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ROLE OF MITES IN AGRICULTURAL PRODUCTION

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1. INTRODUCTION

The Acarina or mites are found in almost every habitat available to animal life. They are found in the soil, on vegetation and in water. There are species which thrive in sea water and a few others even in hot springs. The group includes not only those which suck sap out of plants, but also several which live parasitically on other animals including insects. Some species live on all kinds of organic matter, infesting such materials as preserved meat, cured and raw hides, seeds, grains, processed food products, and almost any dead animal or plant matter. Some of these act as scavengers. Others, which infest stored products, may bring about serious deterioration of the products and the resulting heavy losses. Most of the higher plants act as hosts of one or more species of mites. Some of those that feed on crop plants have been observed to become serious pests at times and cause heavy loss of infested crops. A further point of importance of this group is that certain of these are known to be vectors of some of the fungus and virus diseases of plants and carriers of various disease-producing agents amongst domestic stock and man.

Mites, like insects, play an important role in agricultural production. The role may be a negative one, so far as production is concerned, in that several species infest crops and agricutural produce, and many bring about serious deterioration and consequent losses. Some of the mites are known to be vectors of certain virus diseases of plants. On the other hand, there are certain species which act as parasites and predators of injurious insects and mites, and which indirectly help to prevent losses that might otherwise be caused by different insect and mite pests of crops, by keeping the latter under check. It is proposed to briefly review in the following pages, these two aspects of the role played by mites in general in agricultural production. Apart from the above aspects, mites are responsible for affecting agricultural production indirectly in other ways; by attacking domestic stock and man and by carrying several protozoan, rickettsial, virus and other diseases to man and his stock. This aspect of the problem is not taken up in this paper.

2. PHYTOPHAGOUS MITES

Mites on plants are far more common than we have generally realised. Mostly on account of their small size they escape notice, unless they make themselves apparent by outbreaks on some crops.

Several species attract our attention by the discolouration of the plant tissue they induce by feeding and by the deformities of the plant parts they cause. It should not also be taken that all mites which are seen on plants suck sap as it is likely that some of these may be parasitic or predacious on insects and mites that live upon plants.

Though the injurious nature of certain mites to crops has long been recognised, the importance of phytophagous mites as pests of horticultural and agricultural crops has increased considerably in recent years throughout the world. The main contributing factor for this increase in mite populations has been stated to be the widespread use of non-selective pesticides mainly of the chlorinated hydrocarbon and organophosphorus types. The use of certain of these pesticides in the control of insect pests of crops has converted into serious pests mites which were innocuous before the use of such chemicals and thus created new problems of plant protection. The increased importance which these phytophagous mites have gained in recent years, coupled with the difficulties encountered in their control by chemical methods, and the fact that some of them are vectors of certain virus diseases of crops is at present stimulating research on the taxonomy, biology and ecology of these mites in America, Europe and certain other parts of the world. In India, however, this field is still unexplored, with the result that very little is known about this group of animals which is almost as important as insects in agricultural production.

The phytophagous mites which are potential reducers of agricultural produce are confined to certain groups of mites. Of the plant-feeding mites the spider mites (Tetranychidae) are said to be the most injurious to crops and are responsible for great damage throughout the world (Essig, 1958). The false spider mites (Tenuipalpidae), are also exclusively phytophagous and are known to do similar damage to their host plants. Likewise, the

rust, gall or erineum mites (Eriophyidae) are also exclusively plant feeders and several of them are of great economic importance. In addition, certain species of tarsonemid mites (Tarsonemidae) and a few eupodids (Eupodidae) are phytophagous, and some of them become serious pests of certain crops and reduce their yield. All these families are grouped under the sub-order Trombidiformes. The Acaridae, which have a wide range of feeding habits, include some forms which infest stored grains, dry fruits and other stored products.

Of the plant-feeding mites, the spider mites attack nearly all kinds of crops and sharply reduce their yield. As a rule the spider mites are most numerous during summer months. They can pass through several generations in a short period of time and thus have the potentialities of building up to very heavy population under favourable conditions. It is estimated that one female is capable of producing in one month's time a progeny of 20 mites at 60°F, about 13,000 at 70°F and over 13 million mites at 80°F of constant temperature.

Certain spider mites, like *Eotetranychus*, *Schizotetranychus* and *Tetranychus*, spin fine strands of silk which become apparent when mite-population is heavy, and may envelope the entire plant and even extend to the ground underneath the affected plants. It is interesting to note that *Schizotetranychus andropogoni* (Hirst) develops in small individual colonies each of which is covered by an elongate-oval, compact web. These webs can be seen even from a distance as pale whitish or greyish spots on the leaves of the host plants. The plant feeding tarsonemids (e.g., the cyclamen mite) are well known for inducing in their host plants symptoms similar to those caused by certain virus diseases of plants. Tender parts of plants are seriously deformed, the leaves are narrowed, curled and crinckled and the terminal growth is severely stunted. The flower-buds fail to open or even if they open they are distorted and reduced in size. The affected plants may be rendered sterile.

Though the entire family Eriophyidae are exclusively Phytophagous, all species do not induce visible symptoms on their

host plants. However, a good majority of these peculiar mites is responsible for development of different characteristic symptoms on their respective host-plants. Though at first sight some of these symptoms are apt to be mistaken as due to certain viruses or fungi or bacteria, a closer study will reveal the presence of mites on such malformed parts of plants. Among the eriophyid mites there are the surface vagrant type, the rust mites or the russet mites, which feed and breed more or less on open plant surfaces and which may cause silvering or browning. Then there are several others which live nearly concealed amongst the surface-hairs or underneath bud-scales or in the deformities which they induce on their host-plant. Some of these induce growth of excessive surface-hairs resulting in patches of dense hairs amidst which a large number of mites lives. These patches (erinea) may be formed on leaves, stem or floral parts and fruits. The erineum patches in the case of certain species may lead on to dimple galls with the area of the patch a little depressed, or the leaf may become curled and twisted. In certain other cases galls of various shapes may develop on leaf surface and occasionally on stem surface. Such galls are always of the open type and the opening may be guarded with hairy outgrowth. These galls may be lined internally with hairy outgrowth or only with a spongy, soft tissue.

Some of the eriophyids induce development of warty patches on leaf and stem-surfaces. The wart consists of closely packed outgrowth of short papillae which may be simple or branched. The mites live and breed concealed amidst the papillae. Blister galls on leaves (lamina or leaf sheath), in which the tissue in between epidermal layers becomes spongy, are also caused by certain species of eriophyid mites. Development of woody galls arround buds and appearance of malformed flower buds are also some of the symptoms caused by species living underneath scales of buds. Certain other bud-dwelling eriophyids may induce stunted shoots. Similarly they may induce witches'-broom effect on their host-plants.

3. MITE-PESTS OF DIFFERENT CROPS

No crop is free from the attack of one or more species of

plant feeding mites. However, several of these mites may often be innocuous and cause no damage to their host plants. A species which was previously of no economic importance may, under favourable conditions, assume a pest status on its host crop. Instances are not lacking where species which were previously unknown as pests have developed into pests and have done considerable damage to the crops concerned. In the following few pages only those species that are known to appear as pests commonly on different crops are included.

A. Graminaceous Crops.

Wheat, barley, oats, maize, sorghum and other graminaceous crops are known to be generally free from heavy attack of mites. However, there are several records of sporadic and heavy attack of sorghum (Jowar) and to a lesser extent sugarcane in India by the spider mite *Oligonychus indicus* (Hirst) (Rahman and Sapra, 1940 a). In South India the mite is more often a pest of sorghum and has been responsible for considerable damage to this crop in certain parts of Mysore and Madras States (Puttarudriah, 1951; Cherian, 1931). In North India the same species often assumes a serious pest-form on sugarcane (Rahman and Sapra, 1940a). The infested leaves show reddish patches where mites colonise and in cases of heavy infestation, the entire leaf-blade turns red and withers, and thus if the mite attack is in the earlier stages of the crop the damage done may be quite heavy, seriously reducing the yield. This species can thrive on many other graminaceous and other plants, like *Areca catechu* (Puttarudriah and Channa Basavanna, 1956), *Panicum javanicum* and *P. distachyeum* (Cherian, 1933), *Sorghum halepense* (Rahman and Sapra, 1940 a), *Dicanthium annalatum* (Khan and Murthy, 1956) and a few dicots in India (Haroonkhan and Bhatia, 1946).

Sugarcane and maize also suffer occasionally from the attack of another spider mite *Schizotetranychus andropogoni* (Hirst) in certain parts of India (Cherian, 1931; Khan and Murthy, 1956).

Wheat in Texas, oats in California and wheat and barley in Arizona and Oklahama are subjected to serious damage by the attack of the mite *Penthaleus major* Duges (Penthaleidae)

(Baker, 1946). It is reported that this species is particularly serious on young wheat-crop in Arizona (Essig, 1958). In addition, the same species occurs as a pest of clover and vegetable crops in Australia. In France it is regarded as a serious pest of peas, lettuce and other vegetable crops (Baker, 1946). In South Africa wheat is infested by the brown mite *Petrobia latens* (Muller) (=*Petrobia lapidum* (Hammer) (Louw, 1955). This species is almost worldwide in distribution, being known to occur in Europe, North and South Africa, North America and Australia. It is especially a pest of low-growing monocotyledonous plants. It occurs on grain crops such as barley, wheat, rye, sorghum and many other low-growing crops (Baker and Pritchard, 1953). Wheat crop, when it is attacked by this pest turns yellowish and appears parched. These species have not been reported to occur in this country.

Recently, Puttarudriah (1960) has reported that considerable damage has been caused to sugarcane in parts of Mysore by the attack of the cane blister mite (*Aceria sacchari* Channa Basavanna). Young cane particularly of ratoon crop, when infested by these mites, showed twisting of leaf-blades and stunting of the seedlings, and in some cases the seedlings later dried up.

B. Fruit Crops.

Almost every fruit crop (both temperate and tropical fruit crops) is subject to the attack of one or more species of mites. Some species often become serious pests of their host crops, and amongst them spider mites are the most common.

Citrus crop is attacked by several species of mites in the different regions of its distribution. The citrus red mite *Panonychus citri* (McGregor) (=*Paratertranychus citri* McGregor) is known to be a serious pest of citrus plant and most destructive of all pests of this crop in Florida, California and Gulf States (Metcalf and Flint, 1958). It is known to occur in India as a pest of citrus (Pruthi and Mani, 1945). The infested leaves are speckled with whitish spots, later turn silvery or brown and drop prematurely. Fruits are also attacked, and these turn grey or yellow. The six-spotted spider mite *Eotetranychus sexmaculatus*

(Riley) (= *Tetranychus sexmaculatus* Riley) is similarly destructive to citrus in Florida, California and Gulf States (Metcalf & Flint, 1958). Presence of depressed and yellow pits on the undersurface of leaves and occasionally on fruits is due to the attack of this species. Another spider mite, *Eutetranychus banksi* (McGregor), is commonly found on the upper surface of citrus leaves, and sometimes becomes serious, causing silvering mainly along the midribs and the veins. This is a polyphagous species and attacks a large number of plants which include many deciduous fruit crops, cotton, castor, etc. The species is found in India on citrus, almond *Zizyphus jujuba*, castor, *Cassia fistula* and a number of other plants (Rahman and Sapra, 1940 a); (=Puttarudriah and Channa Basavanna, 1959 a). It has been reported on citrus and several other plants from the the U.S.A. South Africa, China and Southern Japan (Pritchard and Baker, 1955). Severe infestations of citrus cause stippling on leaves which may fall down (Moutia, 1958).

The citrus rust mite *Phyllocoptruta oleiuorus* (Ashmead) is worldwide in distribution and occurs in every citrus-growing area of the world (Keifer, 1952). The mite causes severe rusting of leaves and fruits and is thus responsible for lowering the quality and attractiveness of fruits. Pinkish-brown blotches which disfigure the surface of the fruits are caused by this rust mite in South India (Ranga Rao *et al*, 1957). The citrus rust mite has recently been noted on pomelo (*Citrus decumara*) and other species of *citrus* near Bangalore (Puttarudriah and Channa Basavanna, 1959a). The citrus bud mite *Acera sheldoni* (Ewing) is the most important citrus eriophyid pest it California (Baker and Wharton, 1952). Severely damaged lemon trees show stunting and clustering of young growth and severe leaf and fruit malformation. This mite is found in citrus growing areas of Hawaii, Australia and Java. The citrus bud mite has recently been reported from Bangalore (South India) on *Citrus* (Channa Basavanna, 1966). It is estimated that about $ 15.00 are required to spray an acre against this pest (Keifer, 1946). Another eriophyid mite *Calacarus citrifolii* Keifer is known to cause concentric ring blotches on citrus in Transvaal (Dippenaar, 1958).

The fruit tree red spider mite *Panonychus ulmi* (Koch) (= *Paratetranychus pilosus*) (Can. & Fan) occurs in almost all fruit growing areas of the world, and is especially a serious pest of apple in the south eastern countries (Blair and Groves, 1952). Similarly many other deciduous fruits are affected by this pest. It is another polyphagous mite and most injurious to plum, pear and prune (Metcalf and Flint, 1962). Among the different varieties of apple the thin-leaved varieties are said to be most susceptible (Garman, 1923). The leaves of apple, pear and prune, as a result of mite attack, are bronzed, the intensity depending upon the population of the mites, and finally drop down, thus resulting in defoliation to different degrees (Newcomer and Yothers, 1929). The fruits are also attacked and are prevented from developing to normal size and are of poor quality and colour. Deciduous orchard crops, including apple, pear, plum, grape, almond, walnut, etc., along the pacific coast of the U.S.A. are subject to heavy destruction by the attack of the pacific mite *Tetranychus pacificus* McGregor (Baker and Pritchard, 1953). Leaves are bronzed and heavily webbed, and often drop down prematurely. Fruits fail to develop proper colour and drop down before harvest, if infestation is very heavy. These species have not been noted in India.

Pear and sometimes apple is generally subject to heavy attack of the pear leaf blister mite *Eriophyes pyri* (Pagensteche) in different parts of Europe, Africa, and North America. It is one of the most important pests of pear, since it can put its host out of production (Keifer, 1946; Ryke and Meyer, 1960). Brownish blisters of varying dimensions appear on the undersides of leaves. Flower-buds are also damaged, turn brown, and produce weak flowers. Fruits are deformed and russeted (Hawley, 1926). It is estimated that $ 10.00 to $ 12.00 are required to spray one acre against this mite (Keifer, 1949).

The clover mite *Bryobia praetiosa* Koch is yet another polyphagous mite which does considerable damage to several deciduous fruits, like apple, pear, plum, prune, cherry, etc., in the U.S.A., Canada, major part of Europe, Britain, Africa and Australia. It has a very wide host-range which includes many forest

trees and herbaceous plants (Kremer, 1956). The clover mite usually attacks upper surface of the leaves and induces premature leaf fall, formation of small fruits which do not mature, and this is followed by yield-losses in the following year. The extremely polyphagous two-spotted spider mite, *Tetranychus telarius* (Linn) (=*Tetranychus bimaculatus* Harvey), is almost world-wide in distribution and attacks a number of fruit crops like apple, pear, peach, plum, nectarine, apricot, cherry, walnut, almond etc., and many truck and forage crops (Baker and Pritchard, 1953). The leaves, flowers and fruits show pale yellow or brownish speckles, appear sickly and if the infestation is heavy, gradually dry and drop off.

Fig crop suffers from the attack of the spider mite, *Eotetranychus hirsti* Pritchard and Baker, which is commonly very serious during the summer months on fig practically throughout India, (Cherian, 1938; Rahman and Sapra, 1940 a; Puttarudriah and Channa Basavanna, 1959 a). The affected plants show yellowish-green, roughend leaves which drop off prematurely. Heavily infested plants can be detected even from a distance by the presence of only a few yellowish green leaves or only branches without leaves. The fruits also turn yellowish as a result of mite attack and are not allowed to attain their normal size and to ripen. This species is responsible for complete failure of the crop, which sometimes occurs, if adequate precautionary control measures are not undertaken (Puttarudriah and Channa Basavanna, 1959 a). The fig mite, *Aceria ficus* (Cotte), though not often a serious pest, can cause considerable damage to fig, if the population is high enough, in certain parts of the U.S.A. and Southern France (Keifer, 1952). This species has recently been reported from Delhi (Channa Basavanna, 1966). The mites live in buds, on leaf surfaces and inside green fruits. The bud scales are scarred and tender leaves destroyed within buds. This scarring may extend to the interior of fruits also.

Grape vine in North America, South Africa and parts of Europe is known to suffer considerably at times from the attack of the bud mite or erineum mite, *Eriophyes vitis* (Pagenstecher) (Baker and Wharton 1952; Keifer, 1946; Ryke and Meyer, 1960).

Smith and Stafford (1948) who made extensive studies on the nature of damage done by this mite in California reported shortening of internodes, Witches'-broom growth on new shoots, death of over-wintering buds and appearance of erineum patches on the under surfaces of leaves as among the different symptoms caused by the mite attack. Losses of crop ranging often from 50 per cent to 100 per cent have been reported from California. In addition, grape vine may suffer occasionally from the attack of different species of spider mites, for example, *Tetranychus telarius* (Linn) *T. equatorius* McGregor, and others.

The cause of mango-malformation in India was first reported by Narasimhan (1954) as due to the attack of a species of *Eriophyes*. The fact that this mite was the cause was definitely established by Puttarudriah and Channa Basavanna, 1961) by conducting inoculation experiments. The causative mite, *Aceria mangiferae* Sayed, has recently been recorded from all parts of India (Channa Basavanna, 1966). Drying and death of terminal and axillary buds due to the feeding activity of a large number of mites underneath the bud scales, crowding of short twigs at the axils and the inflorescences with crowded blossoms turning green and becoming sterile are the main symptoms induced by the mite attack. Similar symptoms on mango have been reported from Egypt and Florida as due to the same species (Attiah, 1951).

As long ago as 1912, Misra noted the damage done by the eripphyid mite on litchi plants in North India. The mite induces extensive, chocolate-brown erinose areas on the leaf surfaces and the leaves which, as a result, show severe curling and twisting. This species which has been identified as *Aceria litchili* (Keifer) occurs in South India also (Puttarudriah and ChannaBasavanna, 1959 a). The litchi mite has been reported from East Pakistan (Alam, 1959) and also from Hawaliian Islands (Keifer, 1944).

Gauva fruits (*Psidium gaujava* L.) in certain parts of Mysore were noted to be severly damaged by a species of *Brevipalpus* (Phytoptipalpidae) (Puttarudriah and ChannaBasavanna, 1959 b). The infected fruit showed reticulated pattern of cracks on the surface, which in severe cases resulted in splitting of fruits,

Similar damage to papaya fruits has been reported as due to *Brevipalpus phoenicis* Geijskes from Hawaii (Jones *et al*, 1941).

Strawberries in different parts of Europe, the U.S.A and Russia suffer seriously from the attack of the cyclamen mite, *Tarsonemus pallidus* Banks (Smith and Goldsmith, 1936). Wrinkling of upper surfaces of leaves, margin-rolling, severe dwarfing and stunting are the symptoms of injury due to the cyclamen mite.

Pine apple in Australia is attacked by another tarsonemid mite, *Tarsonemus ananas* Tryon, which induces rotting of fruit (Hughes, 1959).

Edge-rolling resulting in acute narrowing of leaves of pomegranate has been reported from Italy, California (Keifer, 1952) and India (Puttarudriah and ChannaBasavanna, 1959 a). The leaves are sometimes seriously deformed and new growth is suppressed.

C. Vegetable Crops and Ornamentals.

Most of the vegetable crops and the different kinds of ornamental plants are subjected to the attack, sometime or other, of the two most common spider mites, the common red spider, *Tetranychus telarius* (Linn.) and *Tetranychus equatorius* (McGregor) (=*T. cucurbitae* Rahman & Sapra) (Pritchard and Baker, 1955). Both species are extremely polyphagous and occur on a large number of plants which includes common vegetable and ornamental plants like brinjal, tomato, rose, jasmine, gourds, etc. (Rahman and Sapra, 1946; Janjua, 1942; Cherian, 1931). *T. telarius* is the most widely distributed and highly destructive red spider in the Western States of America (Essig, 1958). The result of injury is at first yellowing and then dropping of leaves, scarring of fruits and complete killing of plants. *T. equatorius* is also a common spider mite and often occurs together with the above species. The injury to leaves may result in the prevention of formation of flowers and fruits.

Many ornamentals and vegetable crops along the Pacific coast of U. S. A., are attacked by the Pacific mite, *Tetranychus*

pacificus McGregor. This species is often very destructive, resulting in the total failure of crops at times (Metcalf and Flint, 1958). Many ornamentals like, cyclamen, geranium, chrysanthemums, snapdragon, marigold, fuchsia, begonia, petunia, etc., are attacked by the cyclamen mite, *Tarsonemus pallidus* Banks, in different parts of Europe, England, Russia and the U.S.A. (Smith and Goldsmith, 1936). The infested plants generally show marked distortion of foliage, wrinkling, rolling, narrowing of leaves and sometimes with purplish area on the leaf surface. Similarly another tarsonemid mite, the dahlia mite or the yellow tea mite *Hemitarsonemus latus* (Banks) is a polyphagous species and attacks a very large number of plants, and is widely distributed in Ceylon, the U.S.A., Trinidad, England, Brazil and South Africa (Lavoipierre, 1940; Ewing, 1939). In India the species has often been a serious pest on tomato, potato, marigold (*Tagetes erecta*), *Amarantus*, chillies, guar (*Cyamopsis tetragonoloba*), zinnia, dahlia, *Mirabilis* and cotton (Mann *et al*, 1920; Kulkarni, 1922; ChannaBasavanna and Puttarudriah, 1959). The affected plants show severely curled and reduced leaves, stunted growth and the flower buds not opening or resulting in ill-formed flowers, if at all they open.

Tomato crop is subjected in all tomato-growing areas of the world, to the attack of the tomato russet mite, *Aculus lycopersici* (Massee) (=*Aculus destructor*) (Keifer), which in certain parts is highly destructive to the crop (Lamb, 1953). The affected plants show browning of leaves, which collapse and die, and severely russeted fruits. The injury creeps up the stalks and when the tips are reached the plant dies (Keifer, 1946). Tomato is subject to the attack of another eriophyid mite, the tomato erinose mite, *Aceria lycopersici* (Wolff.) which is equally worldwide in distribution but much less destructive to the crop. The mite induces growth of dense hairs on the leaves and stems. This species is commonly seen on tomato and brinjal in India (ChannaBasavanna, 1966). Both eriophyid mites occur on other solanaceous plants also (Lamb, 1953). In Mauritius tomato has been subjected to very severe attack of *Tetranychus marianae* McGregor which is often destructive to tomato, potato and brinjal (Moutia, 1958).

Shoots including leaves of sweet potato in South India are often severely bronzed and even dry up due to the attack of an eriophyid mite, *Oxypleurites convolvuli* ChannaBasavanna (David, 1959; ChannaBasavanna, 1966).

Jasmine, especially *Jasminum pubescens*, is often subjected to the attack of an erineum mite (*Aceria jasmini* ChannaBasavanna) in South India. The tender twigs including leaves and flowers are covered with dense white hairy outgrowth. The leaves are reduced and new growth stunted and the production of flowers, for which the crop is grown, completely stopped resulting in heavy loss to the orchardist (ChannaBasavanna, 1966).

Reduced and deformed flowers and clustering of stems in chrysanthemums have been reported from Washington as being caused by the eriophyid, *Paraphytoptus chrysanthemi* Keifer (Breakey and Batchelor, 1950). The eriophyid has recently been found on chrysanthemums in various parts of India (ChannaBasavanna, 1966). The privet mite, *Brevipalpus obovatus* Donnadieu (=*B. inornatus* Baker), is almost worldwide in distribution and is polyphagous occurring on various species of ornamentals and other plants (Pritchard and Baker, 1958). Although many species belonging to the family Phytoptipalpidae appear to do little damage, the privet mite is known to defoliate privet in some parts of the U.S.A. (McGregor, 1916).

Liliaceous bulbs like onion, garlic and tulip are subjected to the attack of an eriophyid mite, *Aceria tulipae* (Keifer), in certain states of the U.S.A. and Canada (Keifer, 1946). The mites live between bulb layers, thus living under ground. This species persists on the bulbs in storage, causing the bulbs to shrink and dry out. The species was recently reported on the leaves of garlic and onion in Mysore (Puttarudriah and Channa Basavanna, 1958). The species has been found on wheat and a few grasses, and it is the vector of wheat streak and wheat spot mosaic diseases in parts of the U.S.A. (Slykhuis, 1955, 1956).

D. Cotton.

Cotton crop is subjected to the attack of several spider mites (Baker and Pritchard, 1953), of which the common red

spider, *Tetranychus telarius* (Linn.) and the Pacific mite, *T. pacificus* McGregor may be considered as more of less regularly occurring and important. The red spider mite has a wide range of hosts and is distributed practically throuhout the world, whereas the pacific mite is confined to the Pacific coast of the U.S.A. and has a wide range of hosts which includes clover, vetch, melon, grapes, beans, etc., *T. telarius* leaves in colonies on the under side of leaves and their constant feeding causes blood-red spots to appear on the tips of leaves, finally resulting in defoliation and death of plants (McGregor, 1913). It is a major pest of cotton in South Eastern United States (Baker and Wharton, 1952).

The dahlia mite, *Hemitarsomemus latus* (Banks), which is a pelyphageus mite and a pest of many ornamental and vegetable crops has been reported on cotton in Belgian Congo (Vrydagh, 1943 and in Mysore (Channa Basavanna and Puttarudriah, 1959). The leaves are reduced in size and narrowed, the veins approximating one another; the entire plant gets stunted.

The Eriophid mite, *Aceria gossypii* (Banks), has been reported from Bombay and the Punjab on Cotton as causing erinose patches on tender twigs (Misra, 1920). The species on Cotton in India appears to have been wrongly put under the above name as recent investigations show. The species concerned is actually *Aceria puttarudriah* Channa Basavanna (Channa Basavanna, 1966). Keifer (1946) has recorded the species *(A. gossypii)* from Florida and West Indias on cotton. The affected plants show extensive outgrowth of erineum on the suface of stem and leaves of tender twigs, which result in stunting, and in cases of severe infestation heavy losses occur.

E. Plantation Crops. (coffee, tea, areca, coconut, etc.)

Tea plantations in India and Ceylon suffer from four important mite pests. The tea spider mite, *Oligonychus coffeae* (Nietner) (=*Tetranychus bioculatus* Wood-Mason) has long been recognise) as a serious pest of tea (Wood-Mason, 1884) and continues to be one of the major pests of tea plantations (Das, 1959). The same spider mite occurs on Jute and Coffee (Misra, 1913).

Cotes (1889) estimated that in one tea estate alone in Sikkim the damage done by this mite during 1888 was of the order of Rs. 20,000. The yellow tea mite *Hemitarsosenus latus* (Banks), is yet another mite which assumes a serious status on tea. The crop is also subjected to the attack of two eriphyid mites: the pink mite, *Acaphylla theae* (Watt) and the purple tea mite, *Calacarus carinatus* (Green). The pink mite was first discovered on tea in Assam in 1895 by George Watt. Now it is known to occur in south India, Indonesia Indochina, Bstum (U.S.S.R.). California and Alabama (Das and Sengupta, 1958). The mites generally inhabit tender twigs and the affected leaves assume a pale colour and become leathery. It is often a serious pest of tea, and in one tea estate the loss due to the mite attack during 1950-51 has been estimated to be about 500 maunds of tea (Das and Sengupta, 1958). The purple mite was recognised as a pest of tea in Ceylon long back (Cotes, 1891-93). It occurs in India and California and in India as a post of tea (Cherian, 1931; Keifer, 1955).

Areca *(Areca catechu)* and coconut palms (*Cocos nucifera*) are often attacked by the spider mites *(Tetranychus spp.)* and the phytoptipalpid mite, *Raoiella indica* (Hirst) in Sbuth India (Puttarudriah and ChannaBasavanna, 1959 a), and the latter has been nosed to assume a pest-form on areca palm at times.

4. MITES ASSOCIATED WITH STORED FOOD PRODUCTS.

Several members of the family Acaridae which are variously known as the cereal mites, the root mites, feed on all kinds of organic matter. Some of them infest various stored and preserved materials such as cured and raw hides, organic powders, seeds, farinaceous products, etc. In stored grains they cause great economic loss not so much by what they eat as by the damage they cause by changing the moisture content of the medium and initiating the growth of moulds (Nesbitt, 1945). Dried fruits such as figs, raisins, apples, etc., are attacked by *Carpoglyphus passularum* Hering (Essig, 1958). Various kinds of bulbs like hyacinth, dahlia, narcissus, lilies and onions are subject to the attack of the bulb mite, *Rhizoglyphus echinopus (Funouze* and *Robin)*, which some times destroys as much as 15 to 20 per cent of the bulbs (Baker and Wharton, 1952).

Several species of acarids are found associated with stored cereals, grains and stored food products. *Tyrophagus lintneri* (Osborne) is a widely distributed pest of stored foods and at times quite serious. *Acarus siro* Linn. is a cosmopolitan and destructive species found in grain, flour, dried fruits, and vegetables as well as in cheese. The flour mite. *Aleorobius farinae* (DeGeer) is yet another common species on cereals, flour, seeds, cheese, etc., and is a serious pest in flour mills, granaries and ware houses. *Tyrophagus longior* (Gervais) is another European species, and it has been stated that an entire haystalk was practically destroyed by this mite. It also infests food stuffs (Essig, 1958).

Onion, garlic and tulip bulbs are attacked by the eriophyid mite, *Aceria tulipaes* (Keifer) which infests the field crop itself and is carried to the store in the bulbs. The mite lives between bulb-laycrs and causes the bulbs to dry up soon (Keifer, 1946).

5. Mites as Vectors of Fungus and Virus Diseases of Crops.

Very little is known about the role of mites in transmitting diseases of plants. It is possible that mites inhabiting plant surfaces infected with fungus diseases may help in machanically transferring spores from the infected plants to healthy ones. Baker and Wharton (1952) quote Sigrianskii (1940) as reporting transmission of spores of *Tilletia tritici* on wheat crop by *Tyroglyphus castellanii* (Hirst) and of *Botrytis allii* from infected onions healthy onions. *Tetranychus telarius* (Linn) is stated to transmit a virus disease of cotton. Similarly *Tarsonemus ananos* Tyron is an agent in the transmission of a pine apple rot in Australia (Baker and Wharton, 1952).

The possibilty of the reversion disease of black currants being transmitted by the big bud mite, *Cecidsphyes (Phytoptus) ribis* (Westw.), was first suggested by Amos *et al* (1927) and was later confirmed by Massee (1952). This was followed by a series of new discoveries relating to the role of certain eriophyid mites as vacters of virus diseases of plants. Eriphyid mites are the only mites know to transmit plant viruses. According to Slykhuis (1960) six viruses, which affect mostly crops, are crops.

known to be transmitted by the eriophyid mites. The wheat streak mosaic disease prevalent in the U.S.A. and Canada is transmitted by *Aceria tulipae* (Keifer). Similarly the wheat spot mosaic disease in Canada is transmitted by the same species (Slykhuis, 1955, 1956).

A mosaic of rye grass (*Lolium perenne* and *L. multiflorum*) that occurs in Britain and certain European countries is transmitted by *Abacarus hystrix* (Nal.) (Slykhuis, 1960).

The fig mosaic which is widespread in California, Britain, Italy and Australia is transmitted by the fig mite, *Aceria ficus* (Cotte) (Flock and Wallace, 1955). Recently, Nagaich and Vashisth (1962) reported that fig mosaic occurs in India also, and is possibly transmitted by an eriophyid mite, which has been identified as *A. ficus* (ChannaBasavanna, 1966). Similarly peach mosaic prevalent in the western parts of the U.S.A. is transmitted by an eriophyid mite, *Eriohyes insidiosus* Keifer and Wilson (Wilson, Jones and Cochran, 1955). The sap transmissible virus responsible for the degeneration of vines in Germany has been reported to be transmitted by *Eriophyes vitis* (Pgst.) (Slykhuis, 1960).

6. Mites that Affect Beneficial Insects.

Not much is known about the mites that affect beneficial insects, like honey bees, lac and silk insects. The scutacarid mite, *Acarapis woodi* (Rennie), is the causative agent of what is known as "Isle of wight disease" in honey bees throughout Europe and other parts of the world. This is a serious fatal disease to which honey bees are subjected. The mites live inside the tracheal tubes, feed on the blood by piercing the wall of the tracheae and breed within the tracheal tubes. Apart from sucking the blood, the mites block the tracheae by their exuvia and excreta thus leading to reduced respiratory exchange. The continued effect is to enfeeble the bee, so that it is unable to fly. The affected bees leave the hive and die in the open (Hughes, 1959). Recently a laelaptid mite *varroa jacobsoni* Ouds. has been noted as an ecto-parasite of pupae and adults of the honey bee (*Apis indica*) round about Bangalore.

7. Beneficial Role of Mites.

A. Parasites and Predators of Plant feeding Mites and Insects.

It is only in recent years that the importance of predatory mites in the control of plant feeding mites and insects is being realised more and more. The main and immediate cause for this realisation must be put as the attempts to control insect and mite pests of crops by the use of chemicals. Several instances are on record where plant-feeding mites, instead of being kept under check, have increased in numbers as a result of the application of certain chemicals. This effect has been mainly due to the killing of mite and insect predators of plant feeding mites by the chemicals used.

The first definite experiment in the biological control of insect pests appears to have been made in 1873 when Plancheon and Riley introduced an American predatory mite, *Tyroglyphus phylloxerae*, into France for the natural control of the phylloxera of the grape vine (Imms, 1957). The role played by mites in the biological control of mite and insect pests of crops has been little investigated. However, one notable exception is in respect of the members of the family Phytoseiidae, which are well known as predators of different stages of phytophagous mites. The importance of these mites in the control of plant feeding mites is being realised more and more in recent years, and several contributions on them have been made (Nesbitt, 1951; Narayanan, Kaur and Ghai, 1960). In addition, the mite families Aceosejidae, Tydeidae, Cunaxidae, Anystidae and Cheyletidae are amongst the important groups which include species predaceous upon plant feeding mites and small insects (Baker and Wharton, 1952). Similarly, there are a number of groups such as Erythreidae, Trombidiidae, Trombiculidae, Tarsonemidae, Podapolipodidae, Gamasidae, Hemisarcoptidae, and Hydryphantidae which are reported to be parasitic on various phytophagous insects. Our knowledge of the feeding habits, the behaviour and ecology of these mites is far from complete.

The phytoseiid mites are predators on the eggs, larval stages and adults of injurious mites. A survey of literature dealing with

the biological control of plant feeding mites by means of predaceous mites reveals that these investigations are being carried out in different parts of the world, especially the United States, Canada, England and Germany. The importance of the phytoseiid mites in the control of the injurious mites has long been recognized. In 1906 the American Entomologist Parrot, after his extensive studies on the eriophyid mites infesting apple and pear trees, stated that the predaceous mite, *Seius pomi* (Parrot), exerts a considerable influence in reducing the numbers of the blister mites. Ewing (1914) reported that *Seius pomi* is one of the most important natural enemies of the spider mite, *Tetranychus telarius* (Linn.). Herbert (1953, 1956), who made extensive studies on the life histories, behaviour, distribution and relative abundance of the predators in the orchards of Nova Scotia, stressed on the important role played by these mites in keeping the phytophagous mites under check. Similar observations were made earlier in respect of the phytoseiid mites preying upon the two-spotted spider mite (Lord, 1949). Huffaker and Kennett (1953 a, 1953 b, 1956) who made extensive investigations on the role of the predatory mites (*Typhlodromus* spp.) in the biological control of the cyclamen mite, *Tarsonemus pallidus* Banks, infesting strawberries in California, have shown that the yield of strawberry plants from plots where the predators of the cyclamen mite were present was seven times more than that from the same number of plants from the predator-free plots. The Aceosejid, *Blattisocius tineivorus* (Oudms.), is interesting in that it is found in stored grains preying upon the eggs and the first instar larvae of *Ephestia kuehniella* and *Sitotroga cerealella* (Olivier) which are pests of stored grains (Hughes, 1959). Though there are not many attempts to mass-multiply some of these beneficial predators and release them in the mite-infested fields, the possibility of such a measure has been demonstrated by Ristick (1956) who was successful in the mass-rearing of *Typhlodromus fallacis* (Garman) on red-spiders.

Members of the families Tydeidae, Cunaxidae, Anystidae and Cheyletidae are stated to be general predators on mites and small insects. *Tydeus californicus* Banks is predaceous on the citrus bud-mite, *Aceria sheldoni* (Ewing), in Southern California and

similarly another tydeid mite, *Pronematus ubiuitus* (McGregor), is a common predator on the fig mite, *Aceria ficus* (Cotte), in California. *Cunaxoides parvus* (Ewing) has been described as a real enemy of the oyster shell scale from Iowa (Baker and Wharton, 1952).

Various families of mites contain members which are either predaceous or parasitic on insect pests of crops and stored produce. Among them, the families Podapolipodidae, Pyemotidae, Tarsonemidae, Erythraeidae, Trombidiidae, Trombiculidae, Acaridae, and Hemisarcoptidae may be mentioned. Mites of the family Podapolipodidae are parasitic on other arthropods, especially beetles and grasshoppers. *Podapolipus diander* Volkonsky is an important parasite of *Locusta migratoria* Linn. and other locusts, and inhabits the lower surface of the bases of wings and sucks blood. *Locustacarus trachealis* Ewing is a parasite in the tracheae and air sacs of grasshoppers (Baker and Wharton, 1952). *Pyemotes* (=*Pediculoides*) *ventricosus* (Newport) (Pyemotidae) is a parasite of some lepidoterous store insects such as *Sitotorga cerealella* and even lepidopterous field pests like the satin moth, *Stilphopia salicia* (Linn.), and the peach twig borer, *Anarsia lineatella* Zeller (Baker and Wharton, 1952). Similarly another pyemotid, *Acarophenax triboli* Newstead and Duvall, is known to parasitize feeding on the eggs and adults of the stored grain pest, *Tribolium ferrugineum* (Hughes, 1959). The larvae of Erythraeidae are parasitic on insects as much as the larvae of the Trombiculidae are parasitic on vertebrates. The larvae attach themselves by their mouthparts to the body of their hosts which may be grasshoppers and other insects. Adults are free-living predators living in soil or on plants.

Trombidiids and trombiculids behave almost in the same manner as regards their feeding habits. The Nymphal and adult stages of these mites feed on the eggs and early larval instars of many small arthropods. Larval stages of these mites generally act as parasites of insects and in case of certain trombiculid larvae (Chiggers) they act as parasites of higher animals. Larvae of *Eutrombidium* are generally found on the bodies of mantids, grasshoppers, crickets and locusts (Baker and Wharton, 1952).

The acarid mites *Cosmoglyphus dampfi* (Oudemans) and some species of the genus *Acotyledon* are known to feed on the eggs of Acrididdidae (Hughes, 1959). *Hemisarcoptes matus* (Shimer) has been reported to feed on the eggs of several coccids (Hughes, 1959) and is of considerable importance in reducing the population of coccids (Baker and Wharton, 1952).

It is seen that very little is known of the role played by the several mite predators and parasites in checking populations of injurious mites and insects. An intimate knowledge of their ecology will help in a better utilization of these natural enemies.

8. Beneficial Soil Mites.

The Oribatei are generally found in large numbers in moss, humus and other types of soil. They have biting mouth parts and feed on partially decayed plant debris. They appear to play an important part in the braking up of soil detritus into small particles and promote soil fertility, as do the earthworms (Hughes, 1959).

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Plant Protection Manual

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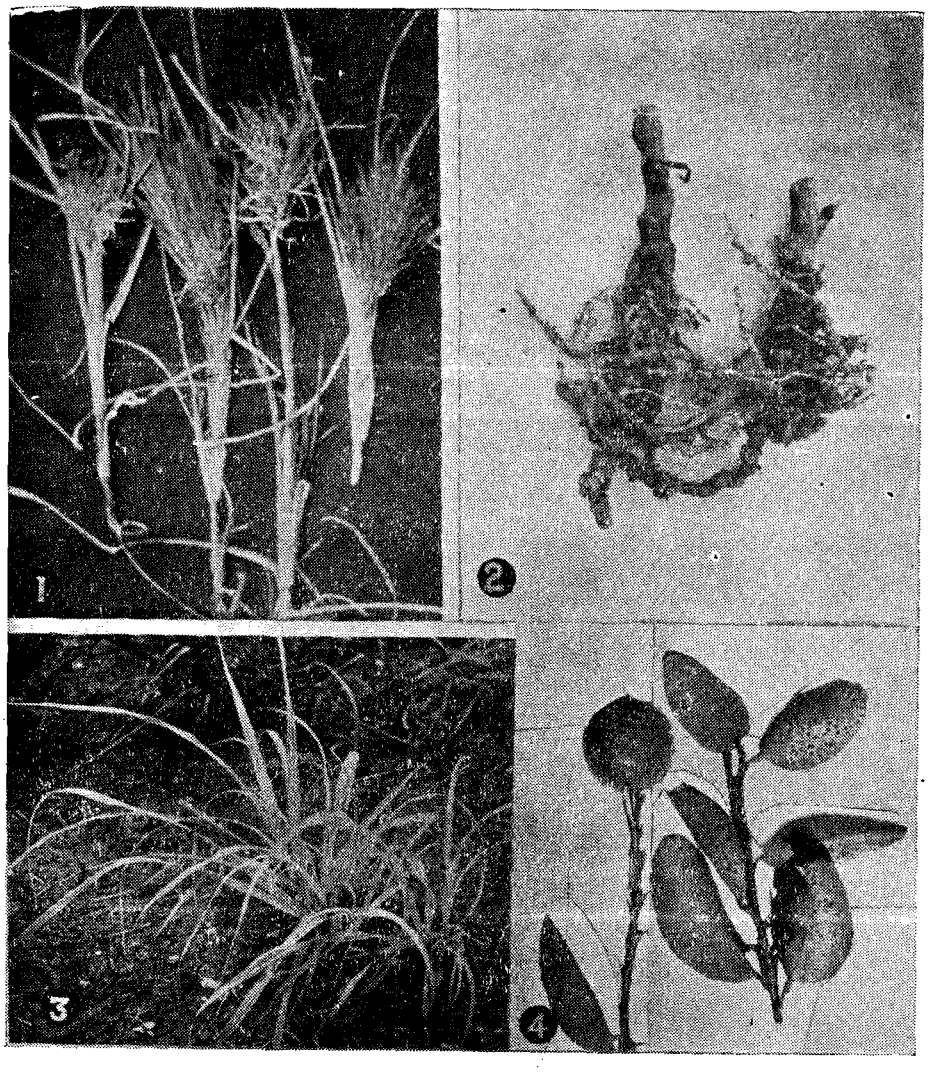


1. Downy Mildew (Crazy Top) of Ragi (Fungus Disease)
2. Root Knot of Tomato (Nematode Disease)
3. Grassy Shoot of Sugarcane (Virus Disease)
4. Canker of Lime (Bacterial Disease)

Plant Diseases and Their Control

Losses due to disease are among the many hazards the farmer must face in crop production. Although exact losses in Mysore State are unknown, a conservative estimate would put it at 10 to 15 per cent of the annual production. At a time when there is a growing gap between production and consumption, any reduction in the losses caused by plant diseases by the adoption of suitable control measures would go a long way in bridging this gap by augmenting food production.

Plant diseases are commonly caused by fungi, bacteria, viruses and nematodes. Some of these are seed borne; some are soil borne; some attack the plant in the seedling stage; others when the plants are fully grown; and for some, the plant remains susceptible throughout its entire period of growth. A plant may be affected by one or more diseases in succession during its cycle of growth from seedling to maturity, and two or more diseases may occur on it at the same time. Disease symptoms vary depending on the disease and host involved. A recognition of these symptoms and an understanding of the nature of the disease is a prerequisite for the adoption of suitable control measures.

In almost all cases, the control measures consist of application of chemicals either to the seed or to the soil or to the aerial parts of the plants. Fungicide control of seed and soil borne diseases require treatment of the seed or soil before sowing. The efficacy of these treatments depends upon proper and timely application. Otherwise effective control is difficult. The old adage "Prevention is better than cure" applies well to plant disease control.

For some diseases, no chemical control is known. In such cases, use of resistant varieties and following of approved cultural practices are helpful.

In this Manual, the diseases of important crops of Mysore State are given in tabular form with the common name of the disease, the causal agent, chief symptoms and control methods for each crop. An appendix including a list of different fungicides along wlth the trade names, common names and active ingredient is given. The information in the Manual is presented in simple non-techical terms. It is hoped that this section of the Manual will become an effective aid in plant disease control.

Disease	Cause	Symptoms	Control
1	2	3	4
		JOWAR	
Grain smut	*Sphacelotheca sorghi*	Ash grey conical smut balls (sori) replace the grain. When the smut balls are crushed, they become a mass of black sooty powder.	Treat the seed with sulphur (300 mesh fine) @ 4 g/kg or use any organomercurial compound. (See appendix for fungicides.)
Loose smut	*Sphacelotheca cruenta*	The diseased earheads emerge to reveal hypertrophied glumes and brackets bearing smut sori which gradually disintegrate into a mass of black sooty powder.	—do—
Downy mildew	*Sclerospora sorghi*	Diseased plants are stunted and leaves are pale yellow. The lower surface of the leaves is covered with dense fur-like fungal growth, with yellowing on the corresponding upper surface. The spots turn brown and later the leaves are shredded.	Rogue out and burn the diseased plants. Practise crop rotation.
Sugary disease	*Spacelia sorghi*	A sugary sticky substance oozes from the diseased earheads which fail to produce grains.	Spray twice with Ziram (40 g in 18 l of water) @ 336–560 l/ha once after earhead formation and again 8–10 days later.

Disease	Cause	Symptoms	Control
1	2	3	4
		JOWAR (Contd.)	
Leaf blight	*Helminthosporium turcicum*	Elongate spindle-shaped straw-coloured spots with reddish margins appear on the leaves. The spots are covered with green mouldy growth and may grow together forming larger spots.	Spray 3 times with Zineb or Ziram (40 g in 18 l of water) @ 900 l/ha at 2 weeks interval, beginning at 4 weeks growth. (See appendix for fungicides.)
Leaf spot	*Colletotrichum graminicola*	Reddish brown elongate spots with red margins appear on the leaves. The spots may spread and merge to form longer spots. The centre of the spot is greyish and bears black raised fruiting bodies of the fungus.	—do—
Rust	*Puccinia purpurea*	Brown rectangular to oval pustules appear on both surfaces of the leaves. In the young stage, the sori are covered by a thin covering which ruptures, exposing a brownish powdery mass.	—do—
Sooty stripe	*Ramulispora sorghi*	Elongate spots with red margins appear on the leaves. The middle of the spot is thickly covered by sooty coloured loosely attached sclerotial bodies.	—do—
Head smut	*Sphacelotheca riliana*	The earhead is converted into a black sooty mass, which is blown away leaving long, stiff, thread-like structures.	Practise crop rotation. Remove all the diseased earheads and burn.

Disease	Cause	Symptoms	Control
1	2	3	4
		PADDY	
Blast or 'Benki roga'	*Piricularia oryzae*	Oval to spindle shaped spots with brown margins and grey centres are formed on older leaves and leaf-sheaths. These spots may coalesce killing the leaves. In severe cases, the neck becomes infected, then shrivels and turns black, resulting in chaffy earheads.	Treat the seeds with 1% organomercurial (1 g in 18 l of water) for 12 hours, dry in shade and sow. Spray 15 to 20 days old seedlings in the nursery with bordeaux mixture (1%) or any copper fungicide. Follow with 2 sprays at intervals of 3 and 6 weeks after transplanting, and 2 applications of Ceresan lime dust (1:5) in the 9th and 11th weeks. (See appendix for fungicides.)
Brown leaf spot	*Helminthosporium oryzae*	Dark brown irregular spots are produced on leaves and leaf-sheaths. In severe cases, these spots coalesce killing the leaves. Diseased earheads produce shrivelled and discoloured grains.	Soak the seed in water overnight, then for one hour in Aureofungin (1 g in 10 ml commercial liquid soap diluted with 45 l of water to which add 1 g copper sulphate). Dry the seed and plant. Follow the spray schedule for the blast substituting a copper fungicide for Ceresan lime dust.
Bacterial blight	*Xanthomonas oryzae*	Linear yellow to straw-coloured lesions appear on leaf margins, progressing downwards from the tip to cover the entire leaf, leaving small green areas	Soak the seeds for 18 hours in a mixture of Streptocyclin (5 g in 18 l) and wettable Ceresan (1%). Spray the nursery with Streptocyclin and copper

Disease	Cause	Symptoms	Control
1	2	3	4
		PADDY (Contd.)	
		in the centre with irregular margins. The disease may extend to the sheath and culm, killing the entire plant.	sulphate mixed in equal proportion and follow with 4 sprays at 3, 6, 9 and 11 weeks after transplanting.
		RAGI	
Leaf blight and Foot rot	*Helminthosporium nodulosum*	Numerous small rusty brown spots are formed on leaves, leaf sheaths and earheads which on the leaves become large. The disease may spread to the culm and the roots. Diseased plants produce chaffy earheads.	Treat the seed with an organomercurial or Captan (2.5 g/kg of seed). Spray the seedlings with Captan (0.2%) when 2-3 weeks old. Follow with three sprays at 2-week intervals commencing from 2-3 weeks after transplanting @ 900 l/ha or Aureofungin may be used as described for paddy.
Blast or 'Benki roga'	*Piricularia setariae*	See paddy	Treat the seed in the same manner as in leaf blight and foot rot before sowing. Spray with Zineb (0.2%) when seedlings are 2-3 weeks old and repeat twice at 2-weeks intervals starting 2-3 weeks after transplanting @ 900 l/ha. Dust with Ceresan lime dust (1-5) 8-9 weeks after transplanting.

Disease	Cause	Symptoms	Control
1	2	3	4
		RAGI (Contd.)	
Disease Complex	*Helminthosporium nodulosum* and Virus	The diseased plants are stunted and tufted due to production of lateral shoots. The leaves show yellow streaks, stripes and mottling. A blackening occurs at the collar region and adventitious roots develop at the soil level and sometimes at the higher nodes.	Treat the seed with an organomercurial or Captan @ 2.5 g/kg. Spray the seedlings with a mixture of Captan (0.2%) and an insecticide (Parathion, Dimacron or Endrin), when 2-3 weeks old and repeat three times at 2-3 weeks intervals starting 2-3 weeks after planting.
		MAIZE	
Leaf blight	*Helminthosporium turcicum*	Elongate grey spots of various sizes with brown margins appear on the leaves. These spots may grow together killing the leaf. The disease usually occurs when the crop is 1 to 1½ months old.	Spray twice with Zineb or Ziram (40 g in 18 l of water) @ 900 l/ha, once when the crop is 30-35 days old and again 16-20 days later.
Rust	*Puccinia sorghi*	Small reddish brown pustules appear on both surface of the leaves and sometimes on the leaf-sheath. In severe cases the leaves become yellow and die. If the disease appears in the seedling stage, the plants are stunted.	Spray 3 times with Zineb or Ziram (40 g in 18 l of water) @ 900 l/ha, at 15-20 day intervals; the first spray when plants are 15 days old.

Disease	Cause	Symptoms	Control
1	2	3	4
		BAJRA	
Downy mildew	*Sclerospora graminicola*	Leaves of diseased plants lose colour and develop broad streaks with a downy growth on the corresponding lower surface. Later, the leaves turn brown and often show slight shredding. The earhead is transformed fully or in part into a loose green head, composed of small twisted green leaflike structures.	Rogue and destroy diseased plants.
Rust	*Puccinia pennisetti*	Numerous, small, brownish mass of spores (sori) are formed in groups, on both surface of the leaves and stems, which later turn black.	Spray Maneb (0.2%) at the rate of 560-1120 l/ha, depending on plant size. (See appendix for fungicides.)
Smut	*Tolyposporium penicillariae*	The grains are converted into sori, which are scattered in the earheads, projecting prominently beyond the glumes. The young sori are bright green or chocolate green, turning dirty green when mature.	Remove and destroy smutted ears.
Ergot	*Claviceps microcephala*	Honey like pink liquid exudes from the spikelets. Later, in place of seeds, dark sclerotia are formed, which project beyond the glumes.	Collect and destroy the affected earheads. Immerse the seed in 20% sodium chloride solution and remove and destroy the floating sclerotial bodies. Dry the seed and sow.

Disease	Cause	Symptoms	Control
1	2	3	4
		WHEAT	
Blackstem rust.	*Puccinia graminis tritici*	Elongate, browh or reddisn brown pustules occur on the leaves, leaf-sheaths, which become black as the season advances.	Grow resistant varieties Sonara 63, Sonara 64, Bijaga and Amrit.
Orange leaf rust	*Puccinia recondita*	Irregularly scattered round to oblong orange pustules occur on the leaves. In severe cases, the pustules occur on stems and leaf-sheaths also.	Grow resistant varieties N.P. 809, N.P. 798.
Loose smut	*Ustilago tritici*	A black powdery mass of spores appears in the diseased ears in place or grains. When the spores are blown away by wind, only the rachis is left behind.	Destroy the diseased plants before spores are shed. Use seed from smut-free crop. Grow resistant varieties. (See appendix for seed treatment.)
		NAVANE	
Downey mildew	*Sclerospora graminicola*	Diseased plants are dwarfed and tiller excessively. The earhead is converted into a malformed leaf structure.	Destroy the diseased plants.
Rust	*Uromyces setariae italica*	Numerous small pustules are formed on both surfaces of the leaves. The pustules are brown at first but turn black later.	Spray with Maneb (0.2%) @ 900 l/ha (See appendix for fungicides.)
Smut	*Ustilage crameri*	Pale greeen sori are formed in the	Treat the seed with an organomer-

Disease	Cause	Symptoms	Control
1	2	3	4
		NAVANE (Contd.)	
		earheads in place of the grains, and on rupture the sori release a black dusty mass of smut spores.	curial @ 2 g/kg. (See appendix for fungicides.)
		SUGARCANE	
Red sheath	*Sclerotium rolfsil*	The lowermost sheaths turn red and the inside of the sheath is covered by a white fungal growth. Diseased leaves, die prematurely.	Treat the setts for 30 mts. with an organomercurial(0.015% a.i.). Destroy the diseased sheaths. (See appendix for fungicides)
Rust	*Puccinia kuehnii*	Minute elongate orange spots appear on the undersurface of the leaves which turn brown later. In severe cases, the leaves are blighted.	Grow the resistant variety Co 419.
Grassy shoot	Virus	The diseased canes tiller heavily, produce chlorotic leaves and slender canes with short internodes. The disease is usually most severe in a ratoon crop.	Use healthy seed stock. Treat the setts for 8 hours with hot air at 54°C, or with hot water for 30 minutes at 45°C, followed by a 2 hour treatment at 50°C and then dip the treatcd setts in an organomercurial 0.015% a.i.) (See appendix for fungicides)
Mosaic	Virus	Yellowish green streaks appear on leaves which later become chlorotic.	Use healthy setts. Do not take ratoon crops.

Disease	Cause	Symptoms	Control
1	2	3	4
		SUGARCANE (Contd.)	
Red rot	*Glomerella tucumanensis*	Red lesions with straw-coloured centres studded with dark minute bodies develop on the midrib of the leaves. The canes are shrunken at the nodes and when split open emit a sour odour and show reddening interrupted with white cross bands.	Destroy diseased canes and grow tolerant variety CO 419. Use healthy setts.
Smut	*Ustilago scitaminea*	The growing shoots at any stage of plant goowth appear as long black whip-like structures at first covered by a silvery white membrane.	Destroy affected canes and grow resistant variety Co. 527, Co. 449 and use healthy setts from disease free localities. Do not take a ratoon crop in infested areas.
Pineapple disease	*Ceratocystis paradoxa*	Diseased setts emit a sour smell similar to pineapple. When split open, an orange red to purplish discolouration is seen, which later is covered by dark fungal growth.	Avoid planting in low lying areas. Treat the setts before planting with an organomercurial (0.015% a.i.) (See appendix for fungiicdes.)
Leaf spot	*Cercospora koepkei*	Yellow spots appear on the leaves and in severe cases, these may coalesce to cause blighting.	Grow the resistant variety Co. 449. Spray with Zineb (0.2%) @ 1800 l/ha. (See appendix for fungicides.)
Leaf spot	*Cercospora longipes*	The spots are brown and occur first on the lowermost leaves.	Spray three times Zineb (0.2%) @ 1100/l/ha at monthly intervals starting from the third month after planting.

Disease	Cause	Symptoms	Control
1	2	3	4
		GRAM	
Wilt	*Fusarium orthoceras var ciceri*	Both young and old plants are susceptible. The diseased plants turn yellow, wilt and die. Roots show blackening and rotting.	Destroy the diseased plants.
		TUR	
Wilt	*Fusarium udum*	A part or all of the plant may wilt, either gradually or suddenly and black streaks occur on the wood beneath the bark.	Destroy the diseased plants.
		CASTOR	
Rust	*Melasmpsora ricins*	Oragnge yellow rust pustules are formed in small circles on the lower surface of the leaves. The corresponding upper surface becomes chlorotic.	Dust both surfaces of leaves with sulphur (200-300 meshfine) @ 17-22 kg/ha.
Leaf spot	*Cercospora ricinella*	Minute black to brown leaf spots appear on both surfaces of the leaves. Later, the spots turn light brown and then greyish to white, with deep brown margins.	Spray the plants with 1% bordeaux mixture or any copper fungicides 900 l/ha, (See appendix for fungicides.)
		GROUNDNUT	
Tikka disease	*Mycospharella personata* *Mycospherella arachidicola*	Dark brown circular or irregular shaped spots usually surrounded by a yellow halo appear on the leaves, causing defoliation. In severe cases, pots also occur on petioles and steus.	Spray with Zineb (40 g in 18 l of water) @ 900 l/ha immediately after flowering and then two applications at 15 to 20 days intervals. (See appendix for fungicides.)

Disease	Cause	Symptoms	Control
1	2	3	4
		GROUNDNUT (Contd.)	
Collar rot	*Sclerotium sp.*	Diseased plants are stunted and pale, and finally dry up. Fungus attacks the collar region and the roots, causing rot. The rotted parts are covered with white fungal growth and numerous small brown bodies (sclerotia) resembling mustard seed.	Treat the seed with organomercurial 2 to 3 g/kg. (See appendix for fungicides.)
Rosette	Virus	Diseased plants are erect with dense tuft of dwarf shoots and small yellow erect leaves.	Destroy diseased plants.
		COTTON	
Angular leaf spot or Black-arm	*Xanthomonas malvacearum*	Black glistening angular spots appear on the leaves and dark elongate lesions on the petioles and stems. In severe cases, defoliation and death of the stems may occur. Round, sunken, darks spots are formed on the bolls.	Delint the seed with concentrated sulphuric acid (0.1 to 0.2%) and treat with an organo-mercurial compound. (See appendix for fungicides.)
Wilt	*Fusarium oxysporum f vasinfectum*	The leaves of diseased plants turn yellow, then brown. The wood beneath the bark is brown, later becoming black. The plants gradually wilt and dry.	Grow resistant varieties (Jayadhar, B.D. 8, Vijaya).

Disease	Cause	Symptoms	Control
1	2	3	4
		COTTON (Contd.)	
Root rot	*Rhizoctonia bataticola*	Diseased plants wilt suddenly. In a field the disease occurs in circular patches. The roots decay. The bark is shredded and the wood beneath is yellow to brown.	Grow Matki (*Phaseolus aconitifoilus*) intermixed with cotton.
Soreshin	*Rhizoctonia bataticola*	Pale redish brown to dark brown lesions appear on the stems of young plants near the soil level. The diseased plants then collapse and die. Older plants produce shrunken, brittle leaves, which fall off, after which they produce new leaves.	Avoid early sowing and if crust is formed after sowing, it should be broken up by tillage.
Grey mildew	*Ramularia areola*	Grey or ash-coloured mycelial growth is produced on the under-surface of the leaves, with a corresponding yellowish discolouration on the upper surface. In severe cases defoliation occurs.	Dust with sulphur (200-300 mesh fine) at 15 days intervals @ 17-22 kg/ha.
Leaf sopt	*Alternaria macrospora; Helminthosporium gossypi; Cercospora gossypina*	Various types of leaf spots occur, usually on the lower leaves. In severe cases, defoliation occurs.	If the disease is severe, spray with 0.2% Zineb @ 900 l/ha. (See appendix for fungicides.)

Disease 1	Cause 2	Symptoms 3	Control 4
		COTTON (Contd.)	
Small leaf or stenosis	Virus	The diseased plants are stunted presenting a bushy appearance. The leaves are crinkled and yellow.	Rogue out and destroy the diseased plants.
		TOBACCO	
Powdery mildew	*Erysiphe cichoracearum*	Whitish powdery patches of fungal growth are formed on both surfaces of the leaves, appearing first on the lower leaves. Diseased leaves turn brown and wither.	Space the plants to avoid overlapping growth. Apply sulphur dust (200-300 mesh fine) to the soil between rows @ 34-45 kg/ha. *Do not allow the sulphur dust to settle on the leaves.*
Frog eye leaf spot	*Cercospora nicotiana*	Ash grey circular spots with narrow brown to black raised borders appear on the leaves.	Treat the seed with silver nitrate solution (1: 1000) for five minutes and spray the seedlings with bordeaux mixture (1%) or any copper fungicide. Destroy the diseased leaves. (See appendix for fungicides.)
Black Shank	*Phytophthora parasitica nicotiana*	The disease occurs both in seedlings and in adult plants. The basal portion of the stem becomes black and when the disease spreads to the roots the plants wilt and collapse.	Destroy the diseased plants. Drench the seed-beds and spray the transplanted seedlings with bordeaux mixture (1%) or any copper fungicide. (See appendix for fungicide.)
Wilt	*Pseudomonas solanacearum*	See tomato.	See tomato.

Disease	Cause	Symptoms	Control
1	2	3	4
		TOBACCO (Contd.)	
Mosaic	Virus	Light to dark green irregular patches appear on the leaves. Diseased plants are stunted and newly formed leaves are distorted, with irregular dark green blisters.	Destroy the diseased plants. Avoid the use of farmyard manure containing diseased tobacco trash. Wash hands clean after touching a diseased plant.
Leafcurl	Virus	The diseased plants are stunted. The leaves become twisted and curled and leafy outgrowths are produced from the veins on the lower surface of the leaves.	Destroy diseased plants.
Flowering parasite	*Orobanche spp.*	Small parasitic plants 25-37 cm high with stout fleshy yellow stems and purple flowers,grow around the tobacco plants attached to the roots.	Destroy the parasite before blooming.
		POTATO	
Late blight	*Phytophthora infestans*	Small brown to purple lesions are formed on the leaves, with a whitish fungal growth on the underside. Under favourable conditions, these spots enlarge rapidly covering the whole leaf. In severe cases, the tubers show a brown to purple discolouration followed by dry rot. In storage wet rot destroys the tubers.	Use disease-free seed stock. Spray 3-4 times at weekly intervals with bordeaux mixture (1%) or any copper fungicide or with any dithiocarbamate (0.2%) @ 900 l/ha. Remove diseased foliage a few days before harvest. (See appendix for fungicides.)

Disease	Cause	Symptoms	Control
1	2	3	4
		POTATO (Contd.)	
Brown rot	*Pseudomonas solanacearum*	Diseased plants develop a brown colour, shrivel and wilt. The entire vascular system turns brown and diseased tubers give out a white exudate when squeezed.	Use disease-free seed stock and rotate planting with jowar, maize or other suitable crops. Disinfect the knife with an organomercurial compound every time a diseased potato is cut. (See appendix for fungicides.)
Early blight	*Alternaria solani*	Dark brown to black spots with concentric rings are produed haphazardly on the leaflets. Diseased leaves are shed.	Spray three times with any dithiocarbamate (0.2%) @ 900 l/ha, commencing one month after planting and at intervals of 15 days. (See appendix for fungicides.)
Leaf roll	Virus	Diseased plants are stunted. The leaves roll upwards, rigid and leathery and show varying degree of chlorosis, reddening and purple discolouration.	Remove diseased plants and use disease-free seed stock.
Mosaic	Virus	Leaves show a mild mosaic symptom or a distinct mottling, a curling of the surface, and are reduced in size. Extensive necrosis may develop along the veins and midribs.	Remove diseased plants and use disease free seed stock.
Root knot	*Meloidogyne spp.*	The diseased p:ants are stunted and root knots or galls nevelop on the roots.	See tomato.

Disease	Cause	Symptoms	Control
1	2	3	4
		BRINJAL	
Little leaf	Virus	Diseased plants appear bushy with numerous malformed leaves crowded on short branches.	Rogue and destroy the diseased plants.
Sclerotium wilt	*Sclerotium rolfsii*	Diseased plants wilt suddenly, followed by yellowing of the leaves. A white mycelial growth bearing mustard-like sclerotial bodies appears at the base of the plant.	Avoid water logging and adopt furrow and ridge method of irrigation to prevent direct contact between stem and water. Drench the soil with PCNB (0-2%) or organomercurial. (See appendix for fungicides.)
Bacterial wilt	*Pseudomonas solanacearum*	The young leaves wilt, followed by the death of the plant. The vascular bundles become discoloured.	Avoid water logging and adopt furrow and ridge method of irrigation to prevent direct contact between stem and water. Practise crop rotation avoiding successive crops of brinjal, chillies, potatoes and tomatoes.
Damping off	*Pythium spp.*	See chillies.	See chillies.
		TOMATO	
Wilt	*Pseudomonas solanacearum*	The lower leaves droop, the upper leaves turn pale green to yellow and then brown and finally the plants wilt and die. If the stem is split open, brown discolouration of the vascular bundles is conspicuous. Diseased plants produce adventitious roots on the stem.	Grow seedling in disease-free area and avoid transplanting seedlings obtained from a contaminated seed bed.

Disease	Cause	Symptoms	Control
1	2	3	4
		TOMATO (Contd.)	
Leaf curl	Virus	Diseased plants are stunted, the leaves curl, twist and roll towards the upper side, giving the plants a bushy appearance. Diseased plants fail to bloom or bloom only partially.	Destroy the diseased plants.
Root knot	Nematode *Meloidogyne spp.*	Typical galls or knots are formed on the roots. Disesed plants are stunted, the leaves become yellow and the plants wilt.	Destroy the diseased plants. Treat the soil at least 2 weeks before sowing, with D. D. @ 170-225 l/ha or E.D.B. @ 18-27 l/ha.
		CHILLIES	
Powdery mildew	*Oidium spp.* *Oidiopsis spp.*	Both sides of the leaves are covered with white powdery fungus growth. In severe cases, the leaves may fall.	Dust with sulphur (200-300 mesh fine) @ 17-22 kg/ha or spray Solabar 1-3% @560-1120 l/ha.
Anthracnose	*Colletotrichum capsici*	Small black circular sunken spots appear on ripe fruits, later elongating along the long axis of the fruit; small black bodies of the fungus, arranged more or less in concentric circles, are formed on the surface.	Spray 1% Bordeaux mixture or any copper fungicide once every 2-3 weeks after fruit set, at the rate of 900-1120 l/ha. (See appendix for fungicides)
Leaf spot	*Cercospora spp.*	Small circular necrotic spots with dark margin appear on leaves. The centre of the dark may drop out leaving a hole. The spots may also occur on stems, petioles and peduncles.	Sparay 1% Bordeaux mixture or any copper fungicide at 2-3 weeks intervals, @ 900–1120 l/ha. (See appendix for fungicides.)

Disease	Cause	Symptoms	Control
1	2	3	4
Damping off	*Pythium spp.*	Seedlings may be killed before emergence. In grown-up seedlings, a water soaked area develops on the stem near soil level and the seedlings collapse and die.	Treat seeds with 1:1000 mercuric chloride for 5-10 minutes or with Thiram 3-4 gms per kg. Drench the seed bed mith 0.1 to 0.2% organo mercurial or Bordeaux mixture (2:2:50) before sowing. (See appendix for fungicides.)
Bacterial Leaf spot	*Xanthomonas vesicatoria*	Small dark glistening spots are produced on leaves and stems. In severe cases, the plants may die due to girdling of stem. On fruits, water soaked sunken spots with pale yellow borders appear, which later turn brown.	Treat the seeds with hot water (52°C) for 30 minutes, or with an organo mercurial 2.3 g/kg seed. Spray with 1% Bordeaux mixture or Streptomycin 250-500 ppm, @ 900 l/ha five times during the monsoon, at intervals of 15 days.
		CRUCIFEROUS VEGETABLES	
Black rot	*Xanthomonas campestris*	Leaves turn yellow and the veins become black. The stem shows vascular discolouration. In older plants, soft rot of the head may occur.	Treat the seed with mercuric chloride solution (1 : 1000) for 30 minutes or treat the seed with hot water (50°C) for 30 mintues. Drench the soil in the nursery to a depth of 15 cm, with commercial Formalin (5%), cover with canvas for one or two days to allow the fumes to act. Sow seed three weeks after treatment. Practise 3 years rotation with non-cruciferous plants.

Disease	Cause	Symptoms	Control
1	2	3	4
		CIUCFERROUS VEGETABLE (Contd.)	
White rust	*Albugo candida*	White prominent spots occur on leaves, stems and flowers, sometimes accompanied by swelling and distortion.	Spray the crop with Ziram (0·2%) at 15 days intervals @ 900 l/ha. (See appendix for fungicides.)
Blight	*Alternaria brassicae*	Small dark coloured spots which rapidly enlarge to form lesions appear on leaves. Later, concentric rings of dark conidiophores appear on these spots. Diseased plants are stunted.	Treat the seed with hot water (50°C) for 30 minutes. Spray with Bordeaux mixture (1%) or any copper fungicide 3 to 4 times @ 900 l/ha. Collect diseased material and burn. (See appendix for fungicides.)
		CUCUMBER	
Powdery mildew	*Erysiphe cichoracearum*	Ash white powdery patches of fungal growth appear on leaves and stems. In severe cases defoliation may occur.	Spray with Maneb (0·2%) @ 450-675 l/ha. (See appendix for fungicides.)
Downy mildew	*Pseudoperonospora cubensis*	Yellow patches appear on the upper surface of the leaves with a corresponding white fungal on the lower surface.	Spray with Bordeaux mixture (0·5%) or any copper fungicide @ 450-675 l/ha. (See appendix for fungicides).
		BHENDI	
Yellow vein mosaic	Virus	Leaf veins of diseased plants are bright yellow, the lamina remaining light or dark green. In severe cases, the whole leaf becomes yellow.	Destory diseased plants.

Disease	Cause	Symptoms	Control
1	2	3	4
Powdery mildew	*Oidium sp.*	The leaves are covered with a white powdery growth on both sides. Severely diseased leaves become yellow and drop.	Spray Ziram 0.1-0.3% or Solabar 1-3% at the rate of 560-1120 l/ha or dust with sulphur (203-300 mesh fine) at the rate of 17-22 kg/ha. (See appendix for fungicides.)
		BEANS	
Mosaic	Virus	Pale yellow patches alternating with dark green patches appear on the leaves. The plants are stunted and bushy.	Use seed obtained from healthy plants. Rogue out and destory the diseased plants.
Anthracnose	*Colletotricum lindemuthianum*	Dark brown lesions with black centre and light brown to pinkish border develop on the leaves, petioles, stems and pods.	Spray the plants with Bordeaux mixture (1%) or any copper fungicide @ 900 l/ha. Use disease free seed. (See appendix for fungicides).
Rust	*Uromyces appendiculatus*	Deep brown powdery pustules which later turn dark brown to black appear on the lower surface of the leaves.	Remove and destroy diseased leaves. Dust the plants with sulphur (200-300 mesh fine) @ 17-22 kg/ha or spray with commercial wettable sulphur (0·5%) @ 1/ha.
		PEAS	
Powdery mildew	*Erysiphe polygoni*	Diseased plants are stunted; the leaves are covered with white powdery fungal growth on both the surfaces.	Dust with sulphur (200-300 mesh fine) @ 17-22 kg/ha.

Disease	Cause	Symptoms	Control
1	2	3	4
		PEAS (Contd.)	
Anthracnose	*Colletotrichum pisi*	Brown lesions with slightly paler centres than margins are produced on leaves, stems and pods.	Not known.
Rust	*Uromyces pisi*	Reddish brown pustules are produced on all parts of the plant, which is later defoliated.	— do —
Root rot or wilt	*Fusarium oxysporum f. pisi*	The leaves of diseased plants turn yellow, the plants wilt and die.	— do —
		ONION	
Smut	*Urocystis cepulae*	Dark elongate blisters appear on the scales and leaves of young seedlings, eventually breaking open to expose a black powdery spore mass. The leaves curve down and die.	Do not grow onion in an infested field. Destory all diseased plants.
Smudge	*Colletotrichum circinans*	Dark spots appear as concetric rings on the outer scales just before harvest.	Destroy diseased bulbs. Avoid white varieties. Dry the onions thoroughly before storage.
		MANGO	
Powdery mildew	*Oidium mangiferae*	An ash white powdery fungal growth appears on the inflorescence and young fruits, and new growth if any, causing heavy shedding of flowers and fruits. White scattered patches occur on the young leaves which turn brown.	Dust with sulphur (300 mesh fine) once before flowers open and again soon after fruit set, @ 450-900 g per tree, depending on the size of the tree.

Disease	Cause	Symptoms	Control
1	2	3	4
Anthracnose	*Gloeosporinm mangiferae*	Small dark brown to black spots appear on tender twigs, leaves and young fruits increasing in size as they mature. In severe cases, the disease causes dieback of the twigs.	Spray the plants 2–3 times with Bordeaux mixture (1%) or any copper fungicide at 15–20 days interval @ 5–9 l/tree, beginning with the appearance of the inflorescence.
		CITRUS	
Gummosis	*Phytophthora palmivora* *P. parasitica* *P. citrophthora*	Large qnantities of gum are exuded from the stems of diseased plants through splits in the bark, near the bud union or ground level. In severe cases, the trunk may be girdled. The infection may spread to the crown and roots, causing death of the plant.	Avoid contact of trunk with wet soil. The bud graft should be at least 30 cm high on the stock. Apply Bordeaux paste to the trunk before monsoon season. Cut out the diseased portions with a sharp knife, extending the cut at least 2·5 cm. allround into the healthy portion. Disinfect the wound with potassium permanganate (1%) and allow it to dry, and then apply Bordeaux paste or Creosote oil.
Canker	*Xanthomonas citri*	Initially water soaked spots appear on leaves, petioles, twigs, fruit stalks and fruits. These spots later turn into brownish crater-like lesions with raised margins. Diseased leaves drop prematurely.	Prune away diseased parts and burn. Spray the plants with Streptomycin (500–1000 pmm) or neem oil cake (450 gms in 9 l of water) at 15-day intervals.

Disease	Cause	Symptoms	Control
1	2	3	4
		CITRUS (Contd.)	
Tristeza	Virus	Diseased trees gradually decline in vigour, flower profusely, set fruits heavily and fail to produce new growth. The leaves turn yellow and are shed, causing dieback of twigs, vein clearing and stem pitting are the characteristic symptoms in Kagzilime.	Remove and destroy diseased plants. Use tolernt root stocks like Jam bheri and virus-free bud wood.
Greening	Virus	Leaves show chararteristic yellowing adjacent to mid rib and are later shed. Affected trees blossom heavily. Sometimes, small well defined green or yellow spots appear on leaves. In advanced stages the branches die back.	Use virus-free bud wood.
Citrus scab	*Sphaceloma fawcettii*	Raised brownish spots appear on young leaves, shoots and twigs. Leaves are distorted.	Give 2 or 3 sprays of 1% Bordeaux mixture or any copper fungicide during the rainy sesaon. Collect and burn diseased leaves. (See appendix for fungicides.)
Powdery mildew	*Oidium tangitaninum*	White powdery growth appears on young leaves, twigs and fruits, which drop prematurely.	Dust the trees with sulphur (200–300 mesh fine) or spray with wettable sulphur (0.5%) 1 or 2 times in the quiet of early morning, during flush period.

Disease	Cause	Symptoms	Control
1	2	3	4
		CITRUS (Contd.)	
Leaf fall and Foot rot	*Phytophthora palmivora*	Water soaked lesion appears on leaves, green twigs and fruits, causing premature dropping. Fallen fruits and leaves are covered with a white fungal growth, and emit a foul odour.	Spray 1% Bordeaux mixture or any copper fungicide at the rate of 1120-2240 l/ha once in May-June before the onset of monsoon and again in August-September. Burn diseased fruits and leaves. (Spray volume depends on age of trees.) Raise canopy at least 45 cm - 60 cm above ground by staking. (See appendix for fungicides.)
Pink disease	*Corticium salmonicolor*	During the monsoon the diseased branches wilt, causing leaf shedding and stem dieback. A film of silvery white mycelium covers the upper surface of the branch, and a pink encrustation forms on the lower side.	Prune and burn diseased branches. Spray the pruned and the surrounding trees with 1% Bordeaux mixture or any copper fungicide. (See appendix for fungicides.)
ottle leaf	Zinc deficiency	The leaves are small and become chlorotic between the main and lateral veins on both sides of the midrib. In advanced cases, dieback of twigs occurs.	Spray the plants with a mixture of zinc sulphate and lime (1250 gm : 625 gm : 100 l of water). Give heavy doses of organic matter (about 100 kg/per tree FYM.)

Disease	Cause	Symptoms	Control
1	2	3	4
		GRAPES	
Downy mildew	*Plasmopara viticola*	Irregular yellow spots appear on the upper surface of the leaves; the corresponding lower side is covered with a white downy fungal growth. In severe cases, the leaves wither and die. When the inflorescence is attacked, all the flowers are shed. Young berries shed prematurely.	Spray with Bordeaux mixture (5:5:50) or any copper fungicide as soon as symptoms appear. Repeat the spray when new growth is 15 to 20 cm and then at an interval of 15 days, till the end of the monsoon. Give final spray immediately after spur pruning. (See appendix for fungicides.)
Anthracnose	*Gloeosporium ampelophagum*	Small dark brown sunken spots appear on leaves and succulent parts of the plant. When attacked, young flowers and berries drop. On older berries, the spots are circular with sunken centres and raised reddish purple margins, suggesting the name 'bird's eye spot'. On diseased canes, the spots are sunken; in severe cases the canes become brittle and break easily.	Prune and destroy the diseased parts. Follow the spray schedule given for Downy mildew.
Powdery mildew	*Uncinula necator*	White powdery fungal growth appears on both surfaces of the leaves which are smaller and crinkled. The diseased flowers and young berries are shed; older fruits crack open.	Dust with sulphur (300 mesh fine) @ 17-28 kg/ha. Make the 1st application when the new growth is 15 to 20 cm and repeat every 15 days.

Disease	Cause	Symptoms	Control
1	2	3	4
Rust	*Phakopsora vitis*	Numerous orange-yellow pustules (sori) appear on the lower surface of the leaves.	Dust with sulphur (300 mesh fine) @ 17-28 kg/ha.
		GUAVA	
Canker	*Pestalotia psidi*	Circular to elongated or irregular spots with sunken centres and raised margins appear on fruits, rarely on leaves.	Spray with Zineb (0.2%) after fruit set and continue at monthly intervals till harvest. (See appendix for fungicides.)
		BANANA	
Wilt or Panama disease	*Fusarium oxysporum f. cubense*	The older leaves turn yellow from the margin, wilt and droop. The younger leaves are affected in succession and hang likewise. In the advanced stage of disease, the pseudostem is brittle and cracks at the base. The vascular bundles in the rhizomes of diseased plants turn brown.	Remove and destroy diseased plants. Obtain suckers from disease-free area. Grow resistant varieties, *i.e.*, Basarai, Rasthala. Change the plantation site.
Bunchy top	Virus	Diseased plants are stunted; they have small erect leaves, characterised by irregular green streaks which are bunched at the top. Fruit production fails.	Rogue out and burn diseased plants. Obtain suckers from disease-free area.

Disease	Cause	Symptoms	Control
1	2	3	4
		BANANA (Contd.)	
Pseudostem rot	*Sclerotium rolfsii*	Leaves turn yellow, droop and gradually dry up. Large discoloured patches appear on leaf-sheaths, which later rot and the plant wilts. Small brownish black round bodies (sclerotia) appear on the inner surface of the leaf sheaths.	Dig out and burn diseased plants, roots included. Plant suckers from healthy plants.
		PAPAYA	
Powdery mildew	*Oidium sp.*	Ashy white irregular powdery fungal patches develop on leaves and shoots, causing defoliation.	Dust the plants with sulphur (200-300 mesh fine) or spray with wettable sulphur (5 g in 1 l of water.)
Leaf curl	Virus	The leaves of diseased plants are severely curled, crinkled and distorted, the petioles and internodes are shortened and flowering is suppressed.	Remove and destroy diseased plants.
		SAPOTA	
Leaf spot	*Phaeophleospora sp.*	Brown to dark brown circular spots with a faint halo are formed on the leaves, causing them to shed.	Spray with Zineb (0.2%) @ 9 l/tree. (See appendix for fungicides.)
		COFFEE	
Rust	*Hemileia vastatrix*	Orange yellow spots are produced on the lower surface of the leaf, the corresponding upper surface becoming brown. In severe cases, defoliation	Grow resistant varieties, i.e., S-795, S-333 and S-288. Spray Bordeaux mixture (0.5%) three times, first 20 days after blossom, second in May-

Disease	Cause	Symptoms	Control
1	2	3	4
		occurs, resulting in stunting of the plant.	June and third in August-September, @ 1120-4480 l/ha, depending on the age of the plant.
Black rot	*Corticium kolerogam*	The under surface of the leaves is covered with a thin growth of fungus extending along the petiole. Diseased leaves, twigs and berries turn black and rot.	Practise approved pruning schedule. Regulate shade to a height of 4.5 - 6 metres above the crown. Spray with 1% Bordeaux mixture or any copper fungicide, once in May-June and again in August-September @ 1120-4480 l/ha. (See appendix for fungicides.)
Pink disease	*Corticium salmonicolor*	See citrus	See citrus.
Brown eye spot and Berry blotch	*Cercospora coffeicola* *Cercospora coffeae*	Small necrotic spots with dark brown margins are formed, mostly on nursery seedlings and in new clearings. Diseased leaves are shed prematurely and the berries shrivelled.	Avoid sudden exposure of nursery seedlings to sun after the monsoon. Spray nurseries and new clearings with 0.5% Bordeaux mixture or any copper fungicide during May, and August-September. (See appendix for fungicides.)
Damping off	*Rhizoctonia solani*	Diseased seedlings rot at the collar region and collapse. Seedlings may also be killed before they emerge.	Regulate shade and provide good drainage. Drench the soil with 1% Bordeaux mixture @ 9 l per 3 sq. metres.
Mottling	Zinc deficiency	Diseased plants produce small narrow thick leathery leaves with interveinal chlorosis. In severe cases defoliation occurs, followed by die-back.	Spray with zinc sulphate 0.25% 3 times a year, either alone or with bordeaux mixture.

Disease	Cause	Symptoms	Control
1	2	3	4
		CARDAMOM	
Katte of Marble disease	Virus	Discontinuous (pale green) strips running more or less parallel to each other from the midrib to the margin appear on the leaves. The fully developed leaves have a characteristic mosaic pattern.	Rogue and burn the diseased plants including the rhizome. Replant with healthy seedlings obtained from disease-free area.
Clump rot	*Pythium vexans* *Pythium aphanidermatum*	The leaves of diseased plants become yellow and the plant wilts and dies. The rhizomes rot.	Rogue out the diseased plants. Drench the soil with cheshunt compound. (For preparation of the compound, see under Ginger)
Leaf spot	*Phyllosticta sp.*	Brown to dark brown round spots of various sizes occur on leaves. In severe cases, the leaves are blighted.	Spray 1% Bordeaux mixture or any copper fungicide at frequent intervals to cover the new growth. (See appendix for fungicides.)
Damping off	*Pythium sp.*	A water-soaked area develops on the stem near the ground level and the seedlings collapse and die.	Soak the seed bed to a depth of 15 cm, with 1 : 50 formalin (37-40% formaldehyde). Cover with canvas for 1-2 days to allow the fumes to act. Sow seeds 3 weeks after treatment. Spray the seedlings with 1% Bordeaux mixture or any copper fungicide at intervals of 10-15 days. (See appendix for fungicides)

Disease	Cause	Symptoms	Control
1	2	3	4
		COCONUT	
'Anabe roga' or Root disease	*Ganderma lucidum*	The fungus attacks the roots and the stem at the collar region causing cracks. A brownish gummy juice exceedes through the cracks in the bark and the leaves turn yellow and droop. In advanced stages, bracket-like fruit bodies of the fungus appear at the base of the palm, eventually the plant dies.	Dig out the diseased plants and roots to a depth of 1.5 metres and burn. Apply sulphur dust (200-300 mesh fine) in a trench 30-60 cm. deep and 30 cm. broad dug around the plant 90 cm. away from the base at the rate of 900 gm. per plant and fill with soil. Provide good drainage.
Bud rot	*Phytophthora palmivora*	Discoloured spots appear on leaves and leaf sheaths which rot. Later the teriminal bud becomes diseased and also rots leading to the death of the plant.	Remove the diseased leaves and spray the crown with 1% Bordeaux mixture or any other copper fungicide. If the disease persists, repeat the spray after one month. (See appendix for fungicide.s) Remove the severely diseased plants and burn the tops.
Stem bleeding.	*Ceratocystis paradoxa*	Symptoms are similar to the stem bleeding disease of Areca. The bleeding patches, however, are confined to higher regions of the stem.	Same as for stem bleeding of Areca.
		PEPPER	
Anthracnose	*Collectotrichum necator*	Brown to black lesions appear on the leaves, more frequently on mature	Spray Bordeaux mixture (0.5%) or any copper fungicides @ 450-500 l/ha

Disease 1	Cause 2	Symptoms 3	Control 4
		PEPPER (Contd.)	
		leaves. The spikes fall off prematurely and diseased berries are shrivelled.	during monsoon or when the disease appears. (See appendix for fungicides.)
Black rot	*Rosellinia bunodes*	The roots of dieased plants are covered with a network of fungal mycelium, white stars of mycelial growth are produced under the bark, leaves become yellow and drop, the plants wilt and ultimately die.	Collect and burn all diseased plant parts. Treat the pit before planting with Boreduex mixture (1%) or any copper fungicide. (See Appendix for fungicides.)
		ARECA	
'Koleroga' or Fruit rot	*Phytophthora arecae*	Affected nuts (on which a whitish felt-like myceial growth develops) are shed prematurely. In severe cases the crown of the plant is killed, causing "Stag heads."	Collect and burn the fallen nuts. Remove dead and drying trees. Spray Bordeaux mixture (1%) or any copper fungicide twice a year, immediately before and after the South West monsoon, usually the first week of June and in August at the rate of 1125 l/ha. (See appendix for fungicides.)
Anaberoga	*Ganoderma lucidum*	A brown liquid oozes from cracks in the bark all round the base of the plant. In advanced stages, the leaves turn yellow, fruiting bodies (Anabe) appear at the base, and the plant eventually wilts.	Dig out diseased plants to a depth of 120 cm and burn. 60 cm away from the base of the plant dig a 22 cm × 22 cm trench. Apply 225 to 450 gm of sulphur (200 to 300 mesh fine) in the trench and fill with soil. Provide good drainage.

Disease	Cause	Symptoms	Control
1	2	3	4
Stem bleeding	*Ceratocystis paradoxa*	Brown liquid, which later turns black oozes through the cracks in the bark of diseased plant, usually on one side of the stem at upper regions. The tissue under the bark becomes yellowish black to black. Diseased young plants are generally swollen at the crown.	Chisel out the diseased portion till healthy tissue is exposed. Paint the wound with Bordeaux paste prepared by mixing equal quantities of finely grounds copper sulphate and lime in a small quantity of water. Apply with a brush.
		ARECA	
'Hidimundige Roga'	Unknown	Diseased plants taper gradually at the top, the crown gets smallers and the plant dies. The inflorescence decays, if formed.	Provide good drainage and apply balanced fertilizers.
Bud rot	*Phytophthora palmivora*	See coconut	See coconut
New yellow leaf disease	Unknown	The leaves remain small and turn yellow and the crown is thin. Diseased plants cease to bear after one or two years and ultimately die. The inner tissues of the crown of diseased plants rot and emit a foul odour.	Provide good drainage and apply balanced fertilizers.

Disease	Cause	Symptoms	Control
1	2	3	4
		BETELVINE	
Wilt	*Phytophthora parasitica var piperina*	The leaves of the diseased vines become yellow and wilt, starting from the bottom upwards. A blackish brown discolouration appears on the stem near the soil level, after which the vine wilts and dies.	Drench the soil to a depth or 15 cm. with Bordeaux mixture (2:2:50) or any copper fungicide, before planting and then at monthly intervals, at the rate of 9 l for every three metre row. Provide good drainage. (See appendix for fungicides.)
		GINGER	
Soft rot or Foot rot	*Pythium myriotylum*	Leaves become yellow and curl downwards. Water-soaked areas develop on the stem near ground level, causing a breaking of the plant. The rhizome and roots show a soft rot.	Obtain sets from disease free areas. Plant on raised beds. Treat the soil with cheshunt compound.
		TURMERIC	
Leaf spot	*Taphrina maculans*	Pale yellow spots which later become deep golden appear on the leaves, usually on the upper surface. The spots may coalesce causing withering of the leaves.	Spray with Bordeaux mixture (0.5%) or any copper fungicide @ 990 l/ha. (See appendix for fungicides.)
Leaf spot	*Colletotrichum capsici*	Oblong brown spots with black concentric rings occur on the leaves. The spots may coalesce and cause blighting of the major portion of the leaves.	Spray with Bordeaux mixture (3:3:50) or use any copper fungicide @ 900 l/ha. (See appendix for fungicides.)

Soil insecticide experiment for control of jowar shoot fly at University of Agricultural Sciences Regional Research Station at Raichur—1968

Insect Pests of Crops and their Control

In this Manual, insect pests are grouped according to the crops attacked. Only the more economically important ones are included.

The key to insect pest control is early detection of infestation. In some cases insect pests can be detected easily; more often visible signs appear only after damage is done. It is, therefore, necessary to be alert for the first sign of infestation, including underground infestations. Adopt control measures only when infestation is detected, unless there is a history of infestation. Use of insecticides is the most common method of control.

Other methods of control include cultural practices, crop rotation and growing resistant varieties. Plough under all infested crop refuse and practise weed control to remove future sources of infestation.

Adopt recommended crop rotation schedule to avoid build-up of infestation, and grow resistant varieties, when available.

Insect	Damage	Control
1	2	3
	CEREALS	
	JOWAR	
Shoot fly, *Atherigone varia soccata* (= *A. indica*)	In plants six weeks old or less the central shoot shrivels, rots at the base and when pulled comes out easily exposing a small yellowish maggot. Side tillers then develop and may also be attacked. The insect occurs in all the jowar growing areas in the State.	1. In irrigated fields, apply phorate granule in the seed furrow at sowing time at 1.5 kg *a.i.*/ha (1.5 gm of 10% g/metre of row). In other words, use 15 kg/ha for row spacing of one metre or 30 kg/ha for row spacing of 0.5 metre. Avoid direct contact of chemical with seed. 2. Sow the crop between March 1 and June 30, which is a period of low infestation. 3. In absence of chemical control, remove and destroy dead seedlings. Also the seeding rate may be increased upto 20% to compensate for plants killed by shoot fly.

a.i. = active ingredient (actual) D.P. = Water dispersible powder; E.C. =Emulsifiable concentrate.
g = granules; lt = litre; W. P. = Wettable powder.
Note : E. C. and W. P. give identical results. W. P. is used chiefly on fruits. Elesewhere E. C. is preferred.

Insect	Damage	Control
1	2	3
Stem borer, *Chilo partellus* *(= zonellus)*	A dirty white caterpillar with brownish spots bores into the stem of young plants, killing the central shoots, commonly referred to as "dead-heart". In older plants, white feeding patches and shot holes appear on the leaves, the stalk is bored and riddled inside and sometimes grain is damaged,	Apply endrin granules into leaf whorls and axils at 0.3 kg *a.i.*/ha (2% g, 15 kg/ha) OR Spray endrin 0.3 kg *a.i.*/ha (20% E.C., 1.5 lt) or DDT 1.5 kg *a.i.*/ha. (50% W.P., 3 kg) in 360* lt water/ha.
	Steam borers appear first about six weeks after planting and persists thro-gh harvest being carried into stacks. All jowar tracts in Mysore State may be infested.	Beginning when the crop is two weeks old, spray three times at intervals of 1-2 weeks with endrin @ 0.3 kg *a.i.*/ha or with DDT @ 1.5 kg *a.i.*/ha. *Do not feed or allow animals to graze on crops treated with endrin.*
Pink borer *Scsamia inferens*	See Ragi	See Ragi.
Plant hopper, *Peregrinns maidis*	Young and adult greenish to brown plant hoppers appear on the leaves or	Same as for Stem borer.

* The quantity of water can be reduced depending upon the growth stage of the crop and the spraying equipment used — conventional or low volume. This holds good for all sprays in these recommendations.

Insect	Damage	Control
1	2	3
	JOWAR (Contd.)	
	the inside of leaf-sheaths and leaf whorls, frequently gathering in tender top shoots and colonising inside the boot leaf sheath, drawing out the plant sap. Severe infestation causes yellowing of foliage, stunted growth, and sometimes death of young plants. In case of severe attack at boot leaf stage, the top leaves twist and bend downwards, preventing emergence of earheads.	
	The bugs are suspected to cause the sugary dicease of the leaf.	
Flea beetle, *Chaetocnema indica*	Small blue beetles feed on the leaves, producing minute holes, round or irregular in shape and white blotches. The leaves appear wilted and young plants may die.	Dust the young crop with BHC 1.5–1.8 kg *a.i.*/ha (10% dust 15–18 kg/ha).
i. Earhead bug, *Calocoris angustatus*	Yellowish green adults and nymphs feed on the developing grains, drawing out sap, resulting in chaffy earheads In severe infestations, a sticky secretion	Spray the earheads 5-7 days after flowering with carbaryl 1.5 kg *a.i.*/ha (3 kg, 50% W.P.) or malathion 1.5 kg *a.i.*/ha (50% E. C. 3 lt. in *200 lt.* water/ha).

Insect 1	Damage 2	Control 3
	and pale brown excretory spots are found on the earhead.	OR Dust carbaryl or malathion 1.75 kg *a.i.*/ha (5% dust, 35 kg/ha) OR Dust with DDT or BHC 3.5 kg *a.i.*/ha (10% dust, 35 kg/ha). Use only when safer chemicals are not available.
ii. Earhead fly (midge), *Contarinia sorghicola*	Minute reddish-brown flies lay eggs in the florets where they hatch into maggots inside the developing grain leaving an empty seed from which brown seed-like puparia protrude. When there is heavy infestation hundreds of flies swarm out if the earhead is disturbed.	Same as for earhead bug.
iii. Earhead webbing caterpillar, *Stenachoria elongella*	Dark grey caterpillars, with whitish stripes on the back, web inside the earheads and feed on the well developed grain. Badly infested earheads show thick webbing with cut grains and excretory pellets.	Same as far earhead bug.

Insect 1	Damage 2	Control 3
	JOWAR (Contd.)	
Deccan wingless grasshopper, *Colemania sphenarioides*	Greenish yellow wingless adult and young hoppers with red and bluish lateral stripes on the thorax, eat the leaves from the margins inwards, leaving only the mid-ribs. They also feed on the flowers and ripening grains.	Dust the crop and field bunds with BHC 2.0–2.5 kg *a.i.*/ha (10% dust, 20–25 kg/ha)
Hairy caterpillar, *Amsacta albistriga*	Active blackish brown hairy caterpillars in large numbers devour the leaf in older plants leaving only the stalk. In young crops the entire plant is eaten.	Dust crop, infested field borders adjacent weed patches with BHC 2·0–2·5 kg *a.i.*/ha. (10% dust, 20–25 kg/ha) when the caterpillars are young. For older caterpillars, mix 2% parathion dust with BHC dust (3:1) Light traps may be set up to attract moths as soon as they occur, usually after the first monsoon shower. Sweep up and destroy caterpillars, and dig trenches to prevent mass movement from one field to another. Plough fields after harvest which may help in killing underground pupae.

Insect	Damage	Control
1	2	3
	JOWAR (Contd.)	
Army worm, *Pseudaletia* (=*Cirphis*) *unipuntta*	Stout smooth dull-green or purplish caterpillars with lateral stripes in large numbers feed on the leaves in the evenings, producing irregular cuts with ragged edges, or white membranous patches. During the day the caterpillars hide in the soil or in the top leaf whorl and sometimes under the leaf sheaths. Infestations follow heavy rains.	Dust the crop with BHC 2·0–2·5 kg *a.i.*/ha (10% dust 20–25 kg/ha) OR Spray with carbaryl 1·5 kg *a.i.*/ha (3 kg, 50% W.P.) or DDT 1·5 kg *a.i.*/ha, (3 kg, 50% W.P.) or parathion 0·25 kg *a.i* /ha (0·5 lt, 50% E.C.) or toxaphene 2·0 kg. *a.i* /ha
Jowar mite, *Oligonychus indicus*	Colonies of minute pale orange young and adult mites feed and breed under thin webbing on the under surface of leaves, forming pale red spots, which later coalesce into patches and spread over the entire leaf. The infested leaves ultimately dry up.	Remove and destroy heavily infested leaves. Spray parathion 0·5 kg *a.i.*/ha (50% E.C., 1·0 lt) or carbophenothion 0·2 kg *a.i.*/ha (20% E.C., 1·00 lt) in 360 lt water/ha. OR Spray with wettable sulphur 1 kg *a.i.*/ha (90% W.P.,I.I.K in 360 lt water/ha.)
	PADDY	
Stem borer, *Tryporyza incertulas*	Pale green or white caterpillars bore into the stem near the node and feed	Nursery: Broadcast diazion granules evenly in

Insect	Damage	Control
1	2	3
	PADDY (Contd.)	
	on the central shoot, resulting in dead hearts in young plants and white ears in adult plants.	the nursery 7–14 days after sowing @ 0·625 kg *a.i.*/ha (5% 1·25 gms per sq.m.) In the crop, apply to standing water diazinon, lindane or phorate granules, 2 kg *a.i.*/ha (5% g, 40 kg/ha or 4 gm per sq.m.) 10–15 days after transplanting and repeat at least at 25 day intervals upto maturity. OR Spray parathion, dimethoate or phosphamidon, 0·5 kg *a.i.*/ha (Parathion 50 E.C., 1 lt, dimethoate 30% E.C., 1.7 lt, phosphomidon 100 E.C., 0·5 lt) in 360 lt water/ha.
Paddy gall fly, *Pachydiplosis oryzae*	The fly which becomes active at the onset of South-west monsoon, completes one or two generations on grasses before migration to paddy fields. The maggots attack the base of growing shoots and produce silvery-	Same as for stem borer.

Insect	Damage	Control
1	2	3
	white tubular galls. Infested shoots fail to bear panicles. The infestation is severe during the tillering phase of the crop. It occurs regularly in the districts of Shimoga, Hassan, Mysore, South and North Kanara.	
Swarming caterpillar, *Spodoptera mauritia*	Dark green caterpillars with orange and yellow bands on sides appear in swarms infesting seedlings mainly feeding on leaves at night and hiding during the day. They migrate from field to field, when cold weather is suddenly followed by a spell of warmth.	Dust with BHC 0.75 kg *a.i.*/ha (5% dust, 15 kg/ha.) OR Spray with DDT 1.5 kg *a.i.*/ha (3 kg of 50% W.P) in 360 lt water/ha.
Rice grasshopper, *Hieroglyphus banian*	Light green grasshoppers which become active on the onset of south-west monsoon migrate from grassy bunds and devour the leaves and tender grains.	Dust the bunds and paddy fields with BHC @ 2 kg *a.i.*/ha, (10% dust, 20 kg.)

Insect	Damage	Control
1	2	3
	PADDY (Contd.)	
	The pest occurs in Shimoga, Dharwar, Mysore, Bangalore and Hassan districts.	
Rice case worm, *Nymphula depunctalis*	Green caterpillars cut the leaves, make cases and scrape the green tissue, leaving long white patches on the leaves, which then dry up.	Same as for the swarming caterpillar. OR Use the kerosene treatment with irrigation water. Close all the water inlets to the field except one at the entrance of which a kerosene soaked gunny cloth is placed. The kerosene released forms a thin oil film on the surface of the water. Pass a long pole or a rope across the crop to dislodge the cases and caterpillars, which die when they fall into the kerosene water. Clip the grasses on the field bunds and channels and spray as in the case of the swarming caterpillars.

Insect 1	Damage 2	Control 3
Paddy leaf roller, *Cnaphalocrocis medinalis*	Green caterpillars roll up the leaf tips and feed on the green matter from inside the rolls.	Dust BHC 2.0 kg *a.i.*/ha (10% dust 20 kg/ha) or spray diazinon 1 kg *a.i.*/ha (50% E.C., 2 lt) in 360 lt water/ha.
Blue beetle, *Leptispa pygmoea*	Tiny metallic blue beetles and yellow grubs feed on green matter and cause elongated white patches on the leaves, which then dry up.	Same as for Paddy leaf roller.
Paddy leaf and plant hoppers, *Nephotettix bipunctatus* *N. impicticeps* and *Nilaparvata lugens* and other species	Both nymphs and adults which may be green or brown suck sap from the leaves, which turn yellow and wither away. These insects also act as vectors of important virus diseases of paddy.	Same as far stem borer.
Rice thrips, *Thrips oryzae*	In severely attacked young plants the leaves curl and dry up from the tips.	Same as for stem borer and jassids.

Insects 1	Damage 2	Control 3
	MAIZE (Contd.)	
Army worm, *Pseudalctia unipuncta*	See jowar	See jowar.
	5. BAJARA	
Deccan wingless grasshopp er, *Colemania sphenariodes*	See jowar	See jowar.
Hairy caterpillar, *Amasacta albistriga*	See jowar	See jowar.
Termites *Odontotermes spp.* *Nicrotermes spp.* and White grub, *Lechnosterna* sp.	Termites feed on the roots,	Incorporate aldrin or heptachlor into the soil @ 3 kg *a.i.*/ha (5% dust, 60 kg) or (20% E.C. 15 lt) in 360 lt water/ha. The effect of this treatment may last as long as three years.
Blister beetles: *Psalydolytta rouxi* *Cylindrothorax tenuicollis* and Chafer beetles: *Oxycetonia versicolor* *Rhyptia indica* *Pachyrhinadoretus rugipennis*	White grubs cut the young plants underground. Both the blister and chafer beetles feed on the flowers and tender earheads.	Dust earheads with a mixture of BHC and Parathion @ 2 kg *a.i.*/ha and 0·1 kg *a.i.*/ha respectively. (BHC 10%, 20 kg and parathion 2%, 5 kg)

Insect 1	Damage 2	Control 3
	6. WHEAT	
Pink stem borer *Sesamia inferens*	See ragi	See ragi
Termites and white grub.	See Bajra	See Bajra
	SUGARCANE	
Seedling borer, *Chilo* (=*Chilotraca*) *Infuscatellus*	Dirty white caterpillars, with rows of brown tubercles bearing minute heirs, bore into stems at the base, killing the central shoots resulting in dead-hearts. Mostly young cane, 4–10 weeks old, is damaged.	Plant borer-free setts. Remove and destroy dead-hearts along with borers. Give two light earthings once when the crop is 4–5 week old and second when it is 8 weeks old, followed by irrigation. *Trichogramma* parasite may be released as per schedule in Mandya area. Spray the setts in the planting furrow with heptachlor, 1 kg *a.i.*/ha (25% E.C., 4 lt) or BHC, 1 kg *a.i.*/ha (25 % E.C., 4 lt) Except in areas where parasites have been released, spray the crop with Endrin three times at 3-weekly intervals commencing when the crop is 3 weeks old @ 0·5 kg *a.i.*/ha (20% E.C., 2·5 lt) in 360 lt water.

Insect 1	Damage 2	Control 3
	SUGARCANE (Contd.)	
Top shoot borers, *Tryporyza (=Scirpophaga) nivella*	Yellowish white caterpillars bore into stems of growing cane from the top making pin holes in leaves and giving rise to brownish, sometimes curved, dead-hearts; in grown-up canes side shoots develop from the attacked central shoots forming bunchy tops.	Collect and destroy egg-masses. dead-hearts and affected shoots. Limited control may be had by spraying the crop with endrin three times at 6 weeks interval, commencing when the crop is 2 months old @ 0·5 kg *a.i.*/ha (20% E.C., 2.5 lt) in 360 lt water. *Do not feed or graze forage from endrin-treated plants.*
Sugarcane leafhopper *Pyrilla perpusilla*	Both nymphs and adults feed on the sap of young leaves which turn yellow and dry up and growth is retarded.	Dust with BHC 2.0 to 2.5 kg *a.i.*/ha (10% dust, 20-25 kg/ha)
Termites: *Microtermes obesi* *Odontotermes* app.	Termites infest, damage or kill the setts and young plants in the soil.	Apply BHC, aldrin, heptachlor or chlorodane to the furrows at the time of planting @ 1·0 kg *a.i.*/ha (5% dust, 40 kg/ha)
Root grubs, *Lachnosterna consanguinea* and *Holotrichia serrata*	The grubs attack the roots of young and grown-up cane damaging or killing the plant.	Mix/aldrin or heptachlor with the soil around the canes @ 3 kg *a i.*/ha (5% dust, 60 kg) or 20% E.C., 15 lt/ha).

Insects 1	Damage 2	Control 3
	PULSES	
	1. REDGRAM	
Gram caterpillar, *Heliothis armigera*	The caterpillars feed on tender foliage and blossoms and bore into the pods to feed on developing seeds; while feeding only a portion of the body is inside the pod.	Spray with DDT 2 kg *a.i.*/ha (50% W.P., 4 kg) or carbaryl 1·5 kg/ha (50% W.P., 3 kg) in 360 lt water. Spray as soon as infestation occurs and if necessary repeat every 10 days.
Plume moth, *Exelastis atomosa*	Greenish brown caterpillars bore into pods and damage the seed.	Same as for gram caterpillar.
	2. BENGAL GRAM	
Gram caterpillar *Heliothis armigera*	See redgram.	See redgram.
	3. FIELD BEANS (AVARE)	
Avare pod borer, *Adisura atkinsoni*	Brownish green caterpillars bore into both tender and ripening pods and feed on developing seeds.	Same as for gram caterpillar.
Gram caterpillar, *Heliothis armigera*	See redgram.	See redgram.

Insect	Damage	Control
1	2	3
	OIL SEEDS	
	1. CASTOR	
Castor semilooper, *Achoeajanata*	Gray to black slender looping caterpillars feed on the leaves, leaving only the midribs.	Spray with DDT 3 kg *a.i.*/ha (50% W.P. 6 kg) or parathion 0.5 kg *a.i.*/ha (50% E.C., 1.0 lt) in 450 lt water.
Hairy caterpillars, 1. *Euproctis fraterma* 2. *Pericallia ricini*	The catrepillars feed on the leaves, occasionally causing severe damage.	Same as for castor semilooper.
Castor shoot and capsule borer, *Dichocrocis punctiferalis*	Reddish brown caterpillars bore into the shoots and the capsules ; webbing mixed with frass is present.	Remove and destroy infested shoots and pods. Dust with DDT 1.5 kg *a.i.*/ha (5% dust 30 kg/ha) when the pest appears, and repeat once or twice at 20-day intervals, if needed. OR Spray as for castor semilooper.
	2. GROUNDNUT	
Groundnut aphid, *Aphis craccivora*	Dark brown to black aphids feed on the sap, reducing plant growth. Infested tender leaves shrivel and turn yellow.	Spray with dimethoate or menazon 0.5 kg *a.i.*/ha (dimethoate 25% E.C., 2.0 lt or menazon 70% W.P., 0.70 kg) in 250 litres water, 3-4 times at 14-day intervals, starting when the crop is 2 weeks old.

Insect 1	Damage 2	Control 3
Groundnut leaf miner, *Stomooteryx nerteria* (= *S. subsecivella*)	Small yellowish green caterpillars mine the young leaves, causing blotches. The leaves are folded and webbed together. Heavy infestation may kill the plants, especially in dry weather.	Dust with DDT 1.0 kg *a.i.*/ha (5%dust, 20 kg/ha) at the first sign of infestation and again four weeks later. OR Spray with diazinon 0.5 *a.i.*/ha(5%E.C. 1.0 lt) or carbaryl 1.0 kg *a.i.*/ha (50% W.P. 2 kg) or parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) in 250 lt water.
Hairy caterpillar, *Amsacta albistriga*	See jowar	See jowar
White grub	Curled white grubs in the soil attack roots, pegs and pods and cause wilting of plants.	Mix heptachlor or aldrin with the soil @ 1.5 kg *a.i.*/ha (5% dust, 30 kg/ha)
	3. SAFFLOWER	
Aphid, *Macrosiphum solidagnis*	Black aphids cluster around the tender shoots and leaves to suck the sap, thereby affecting the growth and yield. In cases of severe infestation, the plants dry up prematurely.	Same as for groundnut aphid. OR Spray with parathion 0.5 kg *a.i.*/ha (50% E.C., 1.0. lt) in 450 lt water.
Leaf-eating caterpillar, *Perigoea capensis.*	Green caterpillars with purple markings feed on leaves and tender shoots.	Same as for aphid. OR Dust with DDT 2·0 kg *a.i.*/ha (10% dust, 20 kg/ha).

Insects 1	Damage 2	Control 3
	4. SESAMUM	
Gall fly, *Aspondylia sesami*	The maggots feed on flowers, causing galls to form in place of pods.	Same as for safflower leaf-eating caterpillar.
Leaf and pod caterpillar, *Antigastra catalaunalis.*	Pale green caterpillars feed on the leaves and bore into the shoots and the pods ; they fold and web the top leaves together.	Same as for safflower leaf-eating caterpillar.
	COTTON	
Cotton spotted and Spiny bollworms: *Earias fabia* and *Earias insulana.*	Dirty white caterpillars with dark spots and hairs bore into the growing shoots, flower buds and bolls. The holes are filled with excreta, the infested top shoots droop down, the calyx of attacked flowers flares up and the squares and bolls drop off.	Remove and destroy the stubbles and other host plants such as Lady's finger. Avoid rattoon crops. Beginning when the crop is six weeks old, spray 5-6 times at 2-week intervals with carbaryl 2·5 kg a.*i.*/ha (85% W.P. 30 kg) or DDT 2.5 kg a.*i.*/ha (50% W.P., 5 kg), or Endrin 0·5 kg a.*i.*/ha (20% E.C. 2.5 lt) in 300 lt of water or dust with carbaryl 2·5 kg a.*i.*/ha (5% dust 50 kg/ha) or endrin 0·5 kg a.*i.*/ha (1% dust 50 kg/ha). If the crop is irrigated give 3 additional sprays.

Insect 1	Damage 2	Control 3
		Note : Mite populations may increase where DDT is used, and addition of a miticide indicated above may be desirable in sprays recommended for bollworms.
Pink bollworm. *Platydra gossypiella*	Pinkish caterpillars bore into the bolls and seed and feed inside causing immature opening and reducing the quality of kapas.	Use seeds fumigated with methyl bromide @ 0.5 kg per 30,500 c.m. of space.
Cotton jassid. *Empoasca devastans.*	Young and adult pale green hoppers with wedge-shaped bodies suck the sap from the leaves causing the leaves to curl down, turn brown and dry up. The infested plants are stunted.	Spray as for bollworms.
Cotton thrips, *Scirtothrips dorsalis*	Young and adult insects lacerate the leaves and flowers and suck the sap, causing the leaves to turn brown and fall.	Same as for bollworms.

Insect	Damage	Control
1	2	3
	COTTON (Contd.)	
Cotton aphid, *Aphis gossypii*	Colonies of aphids suck the sap from the tender leaves, which curl up and fade.	Spray with parathion 0·5 kg *a.i.*/ha (50% E.C. 1.0 lt) in 300 lt water.
Mites :	Colonies of yellowish mites breed and feed on the under-surface of leaves, which become brittle and glossy, and curl up.	Spray with carbophenothion 0.2kg *a.i.*/ha (20% E.C., 1.0 lt) or Parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) or wettable sulphur 2.5 kg *a.i.*/ha (90% W.P., 2.8 kg) in 300 lt water.
1. *Hemitarsonemus latus*		
2. *Tetranychus telarius*	Red mites also usually feed on the lower surface of leaves but under a web causing leaves to be speckled.	OR Dust with sulphur 0.75 kg *a.i.*-/ha (5% dust 15 kg/ha) Sulphur should not be used on *Gossypium herbaceum* varieties (Jayadhar, Suyodhar, or Western-1)
Cotton leaf roller, *Sylepta derogata*	Yellowish green caterpillars roll up the leaves from the margin and feed on the green tissue.	Same as for bollworm.
Red cotton bug, *Dysdercus cingulatus*	Red bugs, both adults and nymphs, suck the sap from the flower buds and bolls tinting the lint, affecting boll opening and lowering the quality of the lint. When the seed is infested it becomes unfit for sowing and for oil extraction.	

Insects 1	Damage 2	Control 3
Dusky cotton bug *Oxycaraenus laetus*	Dark brown bugs suck the sap from the immature bolls, causing them to remain unopened, The lint is stained when open bolls become infested.	Same as for bollworm.
Gram caterpillar or American bollworm, *Holiothis armigera*	See maize	Same as for bollworm.
	TOBACCO	
Tobacco caterpillar, *Spodoptara litroalis* (=*Prodenia litura*)	Dark brown stout caterpillars feed on the leaves or cut the seedlings just below the ground level, both in the nursery and in the field.	When the insects appear spray with DDT 1.5 kg *a.i.*/ha (50% W.P., 3 kg) or parathion 0.5 kg *a.i.*/ha (50% E. C. 1.0 lt) in 300 lt water and repeat if necessary.
Tobacco aphid, *Myzus persicae*	The aphids infest leaves and tender portions of plants sucking the sap and reducing the vigour. The infested leaves appear sickly and are unfit for curing.	Spray with parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) or Phosphamidon 0.5 kg *a.i.*/ha (100% E.C., 0.6 lt) or oxydemethonmethyl 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) or menazon 0.6 kg *a.i.*/ha (70% D.P. 0.85 kg) or thiometon 0.75 kg *a.i*/ha (25% E.C. 3 lt) or dimethoate 0.5 kg *a.i.*/ha (25%E.C. 2.0 lt) in 300 lt water/ha.

Insect	Damage	Control
1	2	3
	TOBACCO (Contd.)	
Tobacco stem borer, *Gnorimoschema heliopa*	Small brownish white caterpillars burrow along leaf stalks into stems, producing gall-like swellings.	In the nurseries: Cover young plants at night with a cloth to prevent egg-laying on plants OR Spray wlth parathion 0.75 kg *a.i.*/ha (50% E.C. 1.5 lt) in 300 lt water/ha or DDT 2 kg *a.i.*/ha (50% W.P., 4 kg) in 300 lt water/ha. Avoid transplanting infested seedlings, slit the gall with a knife and kill the borer by squeezing the gall OR Inject parathion or DDT solution of the above concentration into the galls.

VEGETABLES

Whenever chemical control is used, follow instructions regarding minimum days required from last application to harvest, which are given in Table 2.

1. POTATO

Epilachna beetle, *Epilachna* spp.	Coppery brown spotted beetles and yellow spiny grubs feed on the epidermis in a ring-like fashion and skeletonise the leaves.	When pest appears spray with DDT 2 kg *a.i.*/ha (50% W.P. 4 kg) or parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) in 250 lt water. Repeat every 10 days if necessary.

Insect	Damage	Control
1	2	3
Cut worms, *Agrotis ypsilon* *Euxoa segetis*	See ragi	See ragi
Potato tuber worm, *Gnorimoschema* (=*Pthorimoea*) *operculella*	Slender greenish caterpillars mine the leaves and tunnel into young growing shoots and exposed tubers in the field and tunnel into tubers in storage making zig-zag galleries.	Spray crop as for *Epilachna* beetle and store the tubers under a thin layer of sand or cover tubers with gunny and dust the covering lightly with 5% DDT or fumigate with methyl bromide 1 kg/62 cubic metres of space.
	2. BRINJAL	
Epilachna beetle, *Eplilachna* spp.	See potato	See potato
The fruit and shoot borer, *Leucinodes orbonalis*	Pinkish caterpillars with dark warts and bristles bore into young shoots, which wilt and droop, and into the fruits, plugging the hole with excreta. Infested tender fruits become bent and twisted.	When the pest appears, spray as for potato *Epilachna* OR with carbaryl 2.5 kg *a.i.*/ha (85 S.P., 3.0 kg) in 250 lt water and repeat at 10 days intervals as long as it is necessary.
Brinjal stem borer, *Euzophera perticella*	A smooth yellowish white caterpillar bores into the stems, killing the young plants.	Same as for fruit and shoot borer.

Insect 1	Damage 2	Control 3
	3. TOMATO	
Epilachna beetle, *Epilachna spp.*	See potato	See potato
Cut worm, *Prodenia litura*	See tobacco	See tobacco
Tomato fruit borer, *Heliothis armigera*	See maize	See maize
	4. CHILLIES	
Chilly thrips, *Sciratothrips dorsails* and Spider mite, *Hemitorsonemus latus*	The thrips lacerate the leaf and suck the sap. The mites feed on the sap. Leaves of infested plants curl up from the margins and become brittle and young plants wither and dry.	Spray 15-20 day old seedlings with a mixture of 1.25 kg sulphur 90% W.P. and parathion 0.5 kg *a.i.*/ha (50% E.C., 1 lt) in 250 lt water/ha or malathion 1·0 kg *a.i.*/ha (50% E.C., 2 lt) in 250 lt water/ha or BHC 3.0 kg *a.i.*/ha (50% W.P., 6 kg) in 250 lt water/ha and repeat after 15-20 days. Spray again or dip the seedlings in the same solution just before transplanting. Follow at monthly intervals with one of the above mixtures.
Maize cobworm, *Heliothis armigera*	See maize.	See maize.

Insect 1	Damage 2	Control 3
	5. CRUCIFERS **(Cabbage, Cauliflower, Knol-khol, Raddish, etc.)**	
Mustard sawfly, *Athalia proxima*	Smooth dark larvae resembling caterpillars bite holes into leaves and defoliate the plants.	Dust with DDT 2·0 kg *a.i.*/ha (10% dust, 20 kg/ha) or carbaryl 2·0 kg *a.i.*/ha (10%, 20 kg/ha). OR Spray with malathion 1 kg *a.i.*/ha (50% E.C., 2·0 lt) in 250 lt water.
Cabbage worm or leaf webber, *Corcidolomia binotalis*	Striped green caterpillars feed on foliage, webbing the leaves, sometimes burrowing into heads and stems.	Same as for mustard sawfly.
Diamond back moth, *Plutella maculipennis*	Small green caterpillars scrape the leaf tissue causing whitish membranous patches, and bite holes in the leaves.	Same as for mustard sawfly.
Cabbage borer, *Hellula undalis*	Whitish brown striped caterpillars mine the foliage and tender shoots, and also bore into heads and stems.	Same as for mustard sawfly.

Insect	Damage	Control
1	2	3
	CRUCIFERS (Contd.)	
Aphids, *Myzus persicae* *Brevicorybe brassicae* *Rhophalsiphum preudobrassicae*	Adults and nymphs colonise and suck the sap resulting iu reduced vigour and stunted growth. In severe cases, heads fail to develop.	Spray with paralhion 0·5 kg *a.i.*/ha (52% E.C., 1·0 lt) in 250 lt water.
Painted bug, *Bagrada cruciferarum.*	Dark drown bugs with reddish brown markings suck the sap causing the leaves to turn yellow and dry up.	Same as for mustard fly.
	6. CUCURBITS	
(Pumpkin, ash-gourd, ribbed-gourd, bitter-gourd, snake-gourd, cucumber, bottle-gourd, sponge-gourd)		
Pumpkin beetle, *Aulacophora abdominalis* *Aulacophora* spp.	Brownish blue and red beetles eat holes in the leaves, while grubs damage the roots.	Do not use BHC on cucurbits. Dust carbaryl 2·0 kg *a.i.*/ha (10%, 20 kg/ha).
Epilachna beetle, *Epilachna* sp.	See potato	See potato
Fruit fly, *Dacus cucurbitae*	Reddish brown flies puncture the tender fruits and lay eggs inside and deposit a brown resinous substance around the puncture. Creamy white maggots develop in the pulp and cause rotting. The tender fruits become distorted.	As soon as the fruit is formed, spray at weekly intervals with malathion 1·0 kg *a.i.*/ha (50% E.C., 2.0 lt) or carbayl 1.5 kg *a.i.*/ha (50% W.P., 3 kg) in 250 lt water upto thirty days before harvest.

Insects 1	Damage 2	Control 3
	OTHER VEGETABLES	
	1. BHENDI	
Bhendi fruit borer (= cotton bollworm), *Earias fabia* *Earias insulana*	See cotton	See cotton
Jassids, *Empoasca devastans*	See cotton	See cotton
	2. BEANS	
Bean aphid, *Aphis rumicis*	Colonies of black lice infest the leaves, tender shoots, flowers and fruits, sucking sap, and causing curling and yellowing of leaves.	Spray with parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) or malathion 1 kg *a.i.*/ha (50% E.C., 2.0 lt) in 250 lt water. Repeat after a week, if needed.
Agromyzid fly, *Melanagromyza phaseoli*	The maggots bore into the outer layers of the stem at the collar region of young plants resulting in wilting and death.	Commencing when the crop is one week old, spray three times at 10-day intervals with parathion or malathion at the same concentrations used for bean aphids.
	3. PEAS	
Pea aphid, *Macrosiphum pisi*	Small fat-bodied green aphids, cause damage to the plants as in the cause of the bean aphid, preventing pod formation.	Same as for bean aphid, but apply the last spray at least 2 weeks before harvest.

Insects 1	Damage 2	Control 3
	4. SWEET POTATO	
Sweet potato weevil, *Cylas formicarius*	Ant-like bluish red weevils feed on leaves, making holes in them. Yellowish grubs bore into the vines and exposed tubers in the field, and damage continues in storage of tubers.	When the pest appears, spray the vines in the field and tubers in storage with DDT 2 kg *a.i.*/ha (50% W.P., 4 kg) in 250 lt water and repeat in 10 days if needed.
	5. ONION	
Onion thrips, Thrips tabaci	Young and adult insects in large numbers feed on plants leaving small whitish streaks on the leaves. In severe cases the leaves are blighted and dry up from the tip.	Spray with parathion 0.5 kg *a.i.*/ha (50% E.C., 1.0 lt) in 250 lt water, at least 3 weeks before harvest.
	FRUITS	
	Whenever chemical control is used follow instructions regarding minimum days required from the last application to harvest which are given in Table 2	
Mango hoppers, *Idiocerus atkinsoni* *I. niveosparsus* *I. cylpealis*	Greenish brown wedge-shaped hoppers feed on tender leaves, shoots, inflorescences and buds, sucking the sap, causing the flowers to shrivel and drop, preventing fruit set. A secondary effect is the development of dirty mold on the leaves where honey dew occurs.	As soon as the flower buds appear and until the fruits are formed, spray at 10-day intervals with a mixture of DDT and Sulphur (90% W.P.) @ 4 kg *a.i.*/ha (50% W.P. 8 kgs) and 1 kg/ha respectively. The purpose of sulphur is to control mildew.

Insect	Damage	Control
1	2	3
	2. CITRUS	
Stem borer, *Chelidonium cinctum*	Yellowish grubs bore into the trunk and main branches making circular holes and tunnels inside causing the twigs to dry up.	Remove and destroy all withering and dried-up twigs in June-July. Close all the holes except the topmost one with mud, then fill it with 50% phenyl solution with a syringe.
Citrus butterfly, *Papilio demoleus*	Young brown caterpillars (resembling bird droppings) feed on tender leaves while green mature caterpillars feed on the leaves and new flush, defoliating the plants.	Spray with DDT 2 kg *a.i.*/ha (50%W.P. 4 kg) in 250 lt water. Hand pick and destroy young caterpillars in the nursery.
Citrus leaf miner, *Phyllocnistis citrella*	Tiny greenish caterpillars mine into the tender leaves, making irregular zig-zag whitish tunnels and blotches. In severe cases the infested leaves become twisted, dry up and drop off.	As soon as the pest appears spray with parathion 0.5 kg *a.i.*/ha (50% E.C. 1.0 lt) in 250 lt water, and repeat after 10-15 days if needed.
Fruit sucking moths, *Ophideres fullonica* *O. materna*	Stout golden yellow to orange coloured moths puncture the ripening fruits and suck out the juice after which the fruits rot and drop.	Spraying the fruits with DDT 2 kg *a.i.*/ha (50% W.P. 4 kg) in 250 lt of water gives a limited control.

Insects 1	Damage 2	Control 3
	3. GRAPES	
Flea beetle, *Scelodonta strigicollis*	In the pruning season, coppery brown beetles in large numbers devour the tender leaves and buds, usually after dusk.	Spray with DDT 2·0 kg *a.i.*/ha (50% W.P. 4 kg) in 250 lt water. OR With malathion 1.5 kg *a.i.*/ha (50% E.C., 3 lt) in 250 lt water.
Jassids, Thrips and Mites,	These insects infest the crop throughout the growing period, feeding on the sap of leaves which sometimes curl up.	Same as for flea beetle, except that sulphur 90% W.P., 1 kg/ha is mixed with DDT to protect against mites.
	4. GUAVA	
Guava capsid bug, *Helopeltis antonii*	Reddish brown mosquito-like bugs infest the tender leaves, shoots, blossoms and fruits sucking sap through feeding punctures. The punctured areas turn brown or black and produce warty scabs and blisters. The infested leaves and shoots curl up and wither. The young fruits dry up and drop off. The older fruits become deformed, blistered and scabby.	Spray with DDT 4 kg *a.i.*/ha (50% W.P. 8 kg) on phosphamidon 1.0 kg *a.i.*/ha (100 E.C., 1.0 lt) or carbaryl 5.0 kg *a.i.*/ha (50% W.P. 1 kg) in 250 lt water. Add sulphur 90% W.P., 1 kg/ha to DDT or carbaryl solution, if mite infestation occurs. Make the first application after the plants put forth new flush and blossoms, and repeat at 15-day interval until fruits have developed.
Guava mealy bug, *Pulvinaria psidii*	Mealy bugs colonise in large numbers on tender shoots and leaves, sucking the sap and arresting growth.	Spray with parathion 0.5 kg *a.i.*/ha (50% E.C., 1.0 lt) in 250 lt water and repeat in 7 days, if needed.

Insect	Damage	Control
1	2	3
	5. POMEGRANATE	
Pomegranate fruit borer, *Virochola isocrates*	Stout dark-brown caterpillars bore into the fruits and feed of the seeds, plugging the holes with excreta.	Remove and destroy infested fruits. At flowering time, spray with DDT 2 kg *a.i.*/ha (50% W.P., 4 kg) in 250 lt water and repeat at 3-weekly intervals until the fruits develop.
	6. BANANA	
Banana stem weevil, *Cosmopolites sordidus*	Dark brown weevils and dirty white grubs bore into the rhizomes, making zig-zag tunnels, and into the suckers and stems causing the central growing point to wither and young plants die.	Plant suckers, free from infestation and spray around base of plants and clumps with DDT 2 kg *a.i.*/ha (50% W.P. 4 kg) in 250 lt water.
	7. FIG	
Fig mite, *Eotetranychus hirsti*	Pale yellowish mites infest leaves, tender shoots and fruits. The leaves turn yellow and become rough, and drop prematurely, the fruits fail to develop.	Remove severely infested leaves and burn. Spray with parathion 0.5 kg *a.i.*/ha (5% E.C., 100 lt or corbophenothion 0.25 kg *a.i.*/ha (20% E.C. 1.25 lt) or sulphur 1 kg *a.i.*/ha (90% W.P., 1.1 kg) in 360 lt water.

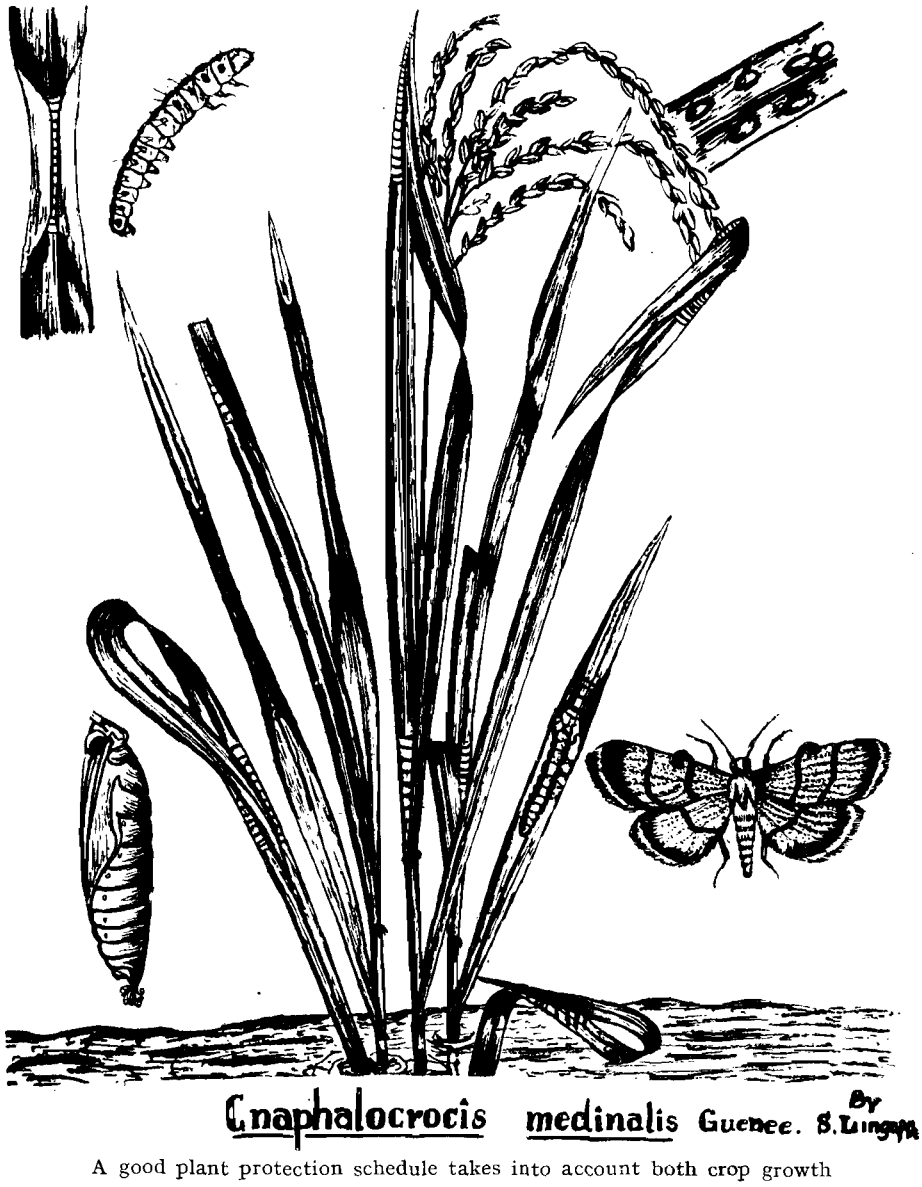
Insect	Damage	Control
1	2	3
	PLANTATION CROPS	
	1. COFFEE	
Coffee stem borer, *Cylotrechus quadripes.*	Infested plants have small yellow leaves, the stems have ridges on the bark and extensive tunnelling when split open.	Remove and destroy infested plants before September. Swab the stems and primaries with a wad of cotton waste with BHC 2 kg *a.i.*/ha (50%W.P. 4 kg) or dieldrin 0.25 kg *a.i.*/ha (50% W.P. 0.5 kg) or dieldrin (18% E.C., 1.5 lt) in 200 lt water/ha. Give two applications, one in March-April and another in September-October.
Shot hole borer, *Xyleborus morstatti.*	Infested branches show 'shot holes' at the internodes surrounded by discoloured areas, wilt, become defoliated and dry up.	Prune the infested branches 3-6 cm from the 'shot holes' towards the centre of the plant and burn and spray with dieldrin 0.9 kg *a.i.*/ha (18% E.C., 5 lt) in 450 lt water. Repeat at 10-day intervals if needed.
Green bug, *Coccus viridis*	Colonies of green bugs suck sap from tender shoots and leaves. When severely infested the twigs wilt and the leaves become yellow, covered with sooty mould.	Spray with Gusathion 0·04 to 0·08 kg *a.i.*/ha (20 E.C. 222-441 ml) in 450 lt water or parathion 0.005 kg *a.i.*/ha (50 E.C., 10 ml) in 450 lt water or fosterno 0.09 kg *a.i.*/ha (50 E.C. 180

Insects 1	Damage 2	Control 3
		ml) in 450 lt water, or malathion 0·09 kg *a.i.*/ha (50 E.C., 180 ml) in 450 lt water.
Coffee mealy bug, *Pseudococcus citri*	Severely infested plants show yellowing, wilting and defoliation.	Same as for green bug.
	2. CARDAMOM	
Cardamom hairy caterpillar, *Eupterote canaraica*	Hairy caterpillars devour the leaves almost completely, leaving only midribs.	Collect and destroy young caterpillars congregating on the trunks of shade trees and spray cardamom plants with DDT 1·5 kg *a.i.*/ha (50% W.P. 3 kg) in 350 lt water.
Cardamom thrips, *Taeniothrips cardamomi*	Adults and nymphs lacerate and suck the sap from flowers and tender capsules. This causes scab (kajji) on the capsules.	Spray the fruit spikes and bases of leaf sheaths with parathion 0·125 kg *a.i.*/ha (50% E.C., 0·25 lt) in 360 lt water at weekly intervals from the formation to maturity of berries.
Shoot borer, *Dichocrocis punctiferalis*	The larvae bore into stems in young plants and in severe cases the stem breaks.	See castor.

Insect 1	Damage 2	Control 3
	3. COCONUT	
Rhinoceros beetle, *Oryctes rhinoceros*	Large black horned beetles bore into the crown through the unopened tender fronds, resulting in a characteristic cut appearance.	Examine trees frequently. When beetles are found, extract them with a hooked pointed rod and kill. Spray the manure pits and compost heaps where the larvae breed every three months with BHC 0·25 kg. *a.i.*/ha (25% E·C., lt) in 180 lt water. OR Mix BHC 0.25 kg/pit (5% dust, 5 kg) into breeding places. Fill the axils of newly developing leaves and beetle holes with a mixture of sand and 5% BHC dust (1:1)
Coconut caterpillar, *Nephantis serinopa*	The caterpillars mine and web the leaflets and feed from inside. Infested trees show dried up patches with frass in the leaflets.	Spray with DDT 4·5 kg *a.i.*/ha (50% E.C. 9 lt) in 450 lt water/ha.
	4. CASHEW	
Capsid bug (tea mosquito)	Infested tender shoots and inflorescences dry up completely, preventing fruit set. See guava also.	See guava.

Insects 1	Damage 2	Control 3
	5. PEPPER	
Pepper flea beetle, *Longitarsus nigripennis*	The larvae feed inside the berries, which appear sickly and dark and have small holes on the surface. Sometimes they damage the stalk of the spike also.	Spray berries with DDT 1.5 kg *a.i.*/ha (50% W.P., 3 kg) in 360 lt water/ha.
Pepper scale, *Lepidosaphes piperis*	Colonies of scales infest the stems and leaves and badly infested vines gradually dry up.	Spray with parathion 0.5 kg *a.i.*/ha (50% E.C.. 1 lt) in 360 lt water and repeat every 7 days if needed.
	6. ARECA	
Areca mite, *Raoiella indica*	Colonies of red mites feed on the lower surface of the leaves, producing yellow patches and a bronzed appearance. Young seedlings become stunted and some of them die.	Prune and burn heavily infested leaves and spray with sulphur 0.02 kg *a.i.*/ha (90% W.P. 25 gm) in 10 lt of water at 4 weeks intervals from February-June. OR with dicofol 0.003 kg *a.i.*/ha (kelthane, 18.5%, 18ml) in 10 lt water/ha
Inflorescence borer, *Batrachedra arenosella*	Slender larvae bore into iuflorescence and feed on flowers. The infested inflorescence becomes a wet mass of frass and the spathe fails to open.	Remove and burn infested spathes and spray the inflorescence with endrin 0.5 kg *a.i.*/ha (20 E.C., 2.5 lt) in 250 lt water/ha.

Insect	Damage	Control
1	2	3
	7. BETEL VINE	
Betel vine bug, *Disphinctus politus*	Reddish brown bugs infest leaves and cause dark angular patches. When heavily infested, leaves shrivel, fade and dry up.	Spray with DDT 1.5 kg *a.i.*/ha (50% W.P., 3 kg) in 360 lt water and repeat after 15 days, if needed, but in any case at least 14 days. before picking leaves for chewing.



A good plant protection schedule takes into account both crop growth and insect development

PLANT PROTECTION SCHEDULES

With the main object of concentrating the limited available resources in areas of assured water supply for securing maximum production per acre I.A.A. programmes based on IADP experiences were developed in the country. During the past three years there has been phenomenal development in agriculture in India and this has been mainly due to the introduction of high-yielding, short-duration hybrid crop varieties, capable of responding to heavy fertilizer usage and timely plant protection measures. These practices have thrown open the road for boosting up food production. The inputs such as improved seeds, fertilizers, pesticides, etc., are being increasingly and rightly diverted to these programmes of intensive agricultural production. As the investment per acre for seeds and fertilizer is high, the practice of applying plant protection measures after the appearance of the pest no longer holds good; pest control should be carried out as a routine practice, the same as cultivation, fertilizer application, watering and weeding.

Consistent with the pest complex of a crop, a control schedule giving the chemicals, dosage, and time and frequency of application has been worked out, and a set of recommendations has been made in respect of a few major crops. To reduce the cost of treatments, the use of insecticides and fungicides has been combined, wherever compatible. The schedule of treatments is intended for adoption as a package instead of viewing the insect pests and disease control problems separately. It is to be expected that further research and experience will lead to changes in these schedules in future editions of this Manual.

Pest 1	Pesticide 2	Time and method of application 3
	JOWAR	
Grain smut	Organo-mercurial compound agroson GN or ceresan or captan (1% active material) or fine sulphur dust (303 mesh)	Before sowing, seed treatment.
Shoot fly	Phorate (Thimet)	At planting; drill granules in rows mixing it with the fertilizer; this should not come in contact with seed.
Flea beetle, grasshoppers,	BHC	Two weeks after planting (2 to 3 leaf stage), dust crop.
cut worms,	endrin	Spray
stem borer	endrin granules	Apply granules in whorls.
	DDT If mites are seen mix 1.0 kg of 90% wettable sulphur with endrin spray.	Spray
Stem borer	endrin	At fortnightly intervals - at least 3 applications.
	endrin granules	Spray.
	DDT	Apply in whorls
	If mites are seen mix 1.0 kg of wettable sulphur with endrin spray.	Spray CAUTION: Do not feed or graze forage from endrin treated plants.

For pesticide rate, see recommendations under the crop in question.

Pest 1	Pesticide 2	Time and method of application 3
Midge or earhead bug or webbing caterpillar *Sitotroga*	Malathion spray 50% E. C., or Carbaryl 50 % W.P.	Spray flower heads after flowering.
	PADDY	
Stem borer, gall fly, thrips, jassids	Diazinon 5% granules or Diazinon 50% E. C., or Parathion 50% E. C., or Phosphamidon 100 E. C., or Rogor 30% E. C.	Broadcast the granules. Spray the nursery Spray nursery (20 days old). ,, ,,
do	Diazinon or Lindane or Phorate 5% granules or Parathion 50% E. C., or Phosphamidon 100 E. C., or Rogor 30% E. C.	Broadcast the granules in standing water. Spray 20 days to one month after transplanting. ,,
Stem borer, thrips, jassids and leaf feeding caterpillars.	Parathion 50% E. C., or Dimecron 100 E. C., or Rogor 30 E. C., Diazinon or Lindane or Phorate 5% granules	Spray two months after transplantation. ,, ,, Broadcast the granules in standing water.

Pest 1	Pesticide 2	Time and method of application 3
Stem borer, leaf eating caterpillars and earhead bugs	Parathion 50% E. C., or Dimecron 100 E. C., or Rogor 30% E. C.	Spray when ears appear (swelling stage). *Note :* Treatment may be omitted if the crop is fairly free from insects. This necessitates regular watch over the crop and diagnosis of the insect pest.
	COTTON	
Cotton spotted boll worm	Carbaryl 85% S. P. + Wettable sulphur 90% W. P., or endrin + wettable sulphur 90% W.P. or carbaryl 50% dust + sulphur 90% or endrin 1% dust + sulphur 90%	Spray or dust at boll formation stage
Cotton jassids, Cotton thrips	Dust carbaryl 5% dust + sulphur 90% or endrin 1% dust + sulphur 90%	Dust when the crop is 1-2 month old.
Mites, Cotton aphids, Cotton leafroller	do do do	5 applications : 1st application when the crop is 4-5 weeks old. Repeat every week.
	JAYADHAR COTTON	
Jassids, thrips, aphids, bollworms.	Endrin 20 E. C., or parathion 50 E. C., or carbaryl 85% S. P. Oxydemethon methyl 25% E.C.	Give 6 sprays beginning when the crop is 8 to 10 weeks old and then at intervals of two weeks.

Pest 1	Pesticide 2	Time and method of application 3
	RAGI	
Soil insects, root grubs, root borers, root aphids, termites	Heptachlor or aldrin	Incorporate into the soil before sowing.
Jassids, thrips, aphids	Parathion 50% E. C., or phosphamidon 100 E. C., or dimethoate 30 E. C.	Spray nursery 2-3 weeks after sowing. ,, ,,
Stem borers, root borers, jassids, leaf hoppers and weevils	do	Spray the crop 5-6 weeks after transplanting

1. In case of dry land ragi the schedule remains the same except in case of 1st spray which is meant for nursery in irrigated ragi where the quantity of spray mixture to be used is 135 lts.
2. In case red-headed hairy caterpillar is noticed, dust the crop with 10-15 kgs mixture of BHC 10% and parathion 2% in 3 : 1 proportion.
3. Avoid seeds from the heavily infested crops. Collect and destroy stubbles, crop refuse etc., before sowing.
4. Apply correct dosage of fertilizer mixture as advised.

Pest 1	Pesticide 2	Time and method of application 3
	GROUNDNUT	
Seed-borne diseases	Organo-mercurial (Agrosan G.N.)	Treat seeds before sowing
Groundnut aphid	Menazon 70% W. P., or dimethoate 25% E. C.	Spray 3 or 4 times at 2 week intervals, starting when the crop is two weeks old
Leaf miner	DDT 5% dust or diazinon 50% E. C., or carbaryl 50% W. P. or parathion 50% E. C.	Spray or dust three times at 2-week intervals, commencing when the crop is six weeks old.
Tikka disease	Zineb	Include zineb in the sprays given for aphid and leaf miners after flowering (3 sprays with zineb are necessary).
	SUGARCANE	
Red rot disease	Agallol or aretan	Treat the setts before sowing
Seedling borer	Heptachlor 25% E.C., or BHC 25% E.C.	Spray the setts in the planting furrow·
do	endrin 20% E. C.	Spray three times at intervals of three weeks, commencing when the crop is 3 weeks old.
Top shoot borer red rot disease.	endrin 20% E. C. + Zineb	Spray thrice at intervals of 6 weeks, commencing when the crop is 2 months old. *Note:* Spray only in areas in which parasites are not released.

Pest 1	Pesticide 2	Time and method of application 3
	TOBACCO	
Seed-borne diseases	Silver nitrate	Treat the seeds before sowing
Tobacco caterpillar black shank disease and frog eye spot disease.	Bordeaux mixture or any copper fungicide + DDT 50% W.P. or parathion	Spray the seedlings in the nursery and repeat if needed.
Powdery mildew	Sulphur dust 200 to 300 mesh	Apply to the soil between rows of the transplanted crop. *Caution* : Do not dust sulphur to leaves.
Tobacco aphid	Parathion 50% E. C., or phosphamidon 100 E. C., or oxydemethon 50% E.C., or menazon 70% D.P., or thiometon 25% E.C., or dimethoate 25% E.C.	Spray the transplanted crop at fortnightly intervals when cut-worms appear. Spray weekly if needed.
	POTATO	
Late blight disease Epilachna beetle	Bordeaux mixture or any copper fungicide + DDT 50% W.P. or Parathion 50%	Spray three to four times at weekly intervals, commencing one month after planting.
Tuber worm	DDT 50% W.P. or parathion 50 E.C.	do
Tuber worm	Methyl bromide (parathion 50% E.C. should not be mixed with Bordeaux mixture).	Fumigate the tubers in an airtight chamber.

Pest 1	Pesticide 2	Time and method of application 3
	GRAPES	
Downy mildew, anthracnose, Powdery mildew and flea beetle	Wettable copper 50% wettable sulphur 90% wettable DDT 50%	Spray the bare vines after back pruning in April and repeat when the growth is 3-6 inches long, 12 inches long, 2 ft long, 3 ft long, 4 ft long, 5 ft long.
do	do	Spray the vines in the month of June or beginning of July.
Downy mildew, anthracnose, powdery mildew.	Wettable copper 50% wettable sulphur 90%	Spray the vines in August and repeat the spray during September.
Downy mildew, anthracnose, powdery mildew and flea beetle.	Wettable copper 50% wettable sulphur 90% wettable DDT 50%	Spray after pruning the vines in October-November. Repeat when growth is 3-6 inches long and one foot long, followed immediately by sulphur dusting against mites.
do	do	Spray when growth is 2 ft long, 3 ft long, 4 ft long and 5 ft long, followed by sulphur dusting. 10 to 12 day spray followed by sulphur dusting when the berries are of the size of a groundnut kernel, give last spray followed by sulphur dusting. *Note :* The spraying must be repeated if rain follows spraying or if there is wet weather in November and December.

Improper weedicide use kills the weeds and the crops

The sorghum crop treated with the proper weedicide

A sorghum crop infested with weeds

The same crop when treated with the proper weedicide

Weeds and Their Control in Crops

Weeds may be conveniently described as plants growing where they are not wanted, especially in competition with agricultural crops. They are troublesome indeed in the agricultural enterprise, being useless as agricultural crops, persistant in occupying farm land, prolific in multiplication, and resourceful both in spreading and in surviving rigorous environmental pressures. Thus, eliminating the weed menace from cultivated crops is a difficult problem of paramount importance to food crop production in India.

Weeds are also troublesome to those concerned with maintenance of rail roads, highways, parks, public lands, play grounds, tanks, irrigation channels, navigation channels and pasture lands.

The weed menace is a continuing one. It has persisted through the ages, being as familiar to the earliest farmers as to the modern day agriculturists. Even so, all too frequently the farmer either fails to recognise the impact of weed competition on crop production or shows no interest in adopting effective weed control measures. Therefore, this section of the Plant Production Manual emphasizes weed problems and how to cope with them.

Classification of Weeds

Apart from the botanical classification, weeds are generally classified, according to their eclogical affinity, as weeds of wet, dry and garden lands. In addition, in this manual their crop association is also given as an aid in control. The list presented here is confined to certain common weeds occurring in agricultural lands.

List of common weeds along with their crop and ecological association.

Botanical Name	*Common Name*	*Crops*	*Habit* * *D W G*
(1)	(2)	(3)	(4)
Cleome monophylla Linn	—	Ragi, Jowar, Groundnut	D — —
Cleome viscosa Linn	Wild mustard	Ragi, Jowar, cotton, groundnut, Vegetables, maize	D — —
Gynandropsis pentaphylla D.C.	—	—,,—	D — G

* D = Dry land G = Garden land
W = Wet land

(1)	(2)	(3)	(4)
Argemone mexicana Linn	Prickly poppy	Ragi, Jowar	D — —
Ionidium suffruticosum Ging	—	Cotton, groundnut	D — —
Polygala chinense Linn	Indian milk wort	Ragi, groundnut	D — —
Polycarpaea corymbosa Lam	—	Groundnut Jowar	D — —
Portulaca oleracea Linn	Purslane	Potato, Maize	— W G
Bergia ammanioides Roxb	Water Firewort	Paddy	— W G
Malvastrum coromandelianum Garcke	—	Ragi, Jowar	D — —
Pavonia zeylanica Cav	—	Jowar, groundnut	D — —
Hibiscus trionum Linn	—	Paddy, cotton, maize potato	— W G
Sida acuta Burn	—	Ragi, Jowar	D — —
Sida cordifolia Linn	—	Jowar, cotton, ragi	D — —
Corchorous olitorius Linn	Jew's mallow	Maize. cotton, Jowar, groundnut, ragi	D — G
Tribulus terrestris Linn	Puncture vine	Jowar, ragi, groundnut	D — G
Oxalis corniculata Linn	Yellow wood sorrel. Lady's sorrel	Groundnut, cotton, Maize, vegetables, Ragi, Jowar	D — G
Oxalis acetocella Linn	—	Paddy	— W —
Rothia trifoliata Pers	—	Ragi, Jowar, groundcotton	D — —
Indigofera ennaephylla Linn	—	Ragi, Jowar, groundnut	D — —
Indigofera hirta Linn	—	Ragi, Jowar	D — —
Atylosia scarabioides Benth	—	Jowar, cotton,	D — —
Tephrosia purpurea pers	—	Jowar, ragi, cotton	D — —
Zornia diphylla pers	—	Jowar, Ragi	D — —
Aeschynomene indica Linn	—	Paddy	— W —
Alysicarpus monilifer DC	—	Jowar, cotton	D — —
Desmodium triflorum DC	—	Ragi, Maize, potato, cotton	D — G
Phaseolus trilobus Ait	—	Paddy, cotton, groundnut	D W —
Rhyncosia minima DC	—	Ragi, Jowar,	D — —

(1)	(2)	(3)	(4)		
Cassia hirsuta Linn	—	Groundnut, Jowar, Ragi, cotton	D	—	—
Mimosa pudica Linn	Touch-me-not	Jowar, cotton ragi, maize, vegetables.	D	—	—
Ammania baccifera Linn	—	Paddy	—	W	—
Jussieua repens Linn	—	Paddy	—	W	—
Ludwigia parviflora Roxb	—	Paddy	—	W	—
Trianthema portulacastrum Linn	—	Ragi, cotton groundnut, vegetables, Maize	D	—	G
Mollugo cerviana Ser	—	Maize, ragi, potato, vegetables, cotton	D	—	G
Centella asiatica Urban	Indian Penny wort	Paddy, potato, vegetables, maize	—	W	G
Oldenlandia aspera DC	—	Ragi, jowar, cotton	D	—	—
Oldenlandia corymbosa Linn	—	Ragi, groundnut, jowar	D	—	G
Borreria hispida K. Sch.	—	Ragi, jowar, cotton, groundnut	D	—	—
Ageratum conyzoides Linn	—	Paddy, maize, ragi, vegetables jowar, groundnut, cotton	D	W	G
Acanthospermum hispidum DC	—	Ragi, jowar, cotton, groundnut	D	—	—
Erigeron asteroides Roxb.	—	Ragi	D	—	—
Blumea lacera DC	—	Paddy, vegetables, maize	D	W	G
Blumea wightiana DC	—	Ragi, jowar, vegetables	D	—	G
Sphaeranthus indicus Linn	—	Paddy, vegetables	—	W	G
Vicoa indica DC	—	Jowar, groundnut, vegetables	D	—	G
Xanthium strumarium Linn	—	Ragi	D	—	—
Lagesca mollis Cav	—	Paddy, ragi, maize, jowar, vegetables, groundnut	D	W	G
Eclipta alba Hassk	—	Paddy, sugarcane vegetables	D	W	G
Spilanthes acmella Murr	—	Paddy, sugarcane, Maize, vegetables	—	W	G
Bidens pilosa Linn	—	Ragi, jowar, cotton	D	—	—

(1)	(2)	(3)	(4)		
Tridax procumbens Linn	—	Ragi, jowar, cotton, groundnut, potato, maize and vegetables	D	—	G
Flaveria australasica HK	—	Paddy, cotton, jowar, ragi	D	W	—
Lactuca runcinata DC	—	Ragi, cotton, jowar	D	—	—
Sonchus arvensis Linn	Corn sow Thistle	Ragi	D	—	—
Anagallis arvensis Linn	pimpernel	Ragi, jowar, groundnut, cotton	D	—	—
Calatropis gigantea R. Br	Gigantic swallow-wort	Ragi, Jowar	D	—	—
Heliotropium indicum Linn	—	Jowar, ragi, groundnut	D	—	—
Trichodesma indicum R. Br	—	Ragi, jowar, cotton, groundnut	D	—	—
Evolvulus alsinoides Linn	—	Ragi, cotton, jowar	D	—	—
Convolvulus arvensis Linn	Deers foot, Field bind weed	Ragi, jowar, Maize, cotton groundnut	D	—	—
Merremia emarginata Hallier F.	—	Cotton, jowar, maize, paddy, groundnut, cotton	D	W	—
Solanum indicum Linn	—	Ragi, jowar	D	—	—
Solanum xanthocarpum SCH & Wend	—	Jowar, cotton, ragi	D	—	—
Solanum nigrum Linn	Black night-shade	Ragi, cotton, maize, potato, vegetables	D	—	—
Physalis minima Linn	—	Ragi, vegetables	D	W	—
Datura metel Linn	Thorn apple	Ragi, jowar, cotton	D	W	—
Bacopa monneira Wettst	Thyme leaved gratiola	Paddy	—	W	—
Dopatrium junceum B. Ham	—	Paddy	—	W	—
Striga densiflora Benth	—	Jowar, sugarcane	D	—	—
Asterocantha longifolia Nees	—	Paddy,	—	W	—

(1)	(2)	(3)	(4)		
Rungia repens Nees	—	Vegetables	—	W	—
Justicia diffusa Willd	—	Ragi	D	—	—
Stachytarpheta urticaefolia Sims	—	Ragi, jowar, groundnut	D	—	—
Lantana camara Linn	—	Ragi, jowar	D	—	—
Lippia nodiflora Mich	—	Paddy, vegetables, maize	—	W	G
Ocimum americanum Linn	Hoary Basil	Ragi, cotton, groundnut	D	—	—
Leucas aspera Spr	—	Jowar, ragi, cotton, potato, vegetables	D	—	G
Boerhaavia diffusa Linn	Spreading Hogweed	Ragi	D	—	—
Celosia argentea Linn	Silver-spiked coxcomb or white coxcomb	Ragi, jowar, groundnut	D	—	—
Amarantus polygamous Linn	—	Ragi, cotton, jowar, maize, vegetables, potato	D	—	—
Amarantus spinosus Linn	Thorny amaranth	Ragi, vegetables	D	—	G
Achyranthes aspera Linn	Prickly chaff-flower	Ragi	D	—	—
Alternanthera echinata Smith	Khaki weed	Ragi, jowar, cotton	D	—	—
Gomphrena decumbens Jocq.	—	Ragi, cotton	D	—	—
Atriplex hortensis Linn	Orachne	Paddy, vegetables	D	W	G
Polygonum plebejum R. Br.	—	Ragi, jowar, cotton	D	—	—
Euphorbia hirta Linn	—	Ragi, groundnut	D	—	—
Euphorbia prostrata	—	Ragi, jowar, vegetables	D	—	—
Phyllanthus niruri Linn	—	Ragi, maize potato, jowar, cotton, vegetables	D	W	G
Phyllanthus madares-patensis Linn	—	Cotton, jowar, groundnut, maize	D	W	G
Croton bonplandianum (L) crozat	—	Ragi, jowar, cotton	D	—	—

(1)	(2)	(3)	(4)		
Acalypha indica Linn	—	Ragi	D	—	—
Commelina benghalensis Linn	—	Vegetables, Maize, potato	D	—	G
Cyperus bulbosus Vah.	Bulbgrass	Ragi, jowar, cotton, vegetables	D	—	G
Cyperus rotundus Linn	Nut grass	Paddy, maize, groundnut, potato, vegetables	—	W	G
Imperata cylindrica (Linn) Beauv	Cotton grass	Paddy	—	W	—
Chrysopogan montanus Trin	—	Ragi, jowar	D	—	—
Dicanthium annulatum Stapf	—	Ragi, jowar	D	—	—
Dicanthium caricosum A Camus	—	Ragi	D	—	—
Apluda veria Hack	—	Cotton, ragi, jowar	D	—	—
Brachiaria distachya Staff	—	Ragi	D	—	—
Echinocloa crus-galli Beauv	Barn yard grass	Paddy	—	W	—
Panicum repens Linn	Ginger grass	Paddy, vegetables	—	W	—
Setaria pallida-fusca Staff and Hubb	—	Ragi, jowar, maize, vegetables	D	—	G
Eragrostis gangetica Steud	—	Paddy	—	W	—
Cynodon dactylon Pers	Hariyali	Jowar, cotton, groundnut, ragi, maize, vegetables	D	—	G
Dactyloctenium aegyptium Picht	Buffallo grass	Vegetables	D	—	G

Damage due to weeds

Weeds compete with crop plants for land, nutrients, moisture and light reducing growth and yield, the extent of reduction depending on the intensity and timing of the competition. The reduction in crop yield due to weeds in India is variously estimated at from 5 to 30%. To this estimated damage can be added the cost of weed control. At every stage of cultivation, harvesting and marketing the crop, weeds add to the cost. Moreover the quality of the produce is impaired.

Weeds harbour insect pests and diseases, sheltering them during adverse conditions. For example, wheat rust spends a part of its life cycle

on the berbery plant and a number of crop insects have weed plants as alternate hosts. Weeds like Striga and Orobanche lead a parasitic life on sorghum and tobacco respectively.

The utility of pasture land is reduced by weeds. Weed control increases the maintenance cost of playgrounds, highways, rail-roads, telegraphic lines and irrigation channels. Land values are depressed by weeds. Navigability and fish fauna of tanks, lakes and ponds are reduced by weeds. Weeds also pose health problems for the people. For example pollen of rag weed causes hay fever and some weeds are poisonous.

Methods of weed control

Weed competition with crop plants may be reduced by prevention, control and eradication. Prevention refers to such measures which reduce the spread and multiplication. Control measures are those which reduce the damage due to weeds when they are already existing in a particular situation. Eradication eliminates the weeds in a particular place, which is possible only under restricted conditions and areas.

Weed prevention

The practices listed below, if followed systematically, would aid in the prevention of weed infestation.

1. Plant weed-free seeds.
2. Remove weeds before seed formation.
3. Keep bunds, borders and marginal lands free of weeds.
4. Avoid driving livestock from weed infested fields to clean fields.
5. Keep all farm implements, including tools, and tractors clean and free of soil and weed seeds.
6. Avoid transferring weed infested soil to clean field.
7. Keep irrigation channels and drains free of weeds.
8. Avoid using of weed infected compost and FYM.
9. Compost, manures and farm wastes so that the temperature inside the pit is high enough to damage the viability of weed seeds.

Weed control

The principal methods of weed control include the adoption of approved agronomic practices, the introduction of biological agents and the use of selective chemicals (weedicides).

1. *Agronomic practices*:

Among the approved agronomic practices, effective in weed control are preparatory tillage, interculture, crop rotation, mulching, handweeding and flooding.

(*a*) *Preparatory tillage*: Two ploughings followed by one harrowing spaced to allow weed seeds to germinate which will reduce the weed population substantially. Clean fallowing in summer, if possible, is also effective.

(*b*) *Intercultural operations*: Intercultural operations in row crops (with implements suitable for working between rows) at frequent intervals together with hand weeding in the rows destroys annual weeds as they develop and holds perennial weeds in check.

(*c*) *Crop rotation*: Rotation involving crops of different growth habits and varieties of management practices may be highly effective in weed control. Such crops as cowpea, lucerne, sunflower, avare and fodder sorghum tend to smother weeds and should be included in rotation. Crops like potato and groundnut in rotation could contribute to weed control through large scale disturbance of soil in the harvest operation.

(*d*) *Mulching*: Mulching with paper or straw or any other material will help in the suppression of the weed growth. For example, weeds can be controlled in pine-apple with paper mulch, as practised in Hawaii.

(*e*) *Flooding*: Flooding is used to control weeds in paddy fields. The crop is flooded to a depth of 3 inches or more and allowed to stagnate for 6 to 8 weeks. This kills all weeds except the aquatic weeds. Then the water is drained off and the land allowed to dry which kills the aquatic weeds.

(*f*) *Hand weeding*: The most common method of weed control is hand weeding. This would be an efficient method for annuals and bienniels which do not reproduce by underground plant parts. Hand weeding should be done before flowering, and although more time consuming and perhaps expensive in some cases, it is easy to perform.

2. *Biological Methods*:

Since weeds are susceptible to certain insect pests, these agents may be used to control weeds under certain circumstances. A prerequisite is that the insect should be specific for its own weed host. For example, the noxious weed prickly pear has been eradicated from different locations by an insect pest which feeds on this weed only. In California, klamath weed beetle has been used effectively to reduce the incidence of klamath weed.

3. *Chemical Methods*:

The discovery that weeds can be selectively killed in a crop field by certain chemicals is the most recent development in weed control. Chemicals that kill weeds are called weedicides. It should be noted that no single weedicide can be used on all crops. Therefore care must be taken to use the right weedicide for any given weed problem.

Preliminary information

Weedicides are selective or non-selective in their action. A selective weedicide applied to a mixed colony of plants will kill certain species without damage to others, for example at a specified rate 2-4-D acts as a selective weedicide killing broad-leaved weeds in cereal crops. On the other hand, non-selective weedicides such as mineral oils kill the cereal crop as well as the weeds. Therefore if these have to be used no crop should be involved.

Weedicides may be applied before seeding, after seeding but before emergence and on a standing crop. These applications are designated as pre-plant, pre-emergence, and post-emergence respectively. The time of application depends on the weed problem on hand with reference to crop; for example, Simazine can be used effectively only as pre-emergence treatment in maize, and Propanil as a post-emergence treatment in paddy. Weedicides vary in their content, concentration of the actual chemical, time of application, suitability for the crop or crops. It is necessary, therefore, to have complete information about each before use. The rate of application is dependent on the concentration of active ingredient present. Thus if 4 kg/ha of 2, 4-D sodium salt is recommended for sugarcane and if a commercial product of 2, 4-D has an acid equivalent of 80%, the product required per hectare works out to 5 kg $\left(\frac{4}{80} \times 100 = 5 \text{ kg}\right)$

Common weedicides

1. *2, 4-D* is available either as sodium or amine salt or as solutions. The active ingredient is 2, 4-dichlorophenoxyacetic acid. This is a selective, translocated auxin type weedicide recommended both as a pre- and post-emergence spray. When given as a pre-emergence spray it lasts for 2-4 weeks in the soil. It is generally effective against broad leaved weeds. Avoid drifts reaching crops like cotton, potato and groundnut. Generally recommended for use in crops like wheat, paddy and sugarcane. Costs about Rs. 13 per kg.

2. *2, 4, 5-T* is available as amine salt. This product is a translocatable selective weed killer with 2, 4, 5-trichlorophenoxy-acetic acid as active ingredient. It is generally recommended for destruction of brush and other woody plants and is especially useful for eradicating weeds in wastelands. Avoid drifts reaching crops like cotton, potato, groundnut.

3. *MCPA* is available as sodium and amine salts, and as an emulsifiable concentrate. This is also a selective weed killer of the hormone type, with 2-Methyl, 4-Chlorophenoxyacetic acid, as active ingredient. Spray drift should be avoided. Generally recommended as a post-emergence spray for paddy. It costs Rs. 8 for five litres.

4. *MCPB* is a selective, post-emergence, translocated weedicide available as emulsifiable concentrate with methylchlorophenoxy-butyric acid as active ingredient. It is used in legumes, mostly peas, both in the seedling and mature plant stages. Do not feed livestock with treated crop.

5. *ATRAZINE* is available as a wettable powder with 50% and 80% active ingredient of 2-chloro-4-ethylamino-6-isopropylamino-1, 3, 5 triazine. It is a soil sterilant, generally recommended as a pre-emergence spray and sometimes as an early post-emergence spray. This weedicide is used against weeds in maize, sugarcane and jowar and is most effective when soil is in fine tilth with optimum soil moisture. Its effect in the soil may last 4 to 14 months, depending on the quantity of weedicide applied. Therefore care should be exercised in using crops sensitive to this weedicide, like groundnut, potato and vegetables in the rotation.

6. *SIMAZINE* is available as wettable powder with 50% to 95% active ingredient of 2 chloro-4, 6-bis (ethylamino) 1,3-5-trazine. It is a soil sterilant, generally recommneded as a pre-emergence spray. In other respects it is similar to Atrazine, but less soluble in water. It costs Rs. 55 per kg. In view of the residual effect, care should be exercised in using crops sensitive to this weedicide like oats, cururbits, rice and tobacco in rotation.

7. *TOK E-25* is available as an emulsifiable concentrate and in granular form, the active ingredient being 2,4-dichlorophenyl-4-nitrophenyl ether (240 gms/litre and 7% respectively). Applied usually as a pre-emergence spray acting as a thin herbicidal barrier on the soil surface. Therefore the soil should not be disturbed 3-4 weeks after application of the weedicide. It is most effective under optimum soil moisture condition.

8. *PROPANIL* is available as an emulsion 3, 4-dichloropropionanlide with 35% and 46% as active ingredient. It is applied as a post-emergence spray and acts as a contact weedicide, killing annual grasses and broad

leaved weeds in paddy. It is most effective when the weeds are in 2-3 leaf stage. Avoid spray drift, which may cause injury to crops like cotton, maize, vegetables and ornamentals. Standing field must be derained before application and can be reflooded, 2 to 5 days after weedicide is applied. Mixed with other Persticides propanil causes injury to paddy. It costs Rs. 20 per litre.

9. *PREFAR* is available as an emulsifiable concentrate with active ingredient S-0, 0-diisopropyl phosphoro dithiote) of *N*- (2-mercapatoethyl) benzene sulfonamide). This weedicide is recommended as pre-emergent spray for cotton, lettuce and cururbits. After application the weedicide should be mixed with the soil to a depth of 2-3 inches and the soil should have optimum moisture condition for good results. Its effectiveness persists for 6-8 months.

10. *DALAPON* is available as a sodium salt with active ingredient 2, 2-Dichloropropionic acid, 85%. This translocatable weedicide is applied both as a post-emergence spray and as spot treatment for the control of grasses. It is most effective when applied during early active stages of growth. The chemical persists in soil for 60 days or longer.

11. *DIURON* is available as a wettable powder with active ingredient, 3,-3, 4-dichlorophenyl-1, 1-dimethyl urea 80%. It is applied as pre-emergence spray for cotton. Soil should be in optimum moisture condition. Since it has a residual effect, avoid growing crops like sorghum in treated fields. It cost Rs. 70/- per kg.

12. *MONURON* is available as a wettable powder with 3-(p-chlorophenyl,) 1, 1-dimethyl urea -80% as active ingredient. This selective pre-emergence weedicide must be mixed into soil. Since it has residual effect, avoid planting for one year with crops other than cotton, maize, and grain sorghum.

13. *PARAQUAT* is available as an aqueous solution with 1,1-dimethyl-4, 4-bypyridylium dichloride as active ingredient. This is a non-selective contact weedicide recommended as a post-emergence spray for undergrowth in plantation crops and a directed spray against weeds only. In other words avoid spray contact with crop plants. The weedicide has no residual effect.

14. *VERNAM* is available both as an emulsifiable liquid and in granular form with n-propyl-di-n-propyl thiolcarbamate 60% as active ingredient. This is a selective, soil-incorporative weedicide given as a pre-planting spray for groundnut, potato and tobacco. This has no residual

effect. This weedicide should not be applied in combination with fertilisers, insecticides, fungicides or other weedicides.

15. *EPTAM (EPTC)* is available both as an emulsifiable concentrate and in granular form with S-Ethyl dipropyl thiocarbamate as active ingredient. This is selective preplant soil-incorporated weedicide; that provides effective control of weeds in general but specially grasses. It is used primarily for carrot, potato, flax and tobacco.

16. *DIPHENAMIDE* is available as a wettable powder with N, N-dimethyl 1, 2, 2-diphenylacetamide (50 to 80%) as an active ingredient. It is a selective pre-emergence weedicide, when mixed with soil for a depth of about 2" it provides weed control over a period of 6-8 months, in crops like tobacco, potato, and groundnut.

Since weedicides may be toxic to man and domestic animals they should be used with care. The following precautions in their handling will minimise the hazards in their use.

Read the label carefully and follow precautionary directions, no matter how often you use a weedicide or how familiar you are with the directions.

Keep weedicides out of reach of children, pets, irresponsible persons and live-stock. Store them away from food, feed and seed, always in their original containers, and keep them tightly closed.

Avoid inhaling sprays or dusts and wash hands and face and change clothing after applying weedicide always. If weedicides are accidently spilled on skin or clothing, remove clothing immediately and wash the cloth and skin thoroughly.

If any illness occurs during or immediately after applying weedicides, consult a doctor. Dispose of left-over material and empty containers so that they pose no hazard to humans, animals, plants or wild life; for example do not dispose of these materials in drainage channels.

Do not siphon liquids from containers or blow out clogged lines and nozzles of syrayers by mouth. Keep the equipment in proper working order.

Confine chemicals to the crop being treated by preventing the drift of spray or dust to crops. Avoid spray applications during dry or hot weather.

The weedicides must be mixed thoroughly with water before spraying. Full syray coverage of the weed foliage is necessary. Spray must be uniform and overlapping should be avoided. It should be stored in a cool, dry place.

Weed Eradication

Weeds may be eradicated by application of weedicides in a high concentration. Although this is relatively easy to do, in so doing soil is made unfit for cropping for varying periods of time. However, this would not be a factor for consideration in the eradication of weeds from places like railroads, high ways, air strips, green houses and along pipe lines. For example, soil sterilants like CMU or Monuron applied at 50 kg/ha kills all vegetation and the soil remains sterile for a number of years. Perunial weeds such as lantana can be eradicated by smearing cut ends of the stumps with a mixture of 2, 4-D and 2, 4, 5-T (2 : 1). Such weeds may also be eradicated by digging them out.

Herbicide	Rate/ha	Volume/ha	Time of application	Weeds controlled	Remarks
1	2	3	4	5	6
			PADDY		
2, 4-D	2.2. kg	900 lt	Post-emergence	Broadleaf and some monocot	Spray six weeks after planting. Later applications may result in sterile ear-heads.
MCPA	2.2. kg	–do–	–do–	All types	Spray once 15 days after planting or when weeds are in 2-3 leaf stage. If necessary spray again 15 days later.
Propanil	7.5 - 10 lt	–do–	–do–	–do–	Spray when leaves are 1-2 leaf stage. Do not mix with any other chemical. Drain field 24 hours before spraying and let in water 24 hrs. later.
			WHEAT		
2, 4-D	1.0 - 2.5 kg	–do–	Post-emergence	Broad leaf	Spray 4 weeks after planting.
MCPA	1.1 kg	–do–	Post-emergence	Broad leaf	
			SUGARCANE		
2, 4-D	2.5 - 4.5 kg	–do–	Pre-emergence	Annuals	Give spray 5 days after planting and another spray 25 days after planting. To all varieties except pundia which is susceptible to injury by this weedicide.
MCPA	2.5 - 4.5 kg	–do–	Post-emergence	Broad leaf	Apply only as a post-emergence spray
Simazine	2.2 - 4.0 kg	900 lt	Pre-emergence	All types	Apply after planting cane and before sprouting
Atarazine	2.2 - 4.0 kg	–do–	–do–	–do–	—

			RAGI		
2, 4-D	1.2 kg	900 lt	Pre-planting	Broad leaf	Apply one week before planting.
EPTC	1.2 kg	–do–	Pre-emergence	All types	Mix into the soil about 2 weeks before transplanting.
			COTTON		
Monuron	0.5 - 1 kg	–do–	Pre-emergence	Grasses and broad leaf	Irrigate 3-4 days after application Residuals remain for one year during which period do not grow susceptible crops.
Diuron	0.5 - 1 kg	–do–	–do–	–do–	
Prefar	5.0 - 6.5 Lit.	–do–	–do–	All types	Mix with the soil to a depth of 2"-3"
			GROUNDNUT		
Tok. E. 25	10 - 15 Lit.	–do–	Pre-emergence	All types	Apply within 7 days after planting and then leave soil undisturbed for 2 weeks.
Vernam 6-E	35 - 4.0 Lit.	–do–	Before planting pre-emergence	All types	Preplanting applications should be mixed with soil to a depth of 3". Pre-emergence application to a depth of $1\frac{1}{2}$" to 2".
			TOBACCO		
Diphenamid	6.5 kg	900 lt	Pre-emergence or immediately after trans-planting.	All types	—
			MAIZE		
Simazine	2.5 kg	–do–	Pre-emergence	Grasses and broad leaf	Spray the soil when in fine tilth one or 2 days after planting seed. Optimum moisture conditions preside effective control.
Atrazine	–do–	–do–	–do–	–do–	–do–
Propazine	–do–	–do–	–do–	–do–	–do–
2, 4-D	–do–	–do–	Pre and post-emergence	Broad leaf	Spray when seedlings are 4-6 six weeks old.

Herbicide	Rate/ha	Volume/ha	Time of application	Weeds controlled	Remarks
1	2	3	4	5	6
		BAJRA			
2, 4-D	1 kg	900 l	Pre and post-emergence	Broad leaf	Spray when seedlings are 4 weeks old
MCPA	1 kg	–do–	–do–	–do–	—
		POTATO			
EPTC	4.0 - 8.0 lt.	–do–	Pre-planting	Annuals	
Dalapon	8 - 10 kg	–do–	–do–	–do–	
DNBP	3 - 4 kg	–do–	Pre and post-emergence	Grasses and broad leaf	—
Monuron	1.25 kg	900 lt	Pre-emergence	Grasses and broad leaf	
		JOWAR			
Simazine	1.0 - 2.0 kg	do	Pre-emergence	Annual grasses and broad leaf	Apply weedicides only to resistant varieties
Atrazine	do	do	do	do	
Propazine	do	do	do	do	
2, 4-D	do	do	Pre- and post-emergence	Broad leaf	Spray when jowar is knee high

CHILLY

EPTC	2.0 - 2.5 Lit	do	Pre-planting	Broad leaf and some grasses	Mix the weedicide with the soil 3-4 weeks before planting.
Pometryne	1.0 - 2.5 kg	do	do	do	Spray 3-4 weeks before planting.

PEAS

MCPB	1 kg	do	Post-emergence	Broad leaf	Spray 3-4 weeks after sowing

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Paraquat	3.0 - 5.5 Lit	do	Post-emergence and spot treatment	All types	Avoid the contact between weedicides and vines.

The rate of chemicals recommended is the amount of actual chemical and not in terms of Active ingredient.

APPENDIX I

Common Name (1)	Trade Name (2)	Remarks (3)
COPPER FUNGICIDES		
Basic copper chloride	Blitox 50 Cuprokylt Cupramar Blue copper 50 Micop W-50-50% Shell copper Cupravit Copper oxychloride 50 WP Kirti Copper Fytolan	Used mainly as foliar sprays against blights, blasts, leaf-spots and mildews. They are also used as soil drenches to control damping off, root-rots and foot-rots.
Copper oxide	Peronox Fungimar Copper Sandoz	Used as foliar sprays and dusts and as seed dressing.
ORGANIC FUNGICIDES		
Zineb — Zinc ethylene Bisdithio Carbamate	Dithane Z-78 Hexathane Blizene Zineb 82 WD	Used as foliar sprays against blights, blasts, leafspots and mildews.

Common Name	Chemical Name	Trade Name	Remarks
Maneb	Manganese ethylene Bisdithio Carbamate	Maneb Dithane M-22	
Ziram	Zinc Dimethyldithio Carbamate	Ziram 65 WP Cuman Ziride 80 WP Hexazir Zerlate	
Ferbam	Ferric Dimethyldithio Carbamate	Ferbam Hexaferb	
Thiram	Tetramethylthiuram Disulphide	Thiram Hexathir Thiride 75 D Thiride 75 WP	Used mainly for seed dressing against seed-borne diseases and for the control of damping off, root rots, and foot-rots. The wettable powders are used as foliar sprays.

ORGANIC MERCURIALS

Phenyl mercury acetate	Ceresan Dry	Used as seed dressing against seed-borne diseases and for the control of damping off, root-rots and foot-rots.
Methoxyethyl mercury chloride	Ceresan Wet	
Phenyl mercury acetate plus Ethyl mercury chloride	Agrosan GN	
Methoxy ethyl Mercury chloride	Aretan	
	Tafasan	
	Tillex Hexasan	

Chemical Name	Trade Name	Remarks
	OTHER FUNGICIDES	
Copper oxychloride + Zinc ethylene-bisdithio carbamate	Blitane	Used as foliar sprays to control blasts, blights, leaf-spots and mildews.
– do –	Zincop	
N. trichloro-methyl-thio-tetrahydrophthalamide	Captan	
– do –	Essofungicide 406	
– do –	Flit 406	
Dinitro-6 (2 octyl) phenyl crotonate	Karathane	
	SULPHUR FUNGICIDES	
Wettable sulphur	Cosan Mico Wettable sulphur Thiovit Microsol Sulkal Hexasul	Used as dusts or sprays to control mildews and leafspots. Also used as seed dressing to control seed-borne diseases.

APPENDIX II

PERTINENT INFORMATION OF INSECTICIDES OF PRESENT OR POTENTIAL USE TO AGRICULTURE IN INDIA

(See footnotes at end of table)

Common name	Chemical name	Trade names (not complete)	Acute oral LD_{50} to male white rate (mg/kg)	Minimum time from last spray to harvest (days)	Commercial formulations	Spectrum of activity and rate per hectare actual in kg (not complete)
1	2	3	4	5	6	7
		Organic Phospate Insecticides				
carbophenothion	S-(p-chloropheny) thiomethyl 0,0-diethyl phoshorodithioate	Trithion	30	5 (melons) 7 (beans) 14 (citrus)	W. P.; E.C.; G.; D.	Insecticide, acaricide and ovicide 0·38–1·0
diazinon	0,0-diethyl 0-(2-isopropyl-6-methyl-1-4-pyrimidinyl phosphorodithioate	Diazinon	100–150	5 (peppers)	W. P.; E. C.; G.; D.	Insecticide and acaricide
dichlorvas	2,2-dichlorovinyl dimethyl phosphate	DDVP; Vapona	56	Not for use on crops	Sprays, baits aerosols and resin impregnations	Insecticide and acaricide. Contact and fumigant

1	2	3	4	5	6	7
dimethoate	0,0-dimethyl S-(N-methyl-carbamoyl-methyl) phosphorodithioate	Rogor; Cygon	215	1 (beans)	W. P.; E. C.; G.; D.	Insecticide and acaricide. Contact and systemic action 0.25–0·50
dioxathion	2,3-p-dioxanedithiol S,S-bis (0, 0-diethyl phosphorodithioate)	Delnav	43	0 (citrus)	W. P.; E. C.; D.; dips	Insecticide and acaricide. Contact and stomach
disulfoton	0,0-diethyl-S-2-(ethylthio) ethyl phosphorodithioate	Solvirex; Di-Syston; Systox	2·6	30 (sugar-beet)	W. P.; E. C.;	Insecticide-acaricide. Systemic
EPN	0-ethyl 0-p-nitrophenyl phenylphosphonothioate	EPN	35	14 (maize) 21 (cherry)	S. W. P.; D.	Insecticide-acaricide
fenitrothion	0,0-dimethyl-0-(3-methyl-4-nitrophenyl)-thiophosphate	Accothion; Sumithion; Folithion	250		W. P.; E. C.; D.; G.	Contact and stomach poison insecticide
fenthion	0,0-dimethyl 0-(4-methylthio)-m-tolyl phosphorothiate	Labaycid; Baytex	190		W. P.; E. C.; D.; G.; aerosol	Insecticide-acaricide. Good residual action
formothion	0,0-dimethyl-S-(N-methyl-N - formoylcarbomyl-methyl)-dithiophosphate	Anthio; Ekatin-M	330	14 (minimum for any crop)	E. C.	Insecticide-acaricide. Systemic and contact

1	2	3	4	5	6	7
malathion	S-1, 2-bis (ethoxycarbonyl) ethyl 0, 0-dimethyl phosphorodithioate	Malathion	1000-1400	1 (cucumber) 3 (pepper) 7 (head-lettuce)	W. P.; E. C.; aerosol; D.; G.; U. L. V.	Insecticide-acaricide. Broad spectrum 1.00–2.00
menazon	S-(4, 6-diamino-S-triazin (2)yl)-0, 0-dimethyl phosphorodithioate	Sayfos	890		W. P.; E. C.	Insecticide-acaricide. Selective
methyl parathion	0,0-dimethyl 0-p-nitrophenyl phosphorothioate	Methyl parathion Folidol-M	9	5 (cotton) 15 (grains)	W. P.; E. C.; D.	Insecticide-acaricide. Stomach, contact and fumigant action 0·25–1·00
mevinphos	methyl 3-hydroxy-alpha-crotonate dimethyl phosphate	Phosdrin	7	1 (tomato) 3 (turnips) 4 (spinch)	W. P.; E. C.; D.; G.; aerosol	Insecticide-acaricide. Systemic and contact
oxydemetonmethyl	dimethyl-ethylmercaptoethylthiophosphate	Metasystox	120	21 (minimum for any crop)	E. C.	Insecticide-acaricide. Systemic
parathion	0,0-diethyl 0-p-nitrophenyl phosphorothioate	Parathion; Folidol; Ekatox; Thiophos	3	5 (potato) 10 (cabbage) 15 (beans)	W. P.; E. C.; D.; G.; aerosol	Insecticide-acaricide. Broad spectrum 0.25–1.00
phorate	0,0-diethyl-S-(ethylthio) methyle phosphordi-	Thimet	1·1	Used at time of planting	E. C.; G.	Insecticide-acaricide. Systemic, contact and fumigant action 1·00–1·50

1	2	3	4	5	6	7
phospha-midon	2-chloro-2-diethylcar-bamoyl-1-methylvinyl dimethyl phosphate	Dimecron	23·5	16 (mini-mum for any crop) 21 (maize)	W. P.; E. C.	Insecticide-acaricide. Systemic with stomach action 0·25–0·50
SD-8447	phosphoric acid, 2-chloro-1-(2, 4, 5-trichloro-phenyl) vinyl dimethyl ester	Gardona	4000	?	E. P.; E. C.	Insecticide. Broad spectrum
thiometon	0, 0-dimethyl-S-ethyl-mercaptoethyl-dithio-phosphate	Ekatin	120	?	E. P.; aerosol	Insecticide-acaricide. Broad spectrum systemic
trichlorfon	dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate	Dipterex;	450	14 (sugar beets) 14 (alfalfa)	W. P.; D.;G.	Insecticide. Selective systemic

Cyclodiene Insecticides (Chlorinated)

aldrin	1, 2, 3, 4, 10,-10-hexa-chloro-1, 4, 4a, 5, 8, 8a-hexahydro-1,4-endo-exo-5,8-dimethanona-phthalene	Aldrin; Aldrex	38	Tolerance ranges from 0 to 0·1 p. p. m.	W. P.; E. C.; D.; G.	Insecticide. Contact and stomach poison 1·00–3·00

1	2	3	4	5	6	7
Chlordane	1, 2, 4, 5, 6, 7, 8, 8-octachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindane and related compounds	Chlordane	250	Tolerance 0·3 p.p.m. on some crops	W.P.; E.C.; D.; G.; aerosol; oil solns.	Insecticide. Contact, stomach and fumigant poison 2·00—5·00
Dieldrin	1, 2, 3, 4, 10, 10-hexachloro 6-7 epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo-exo-5, 8-dimethanonaphthalene	Dieldrin ; Dieldrex	46	14 (onion) 21 (sweet potato)	W.P.; E.C.; D.; G.; baits	Insecticide. Contact and stomach poison
Endrin	1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8 8a-octahydro-1, 4-endo-endo-5, 8, dimethanonaphthalene	Endrin ;	10	Zero tolerance on food crops 14 (cucumber)	W.P; E.C.; D.; G.; baits	Insecticide. Contact and stomach poison 0·25—0·50
Heptachlor	1, 4, 5, 6, 7, 8, 8-heptachloro-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindane	Heptachlor	130	Tolerances of 0 on most crops	W.P.; E.C.; D.; G.	Insecticide. Contact and stomach poison 1.00—3·00
		Other Chlorinated Compounds (DDT, etc.,)				
Benzene hexachloride	1, 2, 3, 4, 5, 6-hexachloro-cyclohexane, consisting of *gamma* and other isomer	BHC and many others	125	60 (pear) Tolerance 5·0 p.p.m. on some crops	W.P.; E.C.; D.; Smokes	Insecticide. Stomach, contact and fumigant 0·25—0·60

1	2	3	4	5	6	7
Chlorobenzilate	Ethyl 4, 4′-dichlorobenzilate	Chlorobenzilate	729	0 (citrus) 7 (pear)	W.P.; E.C.; D.	Acaricide. Effective on most kinds by contact
DDT	1, 1, 1-trichloro-2, 2-bis (p-chlorophenyl)-ethane	DDT and many others	113	5 (tobmato) 14 (mint) 30 (plum)	W.P.; E.C.; D.; G.; Aerosol; oil soln.	Insecticide. Contact and stomach action 1·00—3·00
Dicofol	4, 4′-dichloro-alpha-(trichloromethyl) benzhydrol	Kelthane	684	2 (cucumber 7 (pear) 14 (peach)	W.P.; E.C.; D.	Acaricide with long residual
DMC	Di (p-chlorophenyl) ethanol	DMC; Dimite	500	Zero tolerance on food crops	E.C.	Acaricide with ovicidal action
Endosulfan	6, 7, 8, 9, 10-10-hexachloro-1 5, 5a, 6, 9, 9a-hexahydro-6, 9-methano-2, 4, 3-benzodioxathiepin-3-oxide	Thiodan	43	1 (tomato) 7 (cabbage) 14 (head lettuce)	W.P.; E.C.; D.; G.	Insecticide-acaricide
Lindane	1, 2, 3, 4, 5, 6,-hexachlorocyclohexane, *gamma* isomer of 99 per cent purity	Lindane and many others	91	1 (cucumber) 60 (apple)	W.P.; E.C.; D.; aerosol	Insecticide Stomach, contact and fumigant action
Methoxy chlor	1, 1, 1-trichloro-2, 2-bis (p-methoxyphenyl) ethane	Methoxy DDT; Marlate	5000	1 (pepper) 14 (collards)	W.P.; E.C.; D.; aerosol	Insecticide. Stomach and contact action

1	2	3	4	5	6	7
Perthane	1, 1-dichloro-2, 2 bis (p-ethylphenyl) ethane and related products	Perthane	4000	2 (cherry) 7 (pear)	W.P.; E.C.; D.	Insecticide
TDE	1, 1-dichloro-2, 2-bis (p-chlorophenyl)-ethane	Rhothane; DDT	2500	1 (pepper) 14 (berries) 30 (apple)	W.P.; E.C.; D.	Insecticide Contact and stomach action
Tetradiphon	P-chlorophenyl 2, 4, 5-trichlorophenyl sulfone	Tedion	14700	0 (grape) 10 (mint)	W.P.; E.C.; D.	Acaricide Acts mainly on eggs and young
Toxaphene	Chlorinated camphene containing 67-69 percent chlorine	Toxaphene and many others	90	28 (jowar)	W.P.; E.C.; D.; G.	Insecticide Contact and stomach action
		Miscellaneous Insecticides				
Carbaryl	1-naphthyl methyl-carbamate	Sevin	500	1 (pepper) 3 (beets)	W.P.; D.; G.; aerosol	Insecticide Contact and stomach action 1·00—2·50
Morestan	6-methyl-2, 3-quinoxalinedithiol cyclic, S, S-dithiocarbonate	Morestan	1800	35 (apple)	W.P.;	Acaricide

1	2	3	4	5	6	7
Lead arsenate	Acid lead arsenate	Many brand names	100	30 (apple)	W.P.; D.;	Insecticide. Inorganic stomach poison
Mineral oil		Various brand names	Very low	Exempt from tolerance	E.C.; miscible; stock emulsion	Insecticide-acaricide. Contact action
Nicotine sulfate		Black Leaf 40	50	1 (most crops)	Water-soluble; D.	Insecticide. Contact, stomach and fumigant action
Sodium fluosilicate		Sodium fluosilicate	125	Not applied to foliage	D.; solution bait	Insecticide Inorganic stomach poison
		Fumigants				
Ethylene dibromide	1,2-dibromoethane	Ethylene dibromide	Highly toxic to man	—	Liquid	Fumigant. Soil, fresh fruit, vegetables, etc.
E.D./C.T. mixture	Ethylene dichloride (1, 2-dichloroethane) and carbon telerachloride	E.D./C.T. Fumigant mixture; Three to one mixture	Moderately toxic to	—	Liquid	Fumigant. Grain, godowns dwellings, etc.,

1	2	3	4	5	6	7
Hydrogen cyanide	Hydrocyanic acid	Cyanogas; HCN	Very toxic to man	—	"Cyanogas" and various others	Fumigant General purpose
Hydrogen phosphide (phosphine)		Phostoxin	Relatively safe to handle	—	Tablets	Fumigant. Grain; rodent Burrows
Methyl bromide	Bromomethane	Methyl bromide	Highly toxic to man	—	Liquid under pressure	Fumigant. General purpose
		Rodenticides				
Fumigants		Last five entries above	See above	—	See above	See above
Chronic poisons (anticoagulants)		Warfarin; Tormorin; Pival; Fumarin; Diphacin	Relatively safe to man	—	Dry concentrates or finished baits	Mainly effective on rats
Acute poisons		Endrin; zinc phosphide; Antu, strychnine, etc.	Mostly highly toxic to man	—	Various formulations	Toxic to most warm-blooded animals

Abbreviations:

W.P. = wettable powder — E.C. = emulsifiable concentrate

D. = dust — G. = granular

U.L.V. = ultra low volume

Sources of Information:

Thomson, W.T. 1967. Agricultural Chemicals. Book I—Insecticides Thomson Publications, Davis, California, U.S.A. 365 pages. Authority for: (1) Acute oral LD_{50} values to male white rats, (2) Commercial formulations and (3) Spectra of activity.

U.S. Department of Agriculture: 1967. Suggested guide for the Use of Insecticides to Control Insects affecting Crops, Livestock, Households, Stored Products, and Forest Products—1967 Agricultural Handbook No. 331, 273 pages. This was the primary authority for the information, presented in column 4, i.e., minimum time intervals between last application and harvest (in the United States).

APPENDIX III

PLANT PROTECTION EQUIPMENT

The effectiveness of plant protection depends on the timely and thorough application of the right method, whether it be chemical or non-chemical. Chemical pesticides vary so widely in formulation and physical make-up, that different kinds of application equipment are needed to put them at the proper target area. These specialized types of equipment fall into the general categories of sprayers, dusters, granule applicators, mist blowers, seed treaters and miscellaneous devices.

Sprayers are designed to apply pesticides in water suspensions, emulsions and solutions. They range in size from small hand-operated devices to large tractor-drawn machines. Each consists a sprayer or consists a tank to hold the pesticides, a pump to create the pressure essential for ejecting the pesticide, and a spray-rod or lance with appropriate nozzle for breaking the liquid into a proper spray or mist.

Dusters are used for the application in dust form of pesticide available in powdery form. They vary widely both in shape and capacity, ranging from simple shaker devices to large power-driven machines.

Granule applicators are designed to apply granular formulations of pesticides, to individual plants, to the soil and in irrigation water.

Mist blowers are designed to create a blast of air, into which the wet or dry pesticide is fed, emerging as a fine mist, which envelops the plant foliage covering it with a fine coating of the pesticide. The advantages of mist blowers are that they use air instead of water or inert dust as the carrier or diluent of the pesticide, thus making it possible to treat large areas with a relatively low volume of material.

Seed treaters are devices for applying the pesticide to form a coat on the seed to control seed-borne pests. Some are adapted to apply dry formulations and others to apply liquids and slurry formulations.

Miscellaneous pest control equipment include such things as soil injectors, flame throwers, trapso bird-scarers and electrical fences.

Proper care and maintenance of equipment is essential if it is to be available when needed for the timely application of the pesticide. A good maintenance programme ensuring proper functioning of the equipment at all time will include attention to the following details.

1. Wash sprayers thoroughly after each use, both inside and out and run clear water through the hose and nozzles, until it comes out clear. Dismantle and clean the nozzles.

2. Pour the pesticide into the tank through a strainer and clean and dry the strainer after each use.
3. Protect hoses from abusive use such as sharp' angle bending and lifting or dragging sprayer with them.
4. Use the proper oil-petrol mixture as fuel for motorized sprayers and avoid running the engine of mist blowers at full speed.
5. Lubricate moving parts regularly as recommended by the manufacturer.
6. Avoid abusive treatment of nozzles and strainers such as putting them down or dragging them through dust and mud.
7. Replace worn valves when they begin to leak and show effect of wear.
8. Never leave dust nor granules in dusters and applicators not in use.
9. At the end of the season clean all equipment and repair or replace all worn parts. Dry equipment thoroughly, lubricate, and store carefully for next seasons use.

APPENDIX IV

COMPATIBILITIES OF INSECTICIDES AND MATERIALS WITH WHICH THEY MAY BE COMBINED

1. *The cyclodienes*: This group includes aldrin, dieldrin, chlordane, heptachlor and endrin all of which are compatible with fungicides, acaricides and other common insecticides.
2. *The Chlorinated Compounds (other than the Cyclodienes)*: This category includes DDT, BHC, lindane, toxophene, kelthane, and chlorebenzilate which are compatible with other pesticides except for calcium arsenate, mineral oils and strong alkalies (lime, lime sulphur or Bordeaux mixture).
3. *The Organic Phosphates* include parathion, diazinon and malathion and these are incompatible with strong alkaline materials such as, lime, sulphur, bordeaux mixture, calcium arsenate and organomercurial fungicides. Also combinations of O-P compounds with organomercurial fungicides should be avoided.
4. *The Carbamates*: Carbaryl (Sevin) helongs to this group and incompatible with alkaline materials such as lime, lime sulphur, bordeaux mixture or calcium arsenate.

5. The arsenic compounds include lead arsenate and calcium arsenate. Only lead arsenate is compatible with the common insecticides and fungicides.
6. *Mineral Oils:* Petrolium oil insecticides are incompatible with fungicides like captan and phygon, wettable sulphur and organo-mercurials and with insecticides carbaryl, toxophene and DDT.
7. *Conclusion:* Information on the compatibility of an insecticide with other pesticides is generally given on the label. It is necessary therefore to read the label and follow instructions.

APPENDIX V

CARE IN HANDLING PESTICIDES

The use of chemical pesticides in food crop production is essential to maximum returns in the yield and quality product. In using them, however, proper handling is essential to the health and well-being of those involved as well as others who come near them. Fortunately this safe handling of these materials requires the adoption of only a few simple precautionary practices. Otherwise, their careless handling or misuse may lead to serious injury or tragic consequences.

Safety precautions to observe:

1. Among the pesticides recommended for a specific pest, use the one least toxic to people.
2. Use the safest formulation of the pesticide chosen. Granular forms have the highest safety factor and emulsifiable concentrates the least.
3. Store pesticides in containers adequately labelled as to contents and its poisonous nature and keep them out of reach of people who cannot read, preferably under lock.
4. Take all precautions to avoid or minimise direct contact with the pesticide and wash thoroughly if and when such contacts occur and after general exposure during the application process.
5. Use a face mask to avoid inhaling vapours, dusts and spray mists.
6. Destroy empty containers to prevent their use for other purposes.
7. Apply pesticide from the windward side to avoid exposure to aerial drifting and sprays and dust.

8. Avoid transporting and storing pesticides with food, medicine, and beverages.
9. Follow carefully all recommendations pertaining to dosage, application procedures and last treatment before harvest.
10. Keep reports on pesticides used, dates of application, procedures followed, length of exposure and prevailing temperatures, as possible aids in diagnosis of illness among workers involved.

APPENDIX VI

EMERGENCY TREATMENT AND ANTIDOTES FOR INSECTICIDE POISONING

I. Treatments

First: Call or send for a physician.

Second: In the meantime, if the poison was swallowed, induce vomiting to empty the stomach using the finger or tongue depressor down patient's throat, or give a warm salt solution (one teaspoonful in a glass of warm water). When stomach is emptied, give a demulcent such as raw egg whites, milk or thin flour paste.

Note: (A) Do *not* make an unconscious person vomit.
(B) Do *not* give oil

2. If poison was spilled on clothing and skin, remove clothing and scrub skin with warm soap-water.
3. If a fumigant was inhaled on skin, remove the patient to open air and if necessary give artificial respiration, preferably mouth to mouth.

II. Antidotes

Refer to the label for the name and dosage of the best antidote.

1. The best antidotes for chlorinated insecticides such as endrin, dieldrin, aldrin, chlordane, heptachlor, DDT, BHC, lindane, thiodan and toxaphene are phenobarbital, pentabarbitol, or calcium gluconate.
2. The best antidote for organic phosphate insecticides such as parathion, diazinon, phorate, methyl parathion and EPN are atropine sulphate and protopam chloride (also called pralidoxime chloride and 2-PAM).

3. The best antidotes for the carbamate insecticide Carbaryl (Sevin) is atropine sulphate.
4. The best antidote for lead arsenate poisoning is BAL (Dimercaptrol)

Conclusion: In case of insecticide poisoning, read the label or the package to know the name and suggested dosage of the appropriate antidote.

Reference

Hayes, Wayland J. Jr. 1963: Clinical Handbook on Economic Poisons—Emergency information on treating poisoning, U.S. Department of Health, Education and Welfare, Public Health Service Publication No. 4474, 144 pages (Price U.S. $0·55)

APPENDIX VII

DOSAGE TABLE

% Insecticide	Grams per Ltr.	Number Litres Required to Give Dose in Kgs. or Lbs. in Litres Per Unit of Area					
		2·2 lb. 1 kg.	1·65 lb. ·75 kg.	1·10 lb. ·50 kg.	.82 lb. .375 kg.	.55 lb. .25 kg.	.27 lb. .125 kg.
10.00	100	10 lts.	7·5 lts.	5·0 lts.	·375 lts.	2·50 lts.	1·25 lts.
12.50	125	8·0	6·3	4·00	3·10	2.00	1·00
15·00	150	6.7	5·0	3·30	2·50	1·60	.80
17·50	175	5·7	4·3	2.80	2·20	1·40	.70
20·00	200	5.0	3·75	2·50	1·87	1·25	·625
22.50	225	4·4	3·3	2·20	1.70	1.12	.56
25·00	250	4·0	3·0	2·00	1·50	1.00	·50
27·50	275	3·6	2·7	1·80	1·35	.90	.45
30·00	300	3·3	2·5	1.70	1.25	·80	.40
32·50	325	3.1	2·3	1·50	1·10	.75	.38
35·00	350	2.9	2·1	1·43	1.10	.72	.36
37·50	375	2·7	2.0	1.33	1·00	·67	·33
40·00	400	2·5	1·9	1·25	·95	.63	.31
42·50	425	2·4	1·8	1·20	·90	·60	.30
45·00	450	2·2	1·7	1·10	·85	·55	·28
47·50	475	2·1	1·6	1·06	·80	.53	·26
50·00	500	2·0	1·5	1·00	·75	·50	·25
60·00	600	1.6	1·35	·83	.63	·41	.21
70·00	700	1.4	1·1	·70	.55	.35	·17
80.00	800	1·3	·9	·63	·46	·32	.16
90·00	900	1.1	·8	·55	.42	.26	·13
100	1000	1·0	·8	·50	·38	·25	.12

Furnished by Prof. W. W. Stanley, Plant Protection Adviser, USAID, Department of Agriculture, Bangalore.

APPENDIX VIII

CONVERSION UNITS

1 acre = 43,560 sq. ft. = 4,840 sq. yds. = 4,047 sq. m.
1 ha. = 107,637 sq. ft. = 11,954 sq. yds. = 10,000 sq. m.
1 acre = ·4047 ha; 1 ha = 2.471 acre
1 metre = 39·37 in. = 100·000 cm.
1 yard = 0·91 metre
1 sq. yd. = 1,296 sq. inches; 1 sq. m. = 1,550 sq. inches
1 sq. m. = 1·196 sq. yds; 1 sq. yd. = .8361 sq. m.
1 lb. = 453·59 grams
1 kg. = (1,000 grams or 1 U S. gal = 3,785 c c = 8·33 lb.
(2·2046 lbs. 1 IMP gal = 4,560 c c = 10·00 lb.
1 quintal = 220·46 ,, 4·0 lb/gal US = 48%
10 ,, = 2,204·6 ,, 4·8 lb/gal IMP = 48% or
(1 metric ton
1 lb. per acre = ·0937 grams/sq. yd. or ·1121 grams/sq. m.
1 kg. ,, ,, = .2066 ,, ,, ,, or ·2471 ,, ,, ,,
1 ,, ,, ha. = ·0836 ,, ,, ,, or ·1000 ,, ,, ,,
1 lb. ,, ,, = .0379 ,, ,, ,, or .0454 ,, ,, ,,

Width of Row inches	Acres			Hectares		
	ft. of row	Yds. of row	Metres of row	ft. of row	Yds. of row	Metres of row
42	12,445	4,148	3,794	30,753	10,251	9,374
36	14,520	4,840	4,426	35,878	11,958	10,937
30	17,424	5,808	5,311	43,055	14,350	13,123
24	21,780	7,260	6,239	53,818	17,937	16,404
21	24,891	8,297	7,587	61,506	20,500	18,747
18	29,040	9,680	8,851	71,758	23,916	21,872
16½	38,368	10,560	9,561	78,281	26,091	23,860
15	34,848	11,616	10,622	86,109	28,700	26,246
12	43,560	14,520	13,277	107,636	35,875	32,807

1728 cu. inches = 1 cu. ft; 27 cu. ft. = 1 cu. yd.
1 inch = 2·5 cm.; 1 ft. = 30·48 cm.; 3 ft. = 91·44 cm.
16 drams = 1 oz. = 28·3495 grams
16 oz. = 7,000 grains = 1 lb. = 453·59 grams
14 lbs. = 1 stone
1 sq. mile = 259 ha. = 640 acres
1 pint = 473·2 cc.; 2 pints = 946·3 cc.
1 tinful = 18 litres or 4 IMP gal.

Furnished by Prof. W. W. Stanley, Plant Protection Adviser, USAID, Department of Agriculture, Bangalore.

APPENDIX IX

Insecticides available and the approximate cost of chemical required per acre.

AVAILABLE INSECTICIDES

Name		*Rs. per Ltr. or Kg.*	*Rate per Acre Actual*		*Cost per Acre*	
		Rs.P.	Lbs.	Kg.	Rs. P.	Rs. P.
DDT	50% W.P.	5.20	1.00–3.00	0.45–1.35	5.00 —	15.00
Endrin	25% E.C.	16.00	0.25–0.50	0.12–0.23	8.00 —	16.00
Heptachlor	,, ,,	27.50	1.00–3.00	0.45–1.35	55.00 —	165.00
Chlordane	75% ,,	77.50	2.00–5.00	0.91–2.70	108.00 —	217.00
Aldrin	30% ,,	24.00	1.00–3.00	0.45–1.35	40.00 —	120.00
Carbaryl	50% W.P.	12.40	1.00–2.50	0.45–1.13	24.80 —	42.00
,,	10% dust	2.50	1.00–2 50	0.45–1.13	25.00 —	62.50
Ethyl Parathion	50% E.C.	29.00	0.25–0.50	0.11–0.23	7.25 —	14.50
Methyl Parathion	,, ,,	38.50	0.25–1.00	0.11–0.45	9.60 —	38.50
Malathion	,, ,,	53.40	1.00–2.00	0.45–0.91	53.40 —	106.80
Phorate	10% g.	8.00	1.00–1.50	0.45–0.67	40.00 —	60.00
Dimethoate	25%	40.00	0.25–0.50	0.11–0.45	20.00 —	40.00
Demeton	,,	40.00	0.25–0.38	0.11–1.70	20.00 —	30.00
Phosphamidon	100%	120.00	0.25–0.50	0.11–0.23	15.00 —	30.00
Carbophenothion	25%	20.00	0.38–1.00	0.17–0.45	13.30 —	40.00
Themeton (Ekatin)		44.00	— —			
Menazon	50% W.P.	75.00	— —			
DDVP		10.20	— —			
BHC	10%	1.40	0.25–0.60	— —	7.00 —	11.20
,, W.P.	50%	2.35	0.25–0.60	— —	7.00 —	11.20
,, E.C.	25%	3.50	0.25–0.60	— —	7.00 —	11.20

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APPENDIX X

Metric and Foot Equivalents

Length	Volume	Weight	Fraction or multiple of standard measure
Millimetre	Millilitre	Milligram	0.001
Centimetre	Centilitre	Centigram	0.01
Decimetre	Decilitre	Decigram	0.1
Metre	Litre (1000cc)	Gram	1.0
Decametre	Decalitre	Decagram	10.0
Hectometre	Hectolitre	Hectogram	100.00
Kilometre	Kilolitre	Kilogram	1000.00

One Micron (μ)	=	0.001 m.m.
One Millimetre	=	0.0394 inch or 1/250 of an inch
One Decimetre	=	10 Centimetres or about 4 inches
One Metre	=	10 Decimetres or 3.28 feet
One Kilometre	=	1000 Metres or 0.6214 mile

Pounds per Acre to Kilograms per Hectare

1 lb. per acre = 1.13 kg. per hectare
2 lbs. ,, = 2.26 kg. ,,

Kilograms per Hectare to Pounds per Acre

1 kg. per hectare = 0.89 lb. per acre
2 kg. ,, = 1.78 lb. ,,

Imperial Gallons per Acre to Litres per Hectare

Multiply by 11.38

Litres per Hectare to Imperial Gallons per Acre

Multiply by 0.09

Parts per Million

1 milligram per kilogram = 1 part per million (p.p.m.)
= 0.007 gram per pound
Grain per U.S.A. gallon = 17.1 p.p.m.

1 Imperial gallon	=	277.24 c. inches
	=	0.16 cubic foot
	=	0.454 cubic metre
	=	4.546 litres
	=	4 54 kilograms
	=	10.272 lb. of water

Linear Measures

1 inch	=	25.4 millimetres	1 millimetre	=	0.0394 inch
1 foot	=	0.3048 metre	1 centimetre	=	0.3937 inch
1 yard	=	0.9144 metre	1 metre	=	39.3708 inches
1 mile	=	1.6093 kilometres	1 kilometre	=	1093.63 yards

Areas

1 square foot	=	144 square inches	=	0.0929 square metres
1 square yard	=	9 square feet	=	0.8361 square metres
1 acre	=	43560 square feet	=	4840 square yards
1 square mile	=	640 acres	=	259 hectares

An acre is roughly a square of side 70 yards (208.71 feet)

$\frac{1}{10}$ acre = 66 feet × 66 feet.

Weights — Table and Equivalents

1 grain	=	0.0648 gram	1 centigram	=	0.154 grain
1 ounce	=	28.350 grams	1 gram	=	15.432 grains
1 pound	=	0.4536 kilogram	1 kilogram	=	2.2046 lbs.
1 cwt.	=	50.8 kilograms	1 quintal	=	1.968 cwt.
1 ton	=	1016.0 kilograms	1 tonne	=	0.948 ton

After Mukundan, T. K. Plant Protection Principles and Practice. Asia Publishing House, Bombay. pp. 338-342. 1964.

ERRATA

Page No.	*Line*	*Instead of*	*Read*
8	Under symptoms line 10	place or	in place of
9	Under cause line 1	rolfsil	rolfsi
10	Under symptom line 9	goowth	growth
11	Under cause line 4–5	Melasmspora ricins	Melampsora ricini
11	Under symptoms last line	Pots	spots
16	Under symptoms line 21	nevelop	develop
18	Under control line 4	@ 170–225 l/ha	@ 55–110 l/ha.
20	Under symptoms line 14	fungal on	fungal growth on
23	Under control line 19	(500–1000 pmm)	(500–1000 ppm)
29	Under cause line 1	kolerogam	koleroga.
30	Under disease line 1	Katte of	Katte or
31	Under symptom line 4	exceedes	exudes
31	Under cause line 7	Collectotrichum	Colletotrichum
36	Under insect line 2	Atherigone	Atherigona
37	Under damage line 9	Steam	Stem
37	Under insect line 5	Scsamia	Sesamia
	line 7	Peregrinns	Peregrinus
39	Under insect line 5	Stenachoria	Stenachroia
41	Under insect line 3	unipuntta	unipuncta
46	Under insect		
	line 2	Sesania	Sesamia
	line 6	Loxostage messlais	Loxostege messalis
48	Under insect		
	line 2	Psuedalctia	Psuedaletia
	line 4	sphenariodes	sphenarioides
	line 9	Nicrotermes	Microtermes
	line 10	Lechnosterna	Lachnosterna
48 (a)	Under insect line 5	Chilo (=chilotraca)	Chilo (=chilotraea)

Page No.	*Line*	*Instead of*	*Read*
48 (b)	Under insect line 8	app	spp
50	Under insect line 4	fraterma	fraterna
51	Under insect line 2	Stomadteryx	Stomopteryx
52	Under control line 11	300 kg.	3.00 kg.
53	Under insect line 5	Platydra	Platyedra
55	Under insect line 7	Spodoptcra litroalis	Spodoptera littoralis
56	Under vegetables line 2	Table 5	Appendix II
58	Under insect line 11	Hemitorsonemus	Hemitarsonemus
59	*Under insect line 5*	*Corcidolomia*	*Crocidolomia*
60	Under insect line 4	Rhophalsiphum pruedobrassicae	Rhophalosiphum psuedobrassicae
60	Under control line 3	mustard fly	mustard saw-fly
61	Under damage line 12	cause	case
64	Under control line 10	on	or
66	Under insect line 2	Cylotrechus	Xylotrechus
73	Under pesticide line 9 & 17	Phorate 5%	Phorate
87	Last line	Rs. 13/- per kg.	Rs. 22/- per kg.
89	Line 3	derained	drained
	line 27	than cotton, maize	than cotton, like maize
90	Line 30, 36	Syray	Spray
92	Under remarks line 1	Spray six weeks after planting	Spray within 4-6 weeks after planting
93	Under remarks line 17	preside	provide
101	Under column 2 line 19	methyle phosphordi	methyl phospho-rodithioate
108	Line 12	Column 4	Column 5
115	Line 4	39·37 in= 100.000 cm	39.37 in= 100·00 cm