by tud pod fly in Type-21 variety.

Saxena (1974) reported that most of the early maturing varieties, compact and determinate types, are especially severely damaged by pod boring insects.

Veda *et al.* (1975) observed that *Melanagromyza obtusa*, *E. atmosa* and *Heliothis armigera* are the major insect-pests of *Cajanus cajan* in and around Jabalpur.

Daware *et al.* (1982) reported that the pods of red gram (*C. cajan*) in Maharashtra are subjected to attack by the larvae of *H. armigera*, *M. obtusa* and *E. atmosa*.

2.4 Chemical control of major insect pests

2.4.1 Soybean:

Rawat *et al.* (1969) reported chemical control of leaf folder *Lamprosema indicata* F. by both foliar and soil insecticides. Among foliar treatments, monocrotophos 0.04% gave complete protection to soybean crop against the leaf folder.

Chari and Patel (1972) tested the efficacy of 0.025% methomyl, 0.05% quinolphos, 0.04% monocrotophos and 0.05% fenitrothion against the larvae of *Spodoptera litura* F. in field. 0.025% methomyl, 0.05% quinolphos and 0.04% monocrotophos were found more effective than 0.05% fenitrothion.

Kapoor et al. (1975) evaluated dusts and sprays of 11 insecticides against the larvae of Biloba subsecivella (Stomopteryx subsecivella zeller.) on soybean in field spray of 0.05% fenitrothion and 0.2% carbaryl and parathion 2% dust gave effective control of first and second instar larvae. Yield differences were nonsignificant. None of the treatment was effective against third instar larvae or pupae.

Balasubramanian and Afafalik (1978) conducted an experiment to assess the susceptibility of Spodoptera litura to commonly used as well as newer insecticides. The results indicated leptophos to be the most toxic one followed by chlorpyriphos, phenthoate, monocrotophos and heliotox, respectively.

Thombre (1983) studied relative efficacy of different insecticides against leaf folder, Lamprosema indicata. Out of 7 insecticides, the monocrotophos 0.05% was found to be highly effective even upto 7 days after the treatment. Cypermethrin 0.1% was equally effective against the pest.

2.4.2 Arhar:

Saharia and Datta (1975) concluded that the three sprayings of endosulfan 0.08% gave relatively better results in reducing the mean percentage infestation of gram pod borer, H. armigera (Hb.)

Balasubramanian et al. (1976) reported endosulfan at 0.07% on highly effective against all pod borers and in turn recorded maximum yield.

Sangappa et al. (1977) reported that pod borer, H. armigera (Hb.) is a serious pest of pegion pea and can effectively be controlled by three sprayings of endosulfan 0.07%, carbaryl 0.01% and chlordane 0.07% at 15 days interval commencing from blossom stage.

Sinha et al. (1977) observed that the two sprayings of monocrotophos 0.5 kg.a.i./ha effectively checked the incidence of plume moth while quinolphos 0.6 kg.a.i./ha proved equally effective in reducing the damage of pod fly on early and late varieties of red gram, respectively.

Surulivelu et al. (1977) reported that endosulfan (0.07%), monocrotophos 0.04% and dimethoate 0.03% were highly effective against the pod borers, testes in kharif and rabi seasons at Coimbatore. The plots treated with monocrotophos gave maximum yield.

Subasinghe et al. (1978) reported that pod borers have made cultivation of pegion pea virtually impossible without regular spraying of insecticides. They found Monocrotophos and endosulfan at 1.1 kg.a.i./ha to be most effective and recommended three applications of either insecticides at fortnightly intervals commencing from flowering stage.

Darware et al. (1982) tested seven insecticides for the control of all the three borers, the insecticides were applied once at the beginning of pod formation and again a fortnight later. Emulsions containing 0.04% monocrotophos, 0.04% fenitrothion, 0.07% endosulfan, 0.07% phosalone, 0.03% dimethoate, 0.05% quinalphos and 0.1% formothion, all applied at 500 l/ha proved superior to control with nonsignificant difference among them in controlling the pest. But the yield was higher in monocrotophos than any other compound.

Bandale et al. (1983) conducted an experiment with commonly used compounds BHC 0.2%, endosulfan 0.05%, Carbaryl 0.2%, methomyl 0.05% against Heliothis armigera (Hb.) on red gram (Cajanus cajan). All the treatments except BHC, significantly reduced the pod infestation, compared to untreated plots.

CHAPTER - 3

MATERIALS AND METHODS

In case of soybean, the experiment was conducted in the experimental area of the Department at Jabalpur during *kharif* 1983-84. To evaluate the phytotoxic effects of carbaryl on Arhar the crop sown by the Department of Plant Breeding and Genetics grown for seed multiplication was utilized. The weather conditions prevailed during the crop growth have been presented in Appendix-A.

Details of Experimental Lay out and Treatments:

Crop: Soybean (*Glycine max.* (L.) Merrill)

Variety - J.S. 72-44 (Gaurav)

Design - Randomized Block design (Fig. 3.1)

Replications - 4

No. of treatments - 6

Gross plot size - 4 x 2.5 m = 10 sq.m.

Total No. of plots - 24

No. of rows/plot - 6 rows/plot

Row length - 4 m

Field size - 18 x 18 m = 324 sq.m.

Spacings - (i) plant to plant - 10 cm

(ii) row to row - 40 cm

(iii) plot to plot - 1/2m = 50 cm

(iv) replication to replication - 1 m = 100 cm.

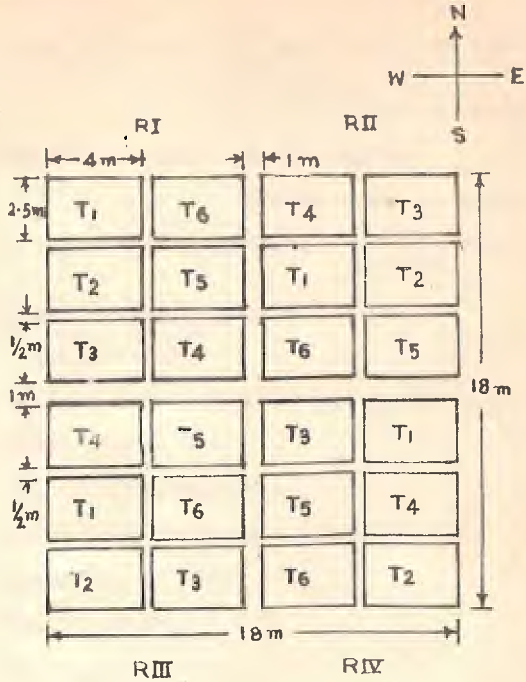

FIG. 3-1 - LAY OUT PLAN - SOYBEAN

TREATMENTS -

T_1 - ENDOSULFAN (0·05%)

T_2 - MONOCROTOPHOS (0·04%)

T_3 - CARBARYL (0·2%)

T_4 - CARBARYL (0·1%)

T_5 - CARBARYL 10% DUST

T_6 - CONTROL (UNTREATED)

Seed treatment – Before sowing the seed, they were treated by soybean inoculum @ 5 gm. of inoculum and 1.5 gm thiram/kg of seed by slurry technique.

Fertilizer dose – N = 20 kg/ha

P = 35 kg/ha as basal dose

Interculture operations – weeding was done thrice by hand.

Crop: Arhar (*Cajanus cajan* (L.) Mill.)

Variety – T-21

Design – Randomized block design (Fig. 3.2)

Replications – 4

No. of treatments – 6

Gross plot size – 4 x 3 m = 12 sq.m.

Total No. of plots – 24

No. of rows/plot – 5

Row length – 4 m

Field size – 20.5 x 19.0 m = 389 sq.m.

Spacings – (i) plant to plant – 15 cm or 0.15 m.

(ii) row to row – 60 cm or 0.6 m

(iii) plot to plot – 0.5 m

(iv) replication to replication – 1 m.

Seed treatment – Arhar seeds were treated before sowing with 1.5 gm thiram/kg. of seed and Rhizobium culture 5 gm/kg. of seed.

Fertilizer dose – N = 20 kg/ha

P = 75 kg/ha as basal dose.

Interculture operations: After one month of sowing, first hoeing and weeding were done. The second hoeing and weeding were done after one month of first interculture operation.

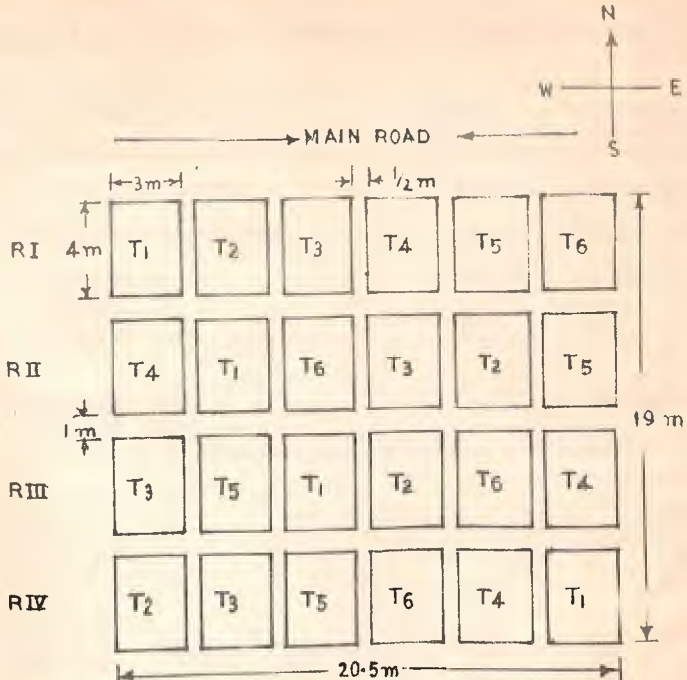

FIG.3·2 - LAY OUT PLAN - ARHAR

TREATMENTS -

T_1 - ENDOSULFAN (0·05%)
T_2 - MONOCROTOPHOS (0·04%)
T_3 - CARBARYL (0·2%)
T_4 - CARBARYL (0·1%)
T_5 - CARBARYL 5% DUST
T_6 - CONTROL (UNTREATED)

Table 3.1: Details of treatments of soybean crop

S.No.	Treatments	Conc. available	Insecticide dose/ha
1.	Endosulfan 0.05%	35 EC	1.50 l/ha
2.	Monocrotophos 0.04%	36 BC	1.11 l/ha
3.	Carbaryl 0.1% (sevin)	50 w.p.	2 kg/ha
4.	Carbaryl 0.2% (sevin)	50 w.p.	4 kg/ha
5.	Carbaryl 10% (sevin) dust	-	20 kg/ha

Table 3.2: Details of treatments of arhar crop

S.No.	Treatments	Conc. available	Insecticide dose/ha
1.	Endosulfan 0.05%	35 EC	1.25 l/ha.
2.	Monocrotophos 0.04%	36 EC	0.925 l/ha
3.	Carbaryl 0.1% (sevin)	50 w.p.	1.66 kg/ha
4.	Carbaryl 0.2% (sevin)	50 w.p.	3.33 kg/ha
5.	Carbaryl 5% dust (sevin)	-	20 kg/ha

Foliar applications of treatments:

Only one foliar treatment was given on October 18, 1983 at flowering-cum-podding stage of Arhar crop, whereas two foliar sprays were given to soybean, first on August 26, 1983 at vegetative stage and second on September 17, 1983 at flowering-cum-podding stage. At flowering stage all pods, which were visible were removed from the sample plants before the application of insecticides in both the crops.

In both the crops the foliar application of insecticides was given to evaluate the phytotoxic effect of carbaryl, compared with endosulfan and monocrotophos sprays as standard and control and their effect on the major pests of soybean andonly pod borer complex of arhar.

Observations:

(A) Study on the phytotoxic effect of carbaryl on soybean and arhar.

Observations on foliage injury:

In order to study the phytotoxic effect of carbaryl on soybean and arhar, the foliage injury was considered important and evaluated visually. The phytotoxic symptoms were evaluated on the basis of mean injury index with grade points of 1, 2, 3 and 4 for healthy plants, slight, moderate and severe injury symptoms, respectively. For this purpose 10 plants per plot were randomly selected in soybean and 5 plants per plot were randomly selected in arhar.

The observations on foliage phytotoxicity were taken 3 days, one week and two weeks after the insecticidal application.

Phytotoxicity assessment:

Foliage injury due to insecticidal phytotoxicity was considered important and evaluated visually. The injury was recorded on a numerical scale of grade point 1-4, in both the crops as follows:

Grade No.	Symptoms
1	- Healthy plants (no injury)
2	- Slight injury symptoms
3	- Moderate injury symptoms
4	- Severe injury symptoms

The observation on leaf deformity, burn, chlorosis etc. were recorded due to insecticidal phytotoxicity on foliage.

Symptamatology of grade points of injury index phytotoxicity:

Grade (1) : This covers the healthy plants and leaves show no phytotoxic symptoms after insecticidal application.

<u>Grade (2)</u>: This includes the slight injury symptoms and leaf shows slight yellowing after insecticidal application.

<u>Grade (3)</u>: This includes the moderate phytotoxic injury symptoms and leaf shows yellowing with brown pin head specks after insecticidal application.

<u>Grade (4)</u>: This covers the severe injury symptoms and the entire leaf shows yellowing with brown pin head specks and marginal browning. At this stage of injury, shading of leaves takes place.

All injury symptoms due to the insecticidal phytotoxicity appears only on the upper surface of leaf and on the basis of injury index, sampled plants were graded.

<u>Formula of calculating mean injury index</u>:

The mean injury index was calculated by the following formula (Vaishampayan and Kogan, 1980)

$$I = \frac{(G_1 \times P_1) + (G_2 \times P_2) + (G_3 \times P_3) + (G_4 \times P_4)}{P_1 + P_2 + P_3 + P_4}$$

where, I = injury index,

G = grade of injury, and

P = number of plants in that category.

Effect on pod setting/pod and grain size:

The total number of pods were counted from three twigs (30 cm of each plant) in soybean and total number of pods counted from five twigs per plant (each twig of 50 cm of height from top) in arhar and total number of pods were also counted from sample plants at harvest. Hundred pod and grain weight were also recorded at harvest.

Effect on yield:

Grain yield on net plot basis were also recorded of both the crops at harvest.

(B) Effect of different insecticidal treatments on the major insect-pests of soybean and pod borer complex of Arhar:

In this experiment the main objective was to evaluate the phytotoxic effect of carbaryl (sevin) and its subsequent effect on yield potential of the plants. Endosulfan (thiodan) and monocrotophos (nuvacron) were taken as standard with control to evaluate the actual loss in yield due to the insecticidal phytotoxicity by comparing the yield of various treatments together. It was assumed that all the three insecticides are equally effective in controlling various insect-pests of both the crops. Hence any reduction in yield in carbaryl, compared to endosulfan or monocrotophos, could be attributed to its phytotoxic effect.

While recording observations on phytotoxicity these insecticides were also evaluated for their effects on the incidence of major pests and ultimately on the yield of crop.

Foliage feeders:

Observations were recorded 24 hrs. before and one week and two weeks after the application of insecticides with a sample unit of 1/2 m. row length of crop per row. Five such samples were randomly observed per plot and the data were statistically analysed.

Pod borer: The total number of healthy and damaged pods due to pod borer, *Heliothis armigera* (Hb.) were counted from 10 randomly selected plants/plot at harvest and percentage pod damage was estimated in different treatments due to pod borer of soybean.

Study on the effect of different insecticides on pod borer complex in Arhar:

Red gram (*Cajanus cajan* (L.) Mill.) crop suffers heavly due to the attack of three important species of pod borers viz.

(i) Gram pod borer : Heliothis armigera (Hb.)

(ii) Tur plume moth : Exelastis atmosa (W.)

(iii) Tur pod fly : Melanagromyza obtusa (Mallock)

The incidence of all these pod borers in combine, in different treatments was estimated by counting total number of healthy and damaged pods from five randomly selected plants/plot/replication and computing percentage pod damage from these borers.

Statistical analysis:

The larval population data were analysed statistically after proper transformation. The population data were transformed following square root transformation ($\sqrt{x + 0.5}$) while percent pod damage data were transformed by angular transformation.

CHAPTER - 4

RESULTS

(A) Results on soybean:

Data were analysed statistically and the results have been presented on the following heads:

4.1 Phytotoxicity to soybean

4. 1.1 Phytotoxicity to foliage

4.1.2 Phytotoxic effect on pod setting

4.1.3 Phytotoxic effect on size of pod and grain

4.1.4 Comparative efficacy of various insecticidal treatments in the control of *Spodoptera litura* (Fb.) on soybean.

4.1.5 Effect of different insecticidal treatments on pod damage in soybean.

4.1.6 Effect on total grain yield of soybean.

(B) Results on arhar:

4.2 Phytotoxicity to arhar

4.2.1 Phytotoxicity to foliage

4.2.2 Phytotoxic effect on pod setting

4.2.3 Phytotoxic effect on size of pod and grain

4.2.4 Percentage pod damage by pod borer complex at harvest.

4.2.5 Effect on total grain yield of arhar.

4.1 Phytotoxicity to soybean:

4.1.1 Phytotoxicity to foliage:

Observations on leaf phytotoxicity, expressed numerically in grade points in a range of 1 to 4, were made three days, one week and two weeks after the insecticidal application.

No phytotoxic symptoms were recorded in observations made after three days of application in all the insecticidal treatments. One week after treatment however, the symptoms appeared in plants treated with Carbaryl 10% dust and Carbaryl sprays (0.1% and 0.2%).

The leaf surface turned slightly yellowish, first the edges and then the entire leaf surface. Later on, light brown specks or pin head spots appeared on the entire leaf surface and the leaf showed marginal browning.

The data of phytotoxicity measured numerically in terms of phytotoxicity index values(weighted mean) in a range of 1 to 4 are summarized in Table 4.1.

The analysis of data (Table 4.1) revealed significant differences in the mean injury index in different insecticidal treatments. The highest mean injury index of 2.175 was recorded in Carbaryl 10% dust (Fig. 4.1) which was significantly higher than all other treatments. In Carbaryl 0.2% spray also the phytotoxicity index (1.35) was significantly higher than endosulfan, monocrotophos and control. Carbaryl 0.1% spray however did not show significant effect. No phytotoxic symptoms were recorded in endosulfan 0.05% and monocrotophos 0.04%.

Table 4.1: Comparative leaf phytotoxicity of Carbaryl, monocrotophos and endosulfan on soybean.

S.No.	Treatments	Mean phytotoxicity grade index values* after insecticidal application on foliage (mean of 4 replications)		
		3 days after	1 week after	2 weeks after
1.	Endosulfan 0.05%	1.000	1.000	1.000
2.	Monocrotophos 0.04%	1.000	1.000	1.000
3.	Carbaryl 0.1%	1.000	1.150	1.200
4.	Carbaryl 0.2%	1.000	1.350	1.325
5.	Carbaryl 10% dust	1.000	2.175	2.225
6.	Control	1.000	1.000	1.000
	S.Em ±	-	0.079	0.068
	C.D. (0.05)	N.S.	0.239	0.207

* Phytotoxicity injury index - 1 to 4 grade

(1) Healthy plant (no injury), (2) Slight injury ; (3) Moderate injury ; (4) Severe injury symptoms.

Fig. 4.1: Phytotoxicity of carbaryl 10% dust on soybean foliage after one week from insecticidal application.

Qualitatively the phytotoxicity was of slight and moderate levels in carbaryl 2% spray and carbaryl 10% dust respectively and absolutely nil in endosulfan 0.05%, monocrotophos 0.04% and control respectively.

Similar results were obtained after two weeks of spray also. Only the carbaryl 10% dust showed some increase in injury index due to its phytotoxicity, increasing from 2.175 to 2.225 after two weeks of application.

The toxicity slightly advanced further and there was no advancement in the symptoms beyond moderate grade. More over the new foliage was free from phytotoxic symptoms.

4.1.2 <u>Phytotoxic effect on pod setting</u>:

Phytotoxicity to pods of soybean was recorded in terms of pod setting after one week from insecticidal application. The data are presented in Table 4.2.

In observations made one week after insecticidal treatment although differences in total number of pods set in different treatments were nonsignificant; numerically they were lower in carbaryl 0.1%, carbaryl 0.2% and carbaryl 10% dust as compared to control.

Pod setting thus, may have been adversely affected in carbaryl treated plots, by dropping of flowers, dropping of developing pods or adversely affecting the viability of pollens.

Table 4.2: Comparative phytotoxicity of carbaryl; monocrotophos and endosulfan on pod setting of soybeans:

S.No.	Treatments	Mean number of pods set/10 samples* (Mean of 4 replications one week after treatment)
1.	Endosulfan 0.05%	249.50
2.	Monocrotophos 0.04%	231.00
3.	Carbaryl 0.1%	210.75
4.	Carbaryl 0.2%	221.00
5.	Carbaryl 10% dust	227.75
6.	Control	234.25
	S.Em. ±	13.939
	C.D. (0.05%	N.S.

* Sample unit - 3 twigs, 30 cm, each/sample plant.

4.1.3 Phytotoxic effect on size of pod and grain (Shrieveling effect):

Observations on phytotoxicity to pods and grains of soybean were made, in terms of weight/100 pods and weight/100 grains at harvest. Data are presented in

Table 4.3. The analysis of data of observations made on the effect of carbaryl on the size of pod, expressed in terms of weight per 100 pods, revealed nonsignificant differences in pod weight in different treatments. Numerically however, the pod weight was lowest in carbaryl 10% dust, even lower than control plot. The highest pod weight was recorded in monocrotophos 0.04%, (46.50 gm.). Results thus indicate that carbaryl may have some adverse effect on pod growth.

Table 4.3: Phytotoxic effect of Carbaryl, monocrotophos and endosulfan on pod and grain size of soybean

S.No.	Treatments	weight/100 pods* (gms)	Weight/100 grains* (gms)
1.	Endosulfan 0.05%	45.45	14.95
2.	Monocrotophos 0.04%	46.50	16.20
3.	Carbaryl 0.1%	44.10	14.37
4.	Carbaryl 0.2%	44.77	14.80
5.	Carbaryl 10% dust	41.30	14.22
6.	Control	44.27	15.32
	S.Em. ±	1.33	0.361
	C.D. (0.05)	N.S.	1.08

* Mean of 4 replications

The analysis of data of observations made on the effect of carbaryl on the size of grain, expressed in terms of weight per 100 grains revealed significant difference in grain weight in different treatments. The grain weight ranged from 14.22 to 16.20 grams. The lowest grain weight was recorded in carbaryl 10% dust (14.22 gms) being significantly lower than control followed by carbaryl 0.1%, carbaryl 0.2% and endosulfan 0.05% with no significant difference among themselves. The highest grain weight was recorded in monocrotophos 0.04% (16.20 gms.) followed by control (15.32 gms) with no significant difference among the two. Compared to control the grain weight, was significantly lower in carbaryl 10% dust. In carbaryl 0.1% as well as 0.2% sprays also the grain weight was lower than control but not significant.

The result thus revealed that carbaryl 10% dust has adversely affected the size of seed also.

4.1.4 Comparative efficacy of various insecticidal treatments in the control of *Spodoptera litura* (Fb.) on soybean:

Almost all the foliage feeders of soybean (*Lamprosema indicata*, *Plusia orichalcea*, *Anarsia ephippias*, *Stomopteryx subsecivella* and *Spodoptera litura*), appeared on the crop have been observed in the present study but their populations were very low except, tobacco caterpillar, Spodoptera litura (Fb.), hence only this foliage feeder has been considered for further studies.

The comparative efficacy of insecticides which included in phytotoxicity trials were tested for their effectiveness against Spodoptera litura (Fb.). The data are summarised in Table 4.4.

The pre-treatment pest population in plots under different treatments showed no significant differences indicating thereby that the pest population was uniformly distributed. Population per 1/2 meter row was 2.25(1.65).

Post treatment observations (after first spray):

(i) After one week on 3.9.83

All insecticidal treatments proved significantly superiority over control.

The population of S. litura (Fb.) was lowest in monocrotophos 0.04% (0.25) followed by endosulfan 0.05% (0.50), carbaryl 0.2% (0.50) and carbaryl 0.1% (0.75) which were at par with monocrotophos 0.04% and also with carbaryl 10% dust, (1.00).

(ii) After two weeks on 11.9.83

The data (Table 4) revealed that the differences due to treatment were significant. Monocrotophos 0.04%

Table 4.4: *Comparative efficacy of various insecticidal treatments in the control of* *Spodoptera litura* *(Fb.) on soybean*

S.No.	Treatments	Concentration	Mean larval population per 25 plants (Mean of 4 replications)				
			Pretreatment	After first application		After second applications	
				1 week after	2 weeks after	1 week after	2 weeks after
1.	Endosulfan (35 EC)	0.05%	2.00 (1.58)*	0.50 (0.96)	1.00 (1.22)	1.00 (1.22)	2.50 (1.72)
2.	Monocrotophos (36 EC)	0.04%	2.25 (1.65)	0.25 (0.83)	0.75 (1.09)	0.25 (0.83)	1.50 (1.40)
3.	Carbaryl (50 w.p.)	0.1%	1.50 (1.40)	0.75 (1.09)	2.00 (1.56)	1.25 (1.31)	2.50 (1.72)
4.	Carbaryl (50 w.p.)	0.2%	2.00 (1.58)	0.50 (0.96)	1.25 (1.31)	0.75 (1.09)	1.75 (1.47)
5.	Carbaryl dust	10%	1.75 (1.49)	1.00 (1.22)	1.75 (1.49)	1.00 (1.18)	2.00 (1.55)
6.	Control	-	2.00 (1.58)	2.75 (1.78)	4.00 (2.11)	5.75 (2.47)	4.00 (2.10)
	S.Em.	-	0.067	0.102	0.106	0.144	1.150
	C.D. (0.05)	-	N.S.	(0.308)	(0.319)	(0.434)	N.S.

* Transformed figures given in parenthesis indicate $\sqrt{n + 0.5}$

proved significantly better than carbaryl 0.1% and carbaryl, 10% dust and on par with endosulfan, 0.05% carbaryl, 0.2%.

Post treatment observation:

(i) After one week on 25.9.83 (after 2nd spray):

All the insecticidal treatments proved significantly superior over control. The monocrotophos 0.04% was found to be significantly superior over the carbaryl 0.1% and on par with the endosulfan 0.05%; carbaryl 0.2% and carbaryl 10% dust.

(ii) After two weeks on 3.10.83:

The analysis of data revealed that no significant difference among different treatments. No insecticidal treatment proved better than control.

4.1.5 Effect of different insecticidal treatments on pod damage in soybean:

The analysis of data (Table 4.5) revealed that pod damage was significantly lower in carbaryl 0.2%; Endosulfan 0.05%; Carbaryl 10% and monocrotophos 0.04% as compared to control with no significant differences among themselves.

4.1.6 Effect on total Grain yield of soybean:

Grain yield of soybean was recorded at harvest,

Table 4.5: Effect of different insecticidal treatments on pod damage in soybean

S.No.	Treatments	Mean percent pod damage (at harvest) (Mean of 4 replications)
1.	Endosulfan 0.05%	2.86 (9.77)*
2.	Monocrotophos 0.04%	3.34 (10.53)
3.	Carbaryl 0.1%	4.65 (12.41)
4.	Carbaryl 0.2%	2.81 (9.54)
5.	Carbaryl 10% dust	3.18 (10.14)
6.	Control	5.14 (13.02)
	S.Em ±	0.700
	C.D. (0.05)	2.108

* Transformed figures (angular) given in parenthesis ( ).

Bar diagram

Carbaryl 0.2%	Endosulfan 0.05%	Carbaryl 10% dust	Monocrotophos 0.04%	Carbaryl 0.1%	Control (untreated)
9.54	9.77	10.14	10.53	12.4	13.02

presented in Table 46. The total number of pods set/10 samples plants at harvest, represented in the same table.

In observations made at harvest on total number of pods set/10 plants in different treatments, although the differences were non-significant, numerically they were lower in carbaryl 0.1% and carbaryl 10% dust as compared to control. Over all pod setting thus, may have been adversely affected in carbaryl 0.1% and carbaryl 10% dust treated plots.

The yield data revealed significant difference in the yield in different treatments. The lowest yield was recorded in carbaryl 0.1% (0.850 kg) which was at par with the carbaryl 10% dust; control and carbaryl 0.2%. The highest yield of 1.271 kg/plot was recorded in monocrotophos 0.04%, which was significantly higher than all other treatments except the endosulfan 0.05% (1.149 kg/plot) which was in turn on par with the carbaryl 10% dust; control and carbaryl 0.2% spray.

4.2 Phytotoxicity to arhar:

4.2.1. Phytotoxicity to foliage:

Observations on leaf phytotoxicity, expressed numerically in grade points in a range of 1 to 4, were

Table 4.6: Effect of carbaryl, monocrotophos and endosulfan on total yield of soybean

S.No.	Treatment	Total No. of pods set*/10 samples (at harvest)	Average yield* per plot 9kg)
1.	Endosulfan 0.05%	811.50	1.149
2.	Monocrotophos 0.04%	732.00	1.271
3.	Carbaryl 0.1%	615.00	0.850
4.	Carbaryl 0.2%	701.75	0.992
5.	Carbaryl 10% dust	675.50	0.901
6.	Control	678.00	0.981
	S.Em. ±	50.53	0.085
	C.D. (0.05)	N.S.	0.255

* Mean of 4 replications

made three days, one week and two weeks after the insecticidal application.

No phytotoxic symptoms were recorded in observations made after three days of application in all the insecticidal treatments. One week after treatment however, the symptoms appeared in plants, treated with carbaryl 0.2% spray, carbaryl 5% dust and carbaryl 0.1% spray.

The leaf surface turned slightly yellowish, first the edges and then the entire leaf surface. Later on, light brown specks or pin head spots appeared on the entire leaf surface and the leaf showed marginal browning.

The data of phytotoxicity, measured numerically in terms of phytotoxicity index value (weighted mean) in a range of 1 to 4 are summarized in Table 4.7.

Table 4.7: Comparative leaf phytotoxicity of carbaryl, monocrotophos and endosulfan in arhar.

S.No.	Treatments	Mean phytotoxic grade Index values* at flowering stage after treatment (mean of 4 replications)		
		3 days after	1 week after	2 weeks after
1.	Endosulfan 0.05%	1.000	1.000	1.000
2.	Monocrotophos 0.04%	1.000	1.000	1.000
3.	Carbaryl 0.1%	1.000	2.150	2.000
4.	Carbaryl 0.2%	1.000	2.750	3.500
5.	Carbaryl 5% dust	1.000	2.450	2.040
6.	Control	1.000	1.000	1.000
	S.Em. ±	0.00	0.050	0.075
	C.D. (0.05)	N.S.	0.151	0.228

* Phytotoxicity injury index

Grade 1 to 4: (1) Healthy plants (no injury); (2) Slight injury; (3) Moderate injury; (4) Severe injury symptoms.

The analysis of data revealed significant differences in the mean injury index in different insecticidal treatments. The highest mean injury index of 2.750 was recorded in carbaryl 0.2% spray (Fig. 4.2) followed by carbaryl 5% dust (Fig. 4.3) and carbaryl 0.1% spray, differing significantly with each other and showed significantly higher phytotoxic effect compared to remaining three treatments viz., endosulfan, 0.05%, monocrotophos 0.04% and control (Fig. 4.4). No phytotoxic symptoms were recorded in these treatments.

The analysis of observation after two weeks of insecticidal application showed significant differences among the various treatments. The highest mean injury index of 3.500 was recorded in carbaryl 0.2% spray, which was significantly higher than all the remaining treatments. The injury index in carbaryl 5% dust and carbaryl 0.1% spray also found to be significantly higher over the endosulfan 0.05% monocrotophos 0.04% and control but not significantly differing with each other. No phytotoxic symptoms were recorded in endosulfan 0.05% and monocrotophos 0.04%.

Qualitatively the phytotoxicity was of slight and moderate levels in all the carbaryl treatments. The toxicity slightly advanced further and the advancement

Fig. 4.2: Carbaryl phytotoxicity on Arhar foliage at 0.2% concentration after one week from insecticidal application.

Fig. 4.3: Phytotoxicity of carbaryl 5% dust on Arhar foliage after one week from insecticidal application.

Fig. 4.4: Foliage of Arhar from control (untreated) plot .

in the symptoms was found to be beyond the moderate grade in carbaryl 0.2% with injury index value of 3.5000. The new foliage was however free from phytotoxic symptoms.

4.2.2 Phytotoxic effect on pod setting:

Phytotoxicity to pods of arhar was recorded in terms of pod setting after one week from insecticidal application. The data are presented in table 4.8.

Table 4.8: Comparative phytotoxic effect of carbaryl, monocrotophos and endosulfan on pod setting of arhar.

S.No.	Treatments	No. of pods set/5 samples* (mean of 4 replications) (one week after treatment)
1.	Endosulfan 0.05%	153.00
2.	Monocrotophos 0.04%	140.75
3.	Carbaryl 0.1%	143.25
4.	Carbaryl 0.2%	142.75
5.	Carbaryl 5% dust	138.75
6.	Control	129.25
	S.Em. ±	10.859
	C.D. (0.05)	N.S.

* Sample unit - 5 twigs, 50 cm. each/sample plant

In observations made one week after insecticidal treatment, the differences in total number of pods set in different treatments were non-significant. Numerically however, the number of pods set in insecticidal treatments was lowest in carbaryl 5% dust.

Pod setting thus, may have been adversely affected in carbaryl, 5% dust treated plot by dropping of flowers, dropping of developing pods, adversely affecting the viability of pollens or adversely affecting the movement of pollinators towards the flower.

4.2.3 Phytotoxic effect on size of pod and grain (Shrieveling effect):

Observations on phytotoxicity to grains and pods of arhar were made, in terms of weight per 100 pods and weight per 100 grains at harvest, and are summarised in Table 4.9.

Observations made on the phytotoxic effect of carbaryl on the size of pods, expressed in terms of weight per 100 pods. The data revealed non-significant differences among different treatments. Numerically however, the pod weight was lowest in carbaryl 5% dust even lower than control. The highest pod weight was recorded in monocrotophos 0.04%, (39.70 gms). This indicates that carbaryl 5% dust may have some adverse effect on pod growth.

Table 4.9: Phytotoxic effect of carbaryl, monocrotophos and endosulfan on pod and grain size of arhar

S.No.	Treatments	Weight*/100 pods(gm)	Weight*/100 grain (gm)
1.	Endosulfan 0.05%	39.12	7.87
2.	Monocrotophos 0.04%	39.70	8.47
3.	Carbaryl 0.1%	39.56	7.87
4.	Carbaryl 0.2%	38.22	7.77
5.	Carbaryl dust 5%	37.90	7.12
6.	Control	38.17	8.05
	S.Em. ±	1.777	0.326
	C.D. (0.05)	N.S.	N.S.

* Mean of 4 replications.

The analysis of grain weight data revealed that the differences due to treatments were nonsignificant. Numerically however the lowest weight was recorded in carbaryl 5% dust (7.17 gm) followed by carbaryl sprays 0.2% and 0.1% respectively. The grain weight was lower in all these treatments compared to control. The highest grain weight was recorded in monocrotophos 0.04% (8.47 gms).

These results have revealed that carbaryl 5% dust may have adversely affected the size of seed also.

4.2.4 Percentage pod damage by pod borer complex at harvest:

The analysis of data (Table4.10) revealed that the percentage pod damage at harvest was found to be non-significant.

Numerically, the infestation of borer complex was minimum in carbaryl 5% dust (18.09%) followed by monocrotophos 0.04% and endosulfan 0.05% and maximum in control plot.

Table 4.10: Percentage pod damage by pod borer complex in arhar

S.No.	Treatments	Mean percent pod damage* (at harvest)
1.	Endosulfan 0.05%	13.06 (21.14)**
2.	Monocrotophos 0.04%	11.14 (19.17)
3.	Carbaryl 0.1%	14.27 (22.07)
4.	Carbaryl 0.2%	14.76 (22.47)
5.	Carbaryl dust 5%	9.56 (18.09)
6.	Control	16.14 (23.25)
	S.Em. ±	2.009
	C.D. (0.05)	N.S.

* Mean of 4 replications
** angular transformed fitures

4.2.5 Effect on total grain yield of arhar:

The data of grain yield/plot and total number of pods per 5 sample plants of arhar recorded at harvest are presented in Table 4.11

Table 4.11: Effect of carbaryl monocrotophos and endosulfan on total yield of arhar.

S.No.	Treatments	Total no. of pods (healthy and damaged both)/5 samples* (at harvest mean of 4 replication)	Average yield per plot (kg) (mean of 4 replications)
1.	Endosulfan 0.05%	1826.75	0.793
2.	Monocrotophos 0.04%	1953.25	0.847
3.	Carbaryl 0.1%	1771.00	0.779
4.	Carbaryl 0.2%	1515.50	0.767
5.	Carbaryl 5% dust	1685.50	0.777
6.	Control	1543.75	0.740
	S.Em. ±	193.259	0.035
	C.D. (0.05)	N.S.	N.S.

* Samples size - 5 plants/plot/replication.

In observations made at harvest on total number of pods/5 plants in different treatments although, the differences were non-significant, numerically the pod setting was lowest in carbaryl 0.2% even lower than the control plot. Although differences in total number of pods in different treatments are nonsignificant compared to control. These results themselves show significant effect of carbaryl in reducing total pods set. Hypothetically, because of insect control, the total pods set at harvest should have been significantly higher in carbaryl over control. Thus, results indicate pod that setting may have certainly been adversely affected in carbaryl 0.2% treated plots.

The analysis of yield data revealed that differences in grain yield among different treatments were nonsignificant. The possible reason for this nonsignificant difference may be due to water logging or some wilt, few plots may have been seriously affected and hence real differences due to treatment may not have been recorded properly.

Yield data should have been recorded following a standard sampling technique observing uniform unit per plot (e.g. 5 random plants/plot).

CHAPTER – 5

DISCUSSION

The phytotoxicity of carbaryl was first reported by Chari and Patel (1970) and by Gangrade (1974) in Arhar (*Cajanus cajan*) and soybean (*Glycine max.*) respectively. Since, then, many other workers (Koehlar and Rachie (1972), Shrivastava 1973, Kapoor *et al*.1975, Bergman and Pediga, 1978, Vaishampayan and Thakur 1982 and Odak, 1983); have observed such a phytotoxicity in both the crops (Kochlar and Rachie 1972, Shrivastava 1973 and Kapoor 1975). But, no one has yet studied its impact in detail on pod bearing, size of pod and grain and ultimately on the grain yield of treated plants. Present investigations were carried out to study these aspects in detail in continuation of the preliminary trials conducted earlier by Vaishampayan *et al*. (1982) at Jabalpur.

Results showed that carbaryl, in dust as well as spray formulation has exhibited clear phytotoxic symptoms on both the crops viz., soybean and arhar.

The phytotoxic symptoms distinctly appeared after one week of insecticidal application on foliage. The leaf surface turned slightly yellowish, first the edges and then the entire leaf surface. Later, on, light brown specks or pin head spots appeared on the entire leaf surface and the leaf showed marginal browning. The phytotoxic effect is a result of the reaction of the chemical applied which causes the loss of chlorophill content of leaves by influencing the physiology of the plants, (Pritam Singh, 1970).

Carbaryl 10% dust was found to be most injurious to soybean which caused moderate phytotoxicity. While carbaryl 0.2% spray caused moderate to severe phytotoxicity and slight to moderate phytotoxicity was observed in carbaryl 0.1% spray and 5% dust respectively to arhar foliage.

The endosulfan 0.05% and monocrotophos 0.04% both were safe to use against the insect-pests of soybean and arhar with no symptoms of any phytotoxicity The overall phytotoxicity grades observed in various formulation of carbaryl compared to standard are presented in Table 5.1.

Observations on the influence of carbaryl treatment on pod setting demonstrated no significant adverse effect but numerically they were less in carbaryl 0.1%, 0.2% spray as well as in 10% dust in case of soybeans and in carbaryl 5% dust in case of arhar.

Table 5.1: Phytotoxicity level on soybean and Arhar at different concentrations of insecticides.

S.No.	Insecticides and concentrations percent	Soybean	Arhar
1.	Endosulfan 0.05%	Safe	Safe
2.	Monocrotophos 0.04%	Safe	Safe
3.	Carbaryl 0.1%	Slight Phytotoxic	Slight Phytotoxic
4.	Carbaryl 0.2%	-do-	moderate to high.
5.	Carbaryl dust (10% and 5%)	Slight to moderate	Slight to moderate

The analysis of data of grain weight per 100 seeds have demonstrated the shrievlling effect of carbaryl treatment atleast in soybean. The reduction in grain weight was significant in carbaryl 10% dust. In case of arhar also the grain weight was much low in carbaryl 5% dust compared to control although differences were non-significant statistically. On arhar only one application was given.

Comparing grain yield at harvest which is an end result of additive effect of insecticidal treatments due to pest control and the substractive effect of phytotoxicity on foliage, flowering, pod setting and grain size etc., the results showed that the differences in yield in carbaryl treated plots and control plots were not only nonsignificant in both the crops but numerically lower than control plots in soybean. Hypothetically, due to pest control, yield should have been significantly higher in all the insecticidal treatments, compared to control. In monocrotophos 0.04% yield is highest on record significantly higher than control.

Therefore this reduction in yield in carbaryl treated plots, even lower than the control plots as observed in carbaryl 0.1% spray as well as in 10% dust, is attributed to their phytotoxic effect on crop plants.

The reduction in yield in carbaryl treated plots has also reported earlier by anonymous 1979, 1981, Vaishampayan _et al_. 1982. Thus, the results in general, have demonstrated the phytotoxic effect of carbaryl on soybean as well as on arhar ~~and~~ to a considerable extent affecting the yield potential of plants also.

Comparing incidence of tobacco caterpillar in soybean and pod borer complex in both the crops, monocrotophos 0.04% proved to be the most effective insecticidal treatment. Endosulfan and carbaryl also controlled in insect pest damage quite effectively in both the crops. Superiority of monocrotophos over many other insecticides has also been reported by Chari and Patel (1972) and Balasubramanian and Afafalik (1978) in controlling *Spodoptera litura* on soybeans.

CHAPTER - 6

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

Summary

The present investigation was carried out at J.N.K.V.V. Research Farm, Jabalpur, during *kharif* 1983-84 to study in detail, various aspects of phytotoxicity of carbaryl on soybean and arhar and confirm the results of earlier trials conducted by Vaishampayan *et al.* in 1982 at Jabalpur.

Observations on foliage injury, pod setting, pod and grain size and reduction in the yield due to insecticidal phytotoxicity to crop plants were recorded. The effect of carbaryl was compared with monocrotophos 0.04% spray and endosulfan 0.05% spray (as standard and control). Side by side, the effect of different insecticidal treatments on the incidence of tobacco caterpillar, *Spodoptera litura* (Fb.) in soybean and pod borer complex in both the crops were also studied.

Conclusion

On the basis of results following conclusions were drawn:

(i) Carbaryl dust as well as spray formulations have exhibited clear phytotoxic symptoms on foliage of both the crops viz. soybean and Arhar.

(ii) Carbaryl 10% dust and 0.2% spray were found to be most injurious which caused moderate and severe phytotoxicity to soybean and Arhar foliage, respectively.

(iii) The endosulfan 0.05% and monocrotophos 0.04% both were safe to use against the insect-pests of soybean and Arhar with no symptoms of any phytotoxicity.

(iv) Pod setting may have been adversely affected in carbaryl treated plots in both the crops.

(v) The significant reduction in the grain size of soybean was found in carbaryl 10% dust. Also in arhar the grain size was reduced in carbaryl 5% dust treated plots (although differences were nonsignificant).

(vi) Monocrotophos 0.04% was found to be most effective to control the tobacco caterpillar, Spodoptera litura (Fb.) on soybean whereas carbaryl 0.2% proved most effective in reducing the pod borer, Heliothis armigera (Hb.) damage in the same crop.

Thus, the results in general, have demonstrated the phytotoxic effect of carbaryl on soybean as well as on Arhar to a considerable extent affecting the yield potential of crop plants also. Hence it is recommended not to be use the carbaryl on both the crops.

Suggestions for Further Work

(i) Phytotoxicity of carbaryl, particularly its effect on pod setting etc. needs to be investigated in other pulse crops also.

(ii) Further studies may be carried out with improved sampling techniques, like recording yield in specific unit as sample rather than of entire plot, and comparing the effects for each factor separately in a paired plot design.

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* Originals not seen

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APPENDIX

APPENDIX-'A'

The sMeteorological observations during crop season

Standard week	Period	Temperature °C Max.	Min.	Average R.M. %	Total rainfall (mm)
31	30.7.83-5.8.83	29.40	24.00	88.50	96.10
32	6.8.83-12.8.83	31.80	25.10	81.00	45.20
33	13.8.83-19.8.83	31.10	25.20	88.50	47.70
34	20.8.83-26.8.83	30.00	24.40	83.00	18.20
35	27.8.83-2.9.83	30.50	24.20	90.50	245.00
36	3.9.83-9.9.83	29.20	23.90	92.50	326.50
37	10.9.83-16.9.83	30.60	24.60	82.50	13.20
38.	17.9.83-23.9.83	31.30	24.00	83.00	9.60
39	24.9.83-30.9.83	30.90	23.60	87.00	173.00
40	1.10.83-7.10.83	30.10	23.60	84.00	23.40
41	8.10.83-14.10.83	31.00	22.40	77.00	38.90
42	15.10.83-21.10.83	30.00	18.00	65.00	0.00
43	22.10.83-28.10.83	28.70	12.50	64.00	0.00
44	29.10.83-4.11.83	27.60	12.10	67.00	0.00
45	5.11.83-11.11.83	26.90	9.20	66.00	0.00
46	12.11.83-18.11.83	26.90	7.70	59.50	0.00
47	19.11.83-25.11.83	26.10	8.10	61.00	0.00
48	26.11.83-2.12.83	25.30	8.70	63.00	0.00
49	3.12.83-9.12.83	24.90	8.30	64.00	0.00
50	10.12.83-16.12.83	24.60	7.40	65.00	0.00
51	17.12.83-23.12.83	27.10	9.40	59.00	0.00
52	24.12.83-31.12.83	23.60	8.80	64.00	8.40

V I T A

The author of this manuscript, Alok Kumar Awasthi, son of Shri R.M. Awasthi was born on 18th February 1961 in a well educated and renowned family based in Jabalpur, Madhya Pradesh. After completing early education at Jabalpur, he completed Higher Secondary Education from Pt. L.S. Jha Govt. Model Higher Secondary School, Jabalpur, (M.P.) with first class, in the year 1978, and B.Sc. from Jabalpur University in 1981.

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