PEST AND DISEASE MANAGEMENT IN ORGANIC ECOSYSTEM

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General

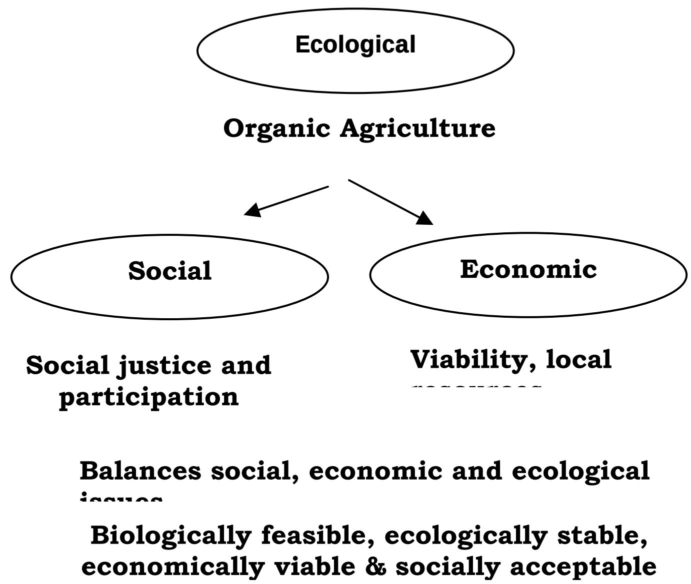
Immense commercialisation of agriculture has had a very negative effect on the environment. The use of pesticides has led to enormous levels of chemical buildup in our environment, in soil, water, air, in animals and even in our own bodies. Fertilisers have a short-term effect on productivity but a longer-term negative effect on the environment where they remain for years after leaching and running off, contaminating ground water and water bodies. The use of hybrid seeds and the practice of monoculture has led to a severe threat to local and indigenous varieties, whose germplasm can be lost for ever. All this for "productivity".

In the name of growing more to feed the earth, it has taken the wrong road of unsustainability. The effects show - farmers committing suicide in growing numbers with every passing year; the horrendous effects of pesticide sprays, pesticide contaminated bottled water and aerated beverages are only some instances. The bigger picture that rarely makes news however is that millions of people are still underfed, and where they do get enough to eat, the food they eat has the capability to eventually kill them.

Another negative effect of this trend has been on the fortunes of the farming communities worldwide. Despite this so-called increased productivity, farmers in practically every country around the world have seen a downturn in their fortunes. This is where organic farming comes in. Organic farming has the capability to take care of each of these problems. Besides the obvious immediate and positive effects organic or natural farming has on the environment and quality of food, it also greatly helps a farmer to become self-sufficient in his requirements for agro-inputs and reduce his costs.

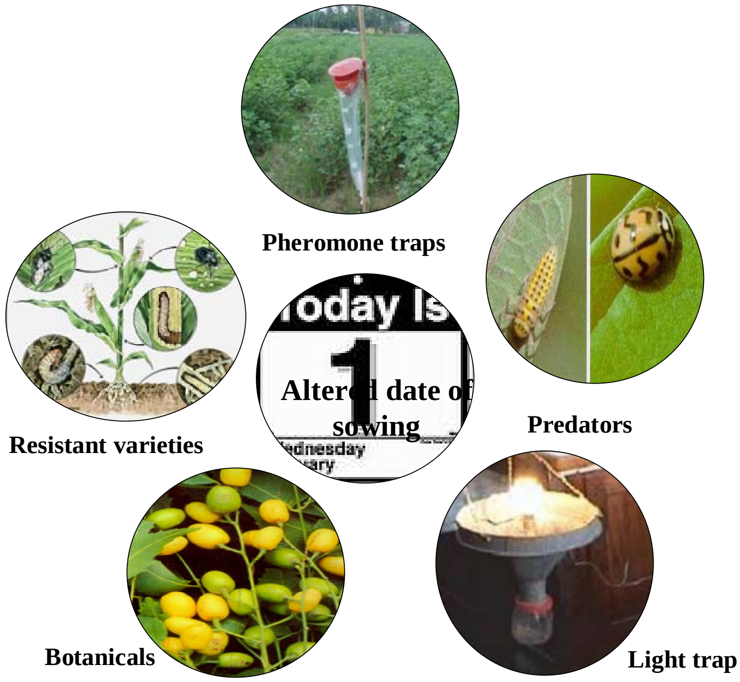
Modern farming affects our world, by the way of land exhaustion, nitrate run off, soil erosion, soil compaction, loss of cultivated biodiversity, habitat destruction, contaminated food and destruction of traditional knowledge systems and traditions. Thus to overcome the ill effects of modern agriculture, can be delineated by adopting organic farming.

Concepts of Organic Farming



Principles of Organic Farming

Modules in Organic Pest and Disease Management



Organic farming methods combine scientific knowledge of ecology and modern technology with traditional farming practices based on naturally occurring biological processes. Organic farming methods are studied in the field of agroecology. While conventional agriculture uses synthetic pesticides and water-soluble synthetically purified fertilizers, organic farmers are restricted by regulations to using natural pesticides and fertilizers. The principal methods of organic farming include crop rotation, green manures and compost, biological pest control, and mechanical cultivation. These measures use the natural environment to enhance agricultural productivity: legumes are planted to fix nitrogen into the soil, natural insect predators are encouraged, crops are rotated to confuse pests and renew soil, and natural materials such as potassium bicarbonate and mulches are used to control disease and weeds. Organic farmers are careful in their selection of plant breeds, and organic researchers produce hardier plants through plant breeding rather than genetic engineering.

In intensive farming systems, organic agriculture decreases yield; the range depends on the intensity of external input used before conversion. In the green revolution areas (irrigated lands and well endowed water regions), conversion to organic agriculture usually leads to almost identical yields. In traditional rain fed agriculture (with low external inputs), organic agriculture has shown the potentials to increase yields. A number of studies have shown that under drought conditions, crops in organic agriculture systems produce significantly and sustainably higher yields than comparable conventional agricultural crops, often out-yielding conventional crops by 7 - 90 per cent. Others have shown that organic systems have less long-term yield variability.

Codex Alimentarius Commission, a joint body of FAO/WHO defines *"organic agriculture as holistic food production management systems, which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system".*

Global View

The popularity of organic farming is gradually increasing and now organic agriculture is practiced in almost all countries of the world, and its share of agricultural land and farms is growing. As per a recent report of International Federation of Organic Agriculture Movements (IFOAM) the total organically managed area is more than 24 million hectares world-wide. Organic farming is practiced in approximately 130 countries of the world and the area under organic management is continually growing. Although production of organic crops is increasing across the globe, sales are concentrated in the industrialized parts of the world.

In addition, the area of certified wild harvested plants is at least a further 10.7 million hectares, according to various certification bodies. The market for organic products is growing, not only in Europe and North America but also in many other countries. The global market for organic food has touched US$ 29 to 31 billions by 2005. The demand for organic food is steadily increasing both in developed and developing countries, with annual average growth rate of 20-25%.

Indian Status

Only 35% of India's total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 65% of arable land, which is mainly rain-fed, negligible amount of fertilizers are being used. Farmers in these areas often use organic manure as a source of nutrients that are readily available either in their own farm or in their locality. The north-eastern region of India provides considerable scope and opportunity for organic farming due to least utilization of chemical inputs. It is estimated that 18 million hectare of such land is available in the North-East, which can be exploited for organic production. With the sizable acreage under naturally organic/default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world organic market.

The report of the Task Force on Organic Farming appointed by the Government of India also observed that in vast areas of the country, where limited amount of chemicals are used; productivity, could be exploited as potential areas for organic agriculture. Arresting the decline of soil organic matter is the most potent weapon in fighting against unabated soil degradation and imperilled sustainability of agriculture in tropical regions of India, particularly those under the influence of arid, semiarid and sub-humid climate. Application of organic manure is the only option to improve the soil organic carbon for sustenance of soil quality and future agricultural productivity. Future of sustainable development of agriculture, next to water, depends on arresting fall in organic matter in soils.

Benefits of Organic Farming

Organic farming is beneficial for both the humans and the nature. Some of the known benefits of organic farming are:

- In organic farming, no fertilizers and pesticides are used, hence, no harmful synthetic chemicals released into the environment.
- Organic farming improves productivity of land by healing it with natural fertilizers.
- Organic farms provide support to the diverse ecosystem by producing safe and healthy environment for humans, plants, insects and animals as well.
- Organic farming is highly beneficial for soil health. Due to the practices such as crop rotations, inter-cropping, symbiotic associations, cover crops and minimum tillage, the soil erosion is decreased, which minimizes nutrient losses and boosts soil productivity. The beneficial living organisms used in organic farming also help to improve the soil health.
- It helps to promote sustainability by establishing an ecological balance. If organic farming techniques are used for long time, the farms tend to conserve energy and protect the environment by maintaining ecological harmony.
- When calculated either per unit area or per unit of yield, organic farms use less energy and produce less waste.
- Organic farming reduces groundwater pollution as no synthetic fertilizers and pesticides are used in this method.
- Organic farming also helps to reduce the greenhouse effect and global warming because it has the ability to impound carbon in the soil.

- In organic farming method, same crop is not located in the farm, which encourages the build-up of diseases and pests that plague that particular crop.

The central activity of organic farming relies on **fertilization, pest and disease control.** Organic farming relies heavily on the natural breakdown of organic matter, using techniques like green manure and composting, to replace nutrients taken from the soil by previous crops. This biological process, driven by microorganisms such as mycorrhiza, allows the natural production of nutrients in the soil throughout the growing season, and has been referred to as *feeding the soil to feed the plant.*

Organic farming tends to tolerate some pest populations while taking a longer-term approach. Organic pest and disease control involves the cumulative effect of many techniques, including:

- allowing for an acceptable level of pest and disease damage;
- encouraging predatory beneficial insects to control pests;
- encouraging beneficial microorganisms and insects; this by serving them nursery plants and/or an alternative habitat, usually in a form of a shelterbelt, hedgerow, or beetle bank
- careful crop selection, choosing disease-resistant varieties
- planting companion crops that discourage or divert pests;
- using row covers to protect crops during pest migration periods;
- using pest regulating plants and biologic pesticides, fungicides and herbicides
- using no-till farming, and no-till farming techniques as false seedbeds
- rotating crops to different locations from year to year to interrupt pest/disease reproduction cycles
- Using insect traps to monitor and control insect populations that cause damage as well as transmit diseases.

Each of these techniques also provides other benefits viz., Soil protection and improvement, fertilization, pollination, water conservation, season extension, etc.and these benefits are both complementary and cumulative in overall effect on farm health. Effective organic pest and disease control requires a thorough understanding of pest life cycles and interactions.

Crop protection in organic agriculture is not a simple matter. It depends on a thorough knowledge of the crops grown and their likely pests, pathogens and weeds. Successful organic crop protection strategies also rely on an understanding of the effects which local climate, topography, soils and all aspects of the production system are likely to have on crop performance and the possible host/pest complexes. Organic agriculture is rapidly expanding and includes novel, edible, fibre and processing crops, diversified rotations and large scale stockless farming companies alongside traditional mixed organic farms. Many of the established strategies that have been developed to prevent and control weeds, pests and diseases in traditional organic systems have limited application in the more novel systems. Research is therefore urgently required to optimize these strategies for use in novel organic systems and necessary to develop new crop protection technologies, where pest, disease or weed problems are limiting expansion of the industry.

Pests/diseases are generally not a significant problem in organic systems, since healthy plants living in good soil with balanced nutrition are better able to resist pest/disease attack. However, major pest/disease damage is sometimes seen in organic crops, which are very susceptible to damage. Pest/disease problems can be particularly severe in large holdings, where several hectares of a single crop species may be grown. Pest/disease control strategies in organic farming systems are mainly preventative rather than curative. The balance and management of cropped and uncropped areas, crop species and variety choice and the temporal and spatial pattern of the crop rotations used all aim to maintain a diverse population of beneficial organisms including competitors, parasites and predators of pests. Damaging populations of pests and pathogens are less likely to establish in soils that sustain high levels of beneficial organisms. Break crop choice and rotation design can have a major impact on the incidence and severity of certain types of pest problems. The less mobile pests or those which have a specific or narrow host range are particularly susceptible to crop rotation. Highly mobile, often non-specific pests such as aphids are less affected, or unaffected by rotation design. Reactive treatments for pest outbreaks, including natural pesticides, are permitted under regulations for specific situations in organic systems, but cultural pest prevention techniques including the use of break crops within balanced rotations will remain the most important means for pest control in organic systems.

Managing Pests and Diseases

Managing the ecosystem on an organic farm is very challenging. It is made even more complex when factoring in insect and disease pests. Since the use of synthetic pesticides are prohibited, the organic cropping system should be focused on the *prevention* of pest outbreaks rather than coping with them after they occur. No single method is likely to be adequate for all pests. Successful pest management depends on the incorporation of a number of control strategies. Some strategies will target insect and disease separately and others will target them together.

Pests in a crop do not automatically result in damage or yield loss. In some instances, low levels of pest feeding have been shown to increase crop yields. Once infestation levels reach a certain point, however, they can produce economic losses. Thresholds vary with the crop and the pest in question and must be closely monitored by the producer.

Planning for effective insect and disease management must involve the entire farm operation and use all information available. Any strategy in organic farming should include methods for:

- insect and disease avoidance
- managing the growth environment
- direct treatment

i. Avoidance Techniques

To manage pests and diseases effectively, producers need to understand the biology and growth habits of both pest and crop. The type and concentration of pests are often responses to previous crop history, pest life cycles, soil conditions and local weather patterns.

Crop Rotations

Crop rotation is central to all sustainable farming systems. It is an extremely effective way to minimize most pest problems while maintaining and enhancing soil structure and fertility.

Diversity is the key to a successful crop rotation program. It involves:

- rotating early-seeded, late-seeded and fall-seeded crops
- rotating between various crop types, such as annual, winter annual, perennial, grass and broadleaf crops; each of these plant groups has specific rooting habits, competitive abilities, nutrient and moisture requirements. (True diversity does not include different species within the same family - for example, wheat, oats and barley are all species of annual cereals.)
- incorporating green manure crops, into the soil to suppress pests, disrupt their life cycles and to provide the additional benefits of fixing nitrogen and improving soil properties
- managing the frequency with which a crop is grown within a rotation
- maintaining the rotation's diversified habitat, which provides parasites and predators of pests with alternative sources of food, shelter and breeding sites
- planting similar crop species as far apart as possible. Insects such as wheat midge and Colorado potato beetle, for example, are drawn to particular host crops and may overwinter in or near the previous host crops. With large distances to move to get to the successive crop, the insects' arrival may be delayed. The number that find the crop may be reduced as well.

Diverse rotations are particularly effective in regulating flea beetles, cabbage butterfly, wheat midge, wheat stem maggot and wheat stem sawfly.

Rotations are also effective in controlling soil- and stubble-borne diseases. The success of rotations in preventing disease depends on many factors, including the ability of a pathogen to survive without its host and the pathogen's host range. Those with a wide range of hosts will be controlled less successfully. For example, sclerotinia stem-rot is a common disease in conventionally grown canola on the Prairies, but it can also infect at least a halfdozen other field crops. Rotations will not have much effect on pathogens that live indefinitely in the soil, but will shorten the life span of pathogens that can survive only brief periods apart from their hosts. Other situations that limit the benefit of crop rotations include: the transmission of pathogens via seed, the presence of susceptible weeds and volunteer crops that harbour pathogens, and the invasion of pathogens by wind and other means.

Rotations should be used with other cultural practices to achieve the greatest benefit.

Field Sanitation / Crop Residue Management

Reducing or removing crop residues and alternate host sites can be used to control some insects and many diseases. Incorporating the residue into the soil hastens the destruction of disease pathogens by beneficial fungi and bacteria. Burying diseased plant material in this manner also reduces the movement of spores by wind.

Insects most affected by tillage will be those that overwinter in crop residue (for example, European corn borer and wheat stem sawfly) and those that lay their eggs in the residue. Conversely, fields where residue has not been disturbed may have higher levels of some beneficial predaceous insects, which may reduce levels of insect pests such as root maggots in canola. Reduced or zero-tillage may also reduce the damage by certain pests, as the crop residue creates a micro-climate less preferred by some insects (for example, flea beetles).

It is important to maintain a balance between crop sanitation and soil conservation. Lighter soils and those prone to wind and water erosion may require postponing tillage until just before seeding to ensure stubble cover for as long as possible.

Alternate host sites, such as field margins, fence lines, pastures, shelterbelts and riparian areas, will usually contain weeds and natural vegetation that may serve as reservoirs for disease, vectors of disease and insect pests. Left uncontrolled, these insect and disease pests can be transmitted to healthy crop plants. Insects may use these plants as alternate habitat until an appropriate crop occurs in a nearby field. However, these areas may also host many beneficial insects and predators, therefore the grower must carefully assess the potential threat from pest insects in these areas before mowing or removing any plants. The ecological importance of areas such as sloughs, wooded bluffs, road allowances, railroad rights-of-way, abandoned farmyards and schoolyards must also be included in long-range planning.

Seed Quality

The use of high-quality seed is especially important in preventing disease. The seed supply should be free of smut, ergot bodies or other sclerotia, and free of kernels showing symptoms of Fusarium head blight infection.

Seed analysis by a reputable seed testing laboratory will help determine specific diseases in the seed supply.

Relatively few diseases are exclusively seed-borne, and it is more common for pathogens to be transmitted from soil, stubble, or wind, as well as with the seed.

Planting physically sound seed is also important. In crops such as flax, rye and pulses, a crack in the seed coat may serve as an entry point for soil-borne micro-organisms that rot the seed once it is planted.

Weed Management

Although weeds need to be controlled to reduce their impact on crop yield and quality, a field completely free of weeds is not necessarily the best objective. In many cases, weeds provide food and shelter for beneficial insects. Parasitic wasps, for example, are attracted to certain weeds with small flowers. Field experience has shown that the number of predators attacking insects increases and the number of aphids and leafhoppers decreases on certain crops as the diversity of weeds (that act as host plants) increases. Research has shown that outbreaks of certain crop insect pests are more likely in weed-free fields.

Insects that are generalist feeders, such as beet webworm, thistle caterpillars and grasshoppers, may prefer to feed on weeds rather than some crops, only damaging the crop after the weeds are eaten.

Each field situation should be considered separately, as weed competition must always be taken into account. Sometimes mowing weeds at the edge of the field results in beneficial organisms moving into the crop where they are needed.

Forecasting

Producers should pay attention to the forecasts for various pest and disease infestations for each crop year. Maps of these forecasts are usually available for many of the major destructive insects such as grasshoppers and wheat midge, as well as some diseases. Agro meteorological warning and forecast can help in this way.

Record-Keeping

Keeping diligent field records can provide very useful information. A complete history of each field should include any insect or disease infestations, which management methods worked and which did not, and a list of management techniques to try in the future.

ii. Managing the Growth Environment - Giving the Crop a Head Start

Any crop management technique that contributes to a vigorous, competitive crop is a tool of insect and disease management. Producers must also be mindful that many practices that work well in conventional systems may not benefit organic systems. Certain crop species, crop varieties and equipment may work well in one system but not in the other.

Healthy Soil

Maintaining favorable soil conditions is the first line of defense against pests. A biologically active soil with good drainage supports vigorous crop growth, allowing a higher level of crop competition with weeds.

Adequate, balanced soil nutrition is essential for crop quality, yield and moisture-use efficiency. The application of nutrients should be based on a sound soil testing program, accompanied by plant tissue analysis when diagnosing problems. High levels of nitrogen can occur after a high-nitrogen plowdown, such as sweet clover. This results in lush leaf tissue and a dense plant canopy that provides an ideal environment for plant pathogens. However, a lush crop may also help disperse the damage by a given number of insects, so astute observations by the producer are necessary at all times.

In contrast, inadequate soil phosphorous can pre-dispose to certain root diseases. Low levels of nitrogen can reduce the incidence of insect outbreaks. A shortage of micronutrients such as zinc or copper can result in disease-like symptoms on crops, while too much of any one micronutrient may be toxic.

The addition of composted livestock manure improves soil quality, including increasing the population of soil micro-organisms that compete with soil-borne plant pathogens.

Field experience has also shown that plants fertilized by the slow release of nutrients from compost are more resistant to insects and diseases than crops fertilized by highly soluble nutrients. Soil testing becomes important when applying compost regularly. An imbalance of nutrients can easily occur if the soil's nutrient profile is not continuously monitored.

Crop and Variety Selection

Producer awareness of insects and diseases in the proximity of the farm is very important and should influence the crop and the variety of crop to be grown. These choices must also fit in with the crop rotation plan that has been developed. Some insect pests are specific to certain crops, such as wheat stem sawfly, while others, such as grasshoppers, will attack numerous crops. The situation is similar with diseases.

The selection of insect- and disease-resistant cultivars can be a useful tool, but under no circumstances can genetically modified varieties be used in organic systems. Wheat varieties with solid stems are more resistant to wheat stem sawfly than hollow-stemmed varieties. Wheat varieties with resistance to wheat midge have been developed and should soon be available. These insect-resistant varieties were developed through conventional plant breeding programs. Certain species may avoid diseases such as Fusarium head blight, but often agronomic factors, such as time of seeding or choosing winter versus spring wheat, have more of an influence on the incidence of disease.

Plants also vary in their degree of attractiveness to insects, diseases and vectors transmitting disease. Factors such as leaf and stem toughness, pubescence, nutrient content, plant architecture, growth habit and differences in maturity between crops and varieties can influence pest growth, reproduction and host preference. For example, earlier-maturing crop varieties may be less attractive to migrating populations of grasshoppers late in the season compared to later-maturing varieties.

Intercropping

The practice of intercropping (where two crops are grown at the same time) can reduce pest problems by making it more difficult for the pests to find a host crop. This technique also provides habitat for beneficial organisms. Strip-cropping row crops with perennial legumes often leads to better pest control. In particular, alfalfa attracts many beneficial organisms that can destroy insect pests in neighbouring crops.

Seeding Date

Planting should be scheduled so that the most susceptible time of plant growth does not correspond to the peak in pest cycles. Early seeding reduces crop damage caused by grasshoppers, aphids in cereal crops, wheat midge in spring wheat, barley yellow dwarf virus in barley and wheat, powdery mildew in peas and pasmo in flax.

Delayed seeding can be effective in avoiding wireworms and cutworms in cereal crops, Hessian fly in winter wheat, barley thrips, Ascochyta in lentils and wheat streak mosaic virus in winter wheat. However, experience on the Prairies has generally shown that delaying seeding too long can reduce a crop's potential yield.

Seeding Rate

Using a higher seeding rate to affect insect or disease infestations may have different results. More plants in a field may reduce the impact of a given aphid population on individual plants, but they may create a more favourable habitat for insects that prefer a dense canopy, such as true armyworm. A dense leaf canopy can also create a moist soil surface and elevated humidity within the crop, conditions favourable to certain leaf disease pathogens.

Reducing the seeding rate may decrease the severity of take-all in spring wheat, but the reduced canopy may also allow weeds to invade. In other crops, reduced seeding may also produce more insect damage, as in the case of aphids, flea beetles and leafhoppers, which are attracted to the contrast between a green host and a dark soil background.

Depth and Timing of Seeding

Optimum seeding depth is also important. Deep seeding in cold soils may result in seedling blights and damping-off, especially in pulses and small-seeded crops. Seeding depth should generally be no deeper than required for quick germination and even emergence. Variables include seed size, soil type and moisture conditions. If the soil is loose before seeding, a packing operation will firm up the soil and bring moisture closer to the surface.

For most crops, seeding should ideally be done when the soil is warm enough for rapid germination. Seeds that remain ungerminated in cool soil are more susceptible to damage by insects such as wireworms.

Trap Strips

Seeding trap strips around the edge of a cropped field or along a fence row helps lure insect pests to a specific area where they can be managed more easily. For example, planting bromegrass near a wheat field attracts wheat stem sawflies and their native parasites away from the wheat crop. Similarly, a trap strip of potatoes planted much earlier than the main crop would attract Colorado potato beetles to the area. The strip could be worked under along with the adult beetles, eggs and larvae before the second generation of beetles spreads to the main crop.

Generally, the insect pests in the trap strips are controlled by mowing or cultivating the strip, or by applying an acceptable organic product, such as *Bacillus thuringiensis*. Trap strips can also act as a barrier to protect the crop field. Producers have found that planting yellow sweet clover or Sirius field peas repels grasshoppers and prevents them from damaging crops. A thorough knowledge of the crop and insect pests of the area is necessary to prevent this technique from backfiring.

Tillage

Tillage can be properly timed before seeding, after harvesting and during summerfallow to reduce populations of insect pests such as cutworms and grasshoppers that spend part of their life cycles in the soil or stubble. Tillage can help starve insects in the spring or during fallow, prevent adults from laying eggs in the soil and expose overwintering insects to predators and inclement weather.

Roguing

Roguing refers to the labour-intensive practice of walking the fields to remove diseased or insect-infested plants. Roguing may not be practical for large fields, but could be suitable for seed plots or crops having highly infectious and destructive diseases (for example, bacterial blackleg in potatoes and certain viruses in other crops).

iii. Direct Treatment

At times, the organic producer will find that, despite all the best efforts, an insect or disease pest will grow to levels that cause substantial crop damage. At this point, direct treatment may be necessary.

Monitoring

Insect monitoring traps are useful in determining which insect pests are present in a field and whether they are at economically important levels. It is imperative that the producer has a positive identification of the insect or disease causing damage before choosing a method of treatment.

Certain types of insect hormones called pheromones may be used as attractants to monitor population levels of insects such as bertha armyworm, diamondback moth, cabbage looper and European corn borer, or to simply attract insects into a trap.

Biological Control

In a healthy, balanced ecosystem, biological control by natural predators is constantly occurring. The more diverse a cropping system becomes, the greater the spectrum of insect species and micro-organisms within it. This leads to the development of more natural predators within the ecosystem.

Ladybugs, ambush bugs, hoverfly larvae, lacewings, spiders, birds, frogs, toads and a host of other insects are predators of aphids, bertha armyworm larvae, sunflower beetles, beet webworms, and both grasshopper eggs and adults. The destructive wheat midge may also be partially controlled by a parasitic wasp, but crop damage may still occur.

Various types of fungi are insect parasites and can either kill their insect hosts or reduce their ability to reproduce. Very few biological controls are available to reduce the effects of plant diseases, as most commercial products do not perform well if the disease is already established in the crop. Mycoparasitism is a form of bio-control where one fungus parasitizes another. Although this process occurs with many fungi under laboratory conditions, it hasn't been successful under field conditions.

Natural Insecticides

Organic certification standards prohibit the use of synthetic pesticides. Permitted disease-management products include copper (fixed copper and copper sulphate), lime-sulphur mixes, elemental sulphur, vinegar, soap and silica. Bordeaux mixture is considered a restricted substance, and farmers should contact their certifying body before using it. Although these products are allowed, it may not be cost-effective or feasible to apply them to field crops. Scientific evidence on product efficacy should be researched before using them.

The high risk of phytotoxicity should also be considered when using these products on certain plants; often the margin of error between benefit and damage to the plant is very small. In addition, there are environmental and ecological concerns surrounding some of these products. Additional soil tests may be required to monitor copper and sulphur levels in the soil. As well, organic certification may be denied to farms that overuse or depend on such products.

Insecticides permitted in organic agriculture include some microbial insecticides containing the bacteria *Bacillus thuringiensis*. Three main strains of these bacteria are used in insect control. One strain, marketed as Dipel or Thuricide, kills only the larvae of moths or butterflies. Another strain, marketed as Novodor, is for beetle larvae only and can be used to control Colorado potato beetles. The third strain is specifically for mosquito and fly larvae.

Botanical insecticides, such as rotenone, are also permitted in organic agriculture, but they are often too expensive to use on large acreages.

Other Control Methods

For pest control, beneficial organisms, dormant oil, diatomaceous earth, plant-derived pesticides, soap, natural and synthetic insect pheromones which disrupt the insect's development, and commercial insect vacuums can be used.

Grain Storage

When stored grain is dry and its temperature is low, problems seldom arise. But if the grain is warm and moist, insects and fungi can multiply rapidly. A grain temperature of 5°C to 10°C is adequate for long-term storage. Bin aeration helps dry and cool the grain. If bins are not equipped with aeration systems, grain can be moved to cool it. Cold temperatures can be used to control insects that exist in stored grain.

Before storing new grain, the bin should be thoroughly cleaned with a grain vacuum. The empty bin can be treated with diatomaceous earth to control stored-grain insects. Many organic producers have found it to be effective when applied as a light coating on the floor of the bin, and around the walls and the bin door. It can also be added to the grain as it is being brought into storage.

Natural products for Pest Control

- Using various naturally occurring substances and products

Eg. Neem, pongamia, NPV, Trichograma, Trichoderma etc

Community Management

- Pest incidence depends not only on the crop a farmer grows and practices he/she follows but also on the neighboring cropping pattern and the practices adopted.

List of inputs permitted for crop protection

S. No.	Input	Permitted / Restricted
1.	Mechanical traps, Neem oil and other preparations, Propalis, Pheromones in traps, plant based repellants, Silicates, Soft soap	Permitted
2.	Copper salts, Chloride of lime/soda, light mineral oils, permanganate of potash, Sulphur, Viral, fungal and bacterial preparations, release of parasite and predators of insect pests	Restricted

All-round Herbal Pesticide

Herbal extracts should be used only as a final remedy only after utilizing & practicing all the above said methods. One should try to use only the locally available weeds or those that are grown as life fence for making herbal extracts. If enough materials are not available in and around the garden, then materials can be collected from other areas. To be self sufficient it is better to develop the herbal plant resources by raising them as hedges along the fence, in the waste areas like slopes, gullies, & rocky patches and along the path.

Basic important procedures to be followed while preparing the herbal extracts are:

- Macerate and grind the plant material to a pulp state. This is mainly to expose the cells and facilitate the extraction of the active principle with the help of water.
- Soak the pulped material in at least 70-80% of the final volume of spray solution.
- Since the water has a limited dissolving capacity, with low volume the extraction will not be full.
- Soak the pulped material only for 3-5 days. If it is allowed to ferment for more number of days the active principles from the herbs that are needed to kill the insects will disintegrate into simpler harmless component.
- After 3 - 5 days of fermentation, the whole solution should be filtered and the final spray volume should be made by adding the balance water.

- The filtered final solution has to be sprayed in such a way that the whole plant is fully drenched at least one or two times in a year.
- To avoid soaking for 3-4 days, soak it at least overnight and then heat it to bearable warmth (60-70°C) for an hour by stirring. After this dilute it to the required final volume of spray solution, filter, allow cooling and spraying.
- Use at least 2-3 different materials at a time to prepare the herbal extract.
- Change the combination of the materials every time.
- Use 2-3% of herbal extract (combination of 2-3 different materials) while the pest attack is at early stage. Increase the dosage to 5-6% if the attack is very severe.
- The first two sprays in a season should by a blanket spray, on observing the attack.

Commonly available plants that can be used for making herbal extracts are as follows

S. No.	Common Name	Botanical Name	Useful Plant Parts
1.	Neem	*Azadirachta indica*	Neem Cake
2.	Pungam	*Pongamia glabra* *Pongamia pinnata*	Leaf & flower
3.	Notchi	*Vitex nugunda*	Leaf & flower
4.	Nithia Kalyani	*Catharanus rosea*	Whole plant
5.	Unni	*Lantana camera*	Leaf & flower
6.	Devils Trumpet	*Datura metal*	Leaf, fruit, flower
7.	Yellow Nelliam	*Nerium thevetifolia*	Flower, fruit, root
8.	Aruku	*Calatropis gigantea*	Leaf, tender stem, flower
9.	Siria Nangai	*Andrographis paniculata*	Whole plant
10.	Parthenium	*Parthenium sp*	Plant before flowering
11.	Adathoda	*Adathoda vasica*	Leaf
12.	Tobacco	*Nicotiana tobaccum*	Dried leaf, plant waste, stem waste
13.	Chevanthi	*Crysanthemum cinerrifolia*	Flower
14.	Thumbai	*Lucus aspera*	Flower, leaf, tender stem
15.	Tobacco Plant (weed)	*Lobilia sp*	Whole plant
16.	Ginger	*Zingiber officinale*	Rhizome

17.	Etti	*Strychnos nuvomica*	Seeds
18.	Turmeric	*Curcuma longa*	Rhizome
19.	Artemesia	*Artemesia vulgaris*	Tender shoots & leaves

Companion planting to repel fungal disease

- Amorphophallus plants between rows of arecanut trees have anti-fungal qualities.

General purpose insecticide

- Crush the nuts of the casaraka tree (Nuxvomica) and add to coconut milk.
- The combination becomes lethal and appropriate concentrations can be sprayed on different insect pests.

To treat paddy leaf curl

- Steep one kilo of agave leaves in 10 litres of boiling water in a copper container and allow to stand for 24 hours.
- Spray the extract on the crop.

To tackle Rhinoceros beetle in coconut plantation:

- Arrange two to three tubelights in various spots in the plantation so that the beetles are drawn to the light instead of to the coconut trees during the night!
- However, in the long run this could be harmful since many predators are also attracted to the light!
- Neem oil is mixed with honey in equal proportions and sprayed on the apical part of the tree.

Liquid extracts for disease management

Disease	Type of compost
Late blight of potato ,tomato	Horse compost extract
Gray mold on beans strawberries	Cattle compost extract
Downy and powdery mildew of grapes	Animal manure-straw compost extract
Powdery mildew on cucumbers	Animal manure-straw compost extract
Gray mold on tomato, pepper	Cattle and chicken manure compost extract
Apple scab	Spent mushroom compost extract

Biological agents to control pests of different crops

S. No.	Biological Agents	Pest	Crop
1.	*Trichogramma brassiliensis* - 1.0 cc/ac. once in 10 days, (Egg parasitoid)	Lepidopteran, Heliothis sp	Cotton, Tomato
2.	*Trichogramma chilonis* - 2 cc/ac once in 15 days	Borers	Sugarcane, paddy, pulses, Vegetables
3.	Nuclear Polyhedrosis Virus (NPV) 100-200 LE/ac	Spodoptera sp & Heliothis sp	Vegetables
4.	Chrysoperla Sp 5000 - 10000 eggs /ha, 3 - 4 times in 15 days, (Green lace wing)	Prudenia, Caterpillars, White flies, thrips, aphids	Vegetables
5.	*Beauveria bassiana* - 1.0% Affects the young stage,	Helicoperva, spodoptera, borers, hairy caterpillars, mites, scales, etc	Vegetables, cereals, fruits
6.	*Metarhizium anisopliae* - 0.5 - 1.0 % affects all stages	White grubs, Beetle grubs, caterpillars, Semiloopers, mealy bugs, BPH	Sugarcane, groundnut, rice, potato, cotton, cereals
7.	*Verticillium lecanii* - 0.5 - 1.0 %, affects all stages	All sucking soft bodies insects	Sugarcane, groundnut, rice, potato, cotton, cereals
8.	Phascilomycetes	Nematodes	All crops
9.	*Bacillus thuringiensis* var *kustaki* 0.3 - 0.4 %	Helicoperva, spodoptera, borers, hairy caterpillars, mites, scales, etc	Vegetables, cereals, fruits
10.	NPV - Nuclear Polyhedrosis Virus of Spodotera litura 250 - 500 ml/ ha 2 - 3 time at 10 days interval	*Spodotera litura*	Cotton, groundnut, pulses, cabbage, chillies
11.	NPV - Nuclear Polyhedrosis	*Helicoverpa*	Cotton,

	Virus of Helicoverpa armigera 250 500 ml/ ha, 2 - 3 time at 10 days interval	*armigera*	groundnut, pulses, cabbage, chillies

Biopesticides and IPM products for various crops

Crop	Pest/Diseases	Biopesticides
Cotton	Bollworms	Traps, lures, BT, NPV, Trichogramma
	Whitefly, jassids, thrips	Neem 1500 ppm
	Mites	Chrysoperla, verticillium, Baeuveria
	Wilts and leaf spots	Trichoderma, Pseudomonas
Rice	Yellow stem borer, leaf folder	Traps, lures, BT, Trichogramma
	Hoppers	Neem 1500 ppm, Baeuveria
	Sheath blight and leaf spots	
Pulses	Bollworms or cutworms	Traps, lures, BT, NPV, Trichogramma
	Wilts	Trichoderma, Pseudomonas
Tomato, capsicum	Heliothis	Traps, lures, BT, NPV, Trichogramma
	Mites	Trichoderma, Pseudomonas
Brinjal, okra	Fruit borer	Traps, lures, BT, NPV, Trichogramma
	Mites	Neem 1500 ppm, verticillium

Pest/Disease Management Packages for Different Crops

Integrated Pest Management package for Organic Rice Ecosystem

Rice is essentially a crop of warm, humid environments conducive to the survival and Proliferation of insects. More than 70 species were recorded as pests of rice and about 20 have major significance. Together, they infest all parts of the plant at all growth stages. The insects act as vectors of virus diseases, and are a major factor responsible for low rice yields particularly in Tropical Asia, the world's rice bowl. The insect problem is accentuated in multi cropping or dormancy but occurs throughout the year in over lapping generations. The yield losses vary from 20 to 50 per cent due to the damage caused by various insect Pests.

Mechanical control methods

- Collection and destruction of rice stubbles from field after harvest as they harbour egg, larvae, pupae of stem borer, gall midge, white tip nematode and root knot nematodes.
- Clipping the tips of the seedlings up to 2 inches prior to transplanting to remove the egg masses of stem borer if any.

- Collection of egg masses of stem borer and silver shoots from the nursery seedlings.
- Flooding the nursery to make the hiding larvae in the soil to come to the surface and thus they are picked by the birds (army worm)
- A rope may be passed over the young crop for dislodging the larval cases from the tillers and then the water should be drained for eliminating them (case worm).
- Providing bird perches of 2-3 ft height in vegetative stage @ 15-20 / acre. They should be removed after seed setting to avoid the bird damage to seeds. Drinking pots with water should be provided around the perches.
- Collection and destruction of egg masses of stem borer and ear head bugs in main field.
- A thorny hedge may be passed over the crop when it is affected by leaf folder to unfold the leaf folds and to expose the larvae within to natural enemies and botanical sprays.

Cultural control methods

- Avoid close planting especially in BPH and leaf folder prone areas or seasons.
- For every 5-6 m leave a spacing of 75 cm (hoppers).
- Grow horse gram, green gram, soy bean on bunds to attract natural enemies.
- Controlled irrigation by intermittent draining (BPH).
- Remove the weeds on bunds that harbour BPH, gall midge, GLH, leaf folder, ear head bug.

Biological control methods

- The crop should be observed from 20 DAT and when stem borer eggs are observed on leaf tips and leaf folder eggs on veins, release *Trichogramma chilonis* (for leaf folder) and *T. japonicum* (for stem borer) thrice @ 1,00,000/ha each and spray *Bacillus thuringiensis* @ 1.0 kg/ha when the stem borer / leaf folder crosses ETL.
- Release *Platygaster oryzae* parasitized galls @ 1 per 10 m^2 on 10 days after transplanting (DAT) (gall midge).

Botanical control methods

- Spray neem seed kernel extract, neem oil, pungam oil (5%) on need base at 15 days interval. Teepol or soap solution should be mixed at 2 ml / litre (general).
- Apply *Acorus calamus* killikulam dust @ 10 kg / ac (ear head bug).

Behavioural control methods

- Install pheromone traps @ 8 / acre (stem borer and leaf folder)
- Installation of light traps with incandescent light at 1-2 m height @ 4 / acre to monitor the population (stem borer, leaf folder, BPH, gall midge and ear head bugs). At the base of light trap put a tub filled with water to which kerosene was added to kill the trapped insects.

Rat management

- Collection and destruction of weeds and maintenance of field sanitation.
- Reduce the width of bunds and close the rat burrows.
- Use different types of rat traps alternatively to trap the rats.

Insects of different stages in rice

Vegetative Phase

Crop stage	Possible pests
Seedling	Rice whorl maggot; Thrip; Defoliator; Stem borer; Green leaf hopper; Plant hopper
Tillering	Thirp; Defoliator, Stemborer; Green leaf hopper; plant hopper
Minor pests (vegetative phase)	Aphids, caseworm, black bugs, grasshoppers, mealy bugs

Reproductive stage

Crop stage	Possible pests
Stem elongation	Defoliator; Stem borer; Greenleaf hopper; Plant hopper
Panicle initiation to booting	Stem borer; Green leaf hopper; Plant hopper
Heading	Plant hopper
Flowering	Plant hopper; Thrips
Minor pests (reproductive phase)	Greenhorned caterpillars, skippers
Mature grain stage	Plant hopper; Rice bug
Dough grain stage	
Mature grain	
Minor pests (reproductive phase)	Panicle mite

Diseases in rice

Disease	Important Stages	Symptoms	Important Season	Factors favoring infection
Blast	All growth stages	Leaf lesions- Grey Centers large in the middle tapering to ends Also attacks nodes on stem Panicle attack (neck rot) can be confused with stem border damage	Mostly wet cloudy skies Frequent rain and drizzle	High N levels, High relative humidity
Sheath Blight	Tillering	Leaf sheath - Grayish green lesions between the water and the leaf blade	Periodic	High temperature and humidity High levels of N
Bacterial Leaf Blight	Tillering to heading	Leaf lesions run along the length of the leaf	Wet	High temperature and humidity
Sheath Rot	Boot leaf	Small water soaked lesions on leaves	Periodic	High temperature and humidity
Brown Spot	Flowering to maturity	Brown round to oval spots on leaves	Periodic	25-30 degrees centigrade temp & High humidity
False smut	Flowering and maturity	Ovaries transformed to large green masses	Periodic	Rainfall accompanied by cloudy days
Tungro virus	Flowering and maturity	Stunting of the plant & yellow to orange laves	Periodic	Usage of more N and more vector activity

Economic Threshold Levels (ETLs) of Major Pests of Rice

Insect Pest	Economic Threshold Level
Stem borer	10% dead hearts or 2 egg masses / m^2 2% white ears
Gall midge	10% silver shoots
Green leafhopper	60/25 net sweeps or 5/hill at vegetative stage or 10/hill at flowering or 2/hill in tungro endemic area
Brown plant hopper	2 / tiller when 1 spider / hill is present 1 / tiller when spiders are not present
Whorl maggot	25% damaged leaves
Case worm	10% damaged leaves
Leaf folder	10 % leaf damage in vegetative phase 5% at flowering
Ear head bug	5 bugs/100 ear heads at flowering and 16 bugs/100 ear heads from milky stage to grain maturity
Thrips	60 numbers in 12 passes or rolling of the first and second leaves in 10% of seedlings.

Biocontrol module for pest and disease management

Pest	Biocontrol	Rate of application
Yellow stem borer	*Trichogramma japonicum* BT	2.00 lakh eggs/ha 0.75 kg/ha
Leaf folder	*Trichogramma japonicum*	2.00 lakh eggs/ha
Hoppers	Neem	1500 ppm
Sheath blight	Trichoderma	Seed treatment @ 4-5 g/kg seed
Leaf spot	Pseudomonas	Seed treatment @ 4-5 g/kg seed
Brown spot	*Trichogramma japonicum*	2.00 lakh eggs/ha
Neck blast	Nimbecidene + *Trichogramma japonicum*	500 g /acre + 2.00 lakh eggs/ha

Integrated Pest/Disease Management Package for Pulses

(Green gram and Black gram)

Pulses are a part of the average diet. Yet, pulse production has remained in the range of 14 million tonnes. Pulses are a crop of the marginal lands, requiring less water and replenishing soil nutrients. Pulses are less concentrated crops. To increase the productivity proper plant protection measures to control insect pests is essential.

Mechanical control methods

- Remove and destroy stem fly damaged seedlings

- Pull out plants manifesting symptoms of sterility mosaic, yellow mosaic, leaf curl and leaf crinkle virus disease since they will serve as a source of inoculum spread by sucking pests
- Collect eggs, larvae, pupae and adults of the insects to the extent possible to reduce their population (leaf feeding caterpillars, beetles, weevils, grasshoppers etc.)
- Burn the crop residues after harvest.

Cultural control methods

- Sow good and healthy seeds
- In stem fly endemic areas use a higher seed rate to the extent of 25 - 30% to compensate the loss of seedlings
- Maintain the fields and bunds free from weeds
- Avoid crops susceptible to some pests either as mixed crops or in crop rotation
- Provide T shaped bird perches
- Grow castor along the borders to trap *S.litura,* marigold to trap *H.armigera* and cowpea to trap stem fly.
- The plant density should not exceed 30 - 35 / sq.m. If it exceeds it creates favourable microclimate suitable for the multiplication of pests and diseases.

Botanical control methods

- Spray NSKE (5%) or neem oil (3%) alternatively (aphid, mite, whitefly)

Biological control methods

- Spray specific NPV suspensions of *H. armigera* and *S. litura* in the evening hours

Behavioural control methods

- Set up sex pheromone traps to attract and kill male moths of *Helicoverpa armigera* and *Spodoptera litura.* Set up five traps per acre from floral bud formation and change the septa once in 3 weeks
- Use of light trap to monitor and kill the attracted adult moths of tobacco cut worm.

Economic Threshold Levels of Major Pests of Pulses

Pest	ETL
Aphid	20/2.5 cm shoot length
Pod borer	10% of affected pod
Spotted pod borer	3/plant

Stem fly	10% of affected plants
Tobacco cut worm	8 egg masses/100 m

Some of the diseases of pulses are Sterility mosaic disease, Alternaria leaf spot, Sterility mosaic disease, Macrophomina blight, Yellow mosaic virus, Bacterial blight, Cercospora leaf spot, Fusarium wilt, Phytophthora stem blight, Ascochyta blight, Powdery mildew. These can be controlled by using disease free seeds and following proper agro techniques.

Integrated Pest/Disease Management Package for Organic Cotton Ecosystem

Cotton, the most important fibre crop of India plays a dominant role in its agrarian and industrial economy. It is the backbone of our textile industry, accounting for 70% of total fibre consumption in textile sector, and 38% of the country's export, fetching over Rs. 42,000 crores. Area under cotton cultivation in India (8.9 million ha) is the highest in the world, i.e., 25% of the world area and employs seven million people for their living.

Cotton productivity in India is quite low as compared to world standards. The modern cotton production technology relies heavily on the use of fertilizers and on chemicals to control insect pests, diseases, weeds and growth regulators. Cotton cultivated on 5% cultivable land consumes 54% of total pesticides used in Indian agriculture, and in some pockets, the rates are higher than this, leaving immense ecological and human hazards as reported by World Health Organization. Use of chemicals at such scale causes a lot of hazards to man, i.e., environmental pollution, soil health, and agro-ecology and poor profitability in cotton farming. This has basically prompted the demand of organically cultivated, eco-friendly or ‘green’ cotton.

Mechanical control methods

- Removal and destruction of crop residues after harvest to avoid the carry over population of American boll worm to next season.
- Removal of terminals of cotton crop (topping) at 80-90 days of growth to reduce *Helicoverpa* oviposition and also to encourage sympodial branching which bears more fruiting bodies.
- Removal and destruction of alternate weed hosts of white fly like *Abutilon indicum*, *Chrozophore rottlari*, *Solanum nigrum* and *Hibiscus ficulensus* from the fields and neighbouring areas and maintaining field sanitation.
- Collection and destruction of leaves infested with white fly
- Hand picking and burning of the pink boll worm affected and dropped squares, flowers and fruits and squashing the pink boll worms in the rosettes.

- Removal and destruction of egg masses, early stage larvae found in clusters and hand picking and destruction of grown up caterpillars to minimize heavy build up of future population of tobacco cut worm.
- Uprooting and destroying the weeds like *Sida* sp., *Abutilon indicum* and *Xanthium* sp. before sowing of cotton crop to reduce the initial build up of boll worm, whitefly and cotton leaf curl virus (CLCV).
- Rouge the plants infested with CLCV regularly.

Cultural control methods

- Growing one variety throughout the area as far as possible.
- Deep summer ploughing on bright sunny days during the months of May or June should be done to expose soil inhabiting or resting stages of insects, pathogens and nematode population. The field should be kept exposed to sunlight for at least 2-3 weeks.
- Growing of less preferred crops like green gram, black gram, soybean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation.
- Growing two rows of maize or sorghum or cowpea along the border to sustain and enhance the build up of natural enemies such as lady bird beetles, staphylinids, *Chrysoperla carnea,* Anthocorids, Reduviids etc. Pollen of maize helps in retaining *Chrysoperla* in main cotton field.
- Plant trap crops like marigold or okra or pigeon pea along the border and irrigation bunds to divert American boll worm oviposition from main cotton crop.
- Growing castor along the border and irrigation bunds as trap crop for tobacco cut worm, okra for spotted boll worm and aphid.
- Use neem cake @ 1 t / ha under assured moisture conditions in nematode infested fields.
- Earthing up on 45th day (stem weevil).
- Basal application of FYM 25 t/ha and 250 kg/ha of neem cake (stem weevil).
- Install 15-20 bird perches per acre for the benefit of predatory birds like black drango, king crow, orange myna etc. after 90 days of crop growth. Provide drinking pots with water to them by placing them around the perches.

Biological control methods

- Application of *Helicoverpa armigera* or *Spodoptera litura* nuclear polyhedrosis virus (NPV) @ 250-500 LE / ha (1 LE = 6x10^9 POBs) (1

LE / litre of water) depending upon the crop growth with jaggery and teepol in evening hours at 7th and 12th week after sowing.

- ULV spray of NPV at 3 x 10 ^{12} POB /ha with 10% cotton seed kernel extract, 10% crude sugar, 0.1% each of Tinopal and Teepol for effective control of *H.armigera*.
- Inundative release of egg parasitoid, *Trichogramma* spp., at 6.25 cc/ha at 15 days interval 3 times from 45 DAS (American boll worm)
- Inundative release of egg-larval parasitoid, *Chelonus blackburnii* and predator, *Chrysoperla carnea* at 100000 / ha at 6th, 13th and 14th weeks after sowing (American boll worm)
- Seed treatment with *Trichoderma* spp. @ 4g / kg of seed for seed borne diseases

Botanical control methods

- Spray NSKE 5% or neem oil (5 ml/l) or fish oil resin soap 25 kg / ha @ 1 kg in 40 l of water or 5 % notchi leaf extract or 5% *Catharanthus rosea* extract (whitefly)
- Spray NSKE 5% or neem oil formulation 0.5% or neem oil 3% thrice at fortnightly intervals (sucking pests)
- Spray NSKE 5% as a strong oviposition deterrent (American boll worm)
- Spray fish oil resin soap 25 kg / ha @1 kg in 40 l of water (mealy bug)

Behavioural control methods

- Use pheromone traps for monitoring American boll worm, pink boll worm, spotted boll worm and tobacco cut worm. Install pheromone traps at a distance of 50 m @ 5 traps per acre for each insect pest. Use specific lures for each insect species and change it after every 15-20 days. Trapped moths should be removed daily. If the number of trapped adult moths is 10 (American boll worm), 20 (tobacco cut worm), 15 (spotted boll worm) and 8 (pink boll worm) necessary action should be taken.
- Installing light traps with incandescent lamp (1-2 / acre) for monitoring of insect activity (American boll worm and tobacco cut worm). The crop around the light trap may be sprayed with neem oil.
- Monitoring the activities of the adult white flies by setting up yellow pan traps and sticky traps at 1 foot height above the plant canopy. Locally available empty yellow palmoline tins coated with grease / Vaseline / castor oil on outer surface may also be used.

- Paint yellow colour on plastic drinking water pot, apply castor oil on it and move it on both sides with hand by walking in the field to attract and trap whiteflies.

Note: 1. Use only incandescent light in light traps, as mercury lamp attracts natural enemies in large numbers.

2. The light trap should be lighted between 8 - 10 pm.

Economic Threshold Levels (ETLs) of Major Pests of Cotton

Insect Pest	Economic Threshold Level
American boll worm	One egg or one larva /plant
Spotted boll worm	10% infested shoots / squares / bolls
Spiny boll worm	10% infested shoots / squares / bolls
Pink boll worm	10% infested fruiting parts
Tobacco cut worm	8 egg masses/100 m row
Leafhopper	50 nymphs or adults/50 leaves
Whitefly	5-10 nymphs and adults / leaf
Aphid	15% of infested plant
Thrips	50 nymphs or adults/50 leaves
Stem weevil	10% infestation
Mite	10 mites/cm^2 leaf area

Cotton Mealy bug - Recent Threat to cotton cultivation

Eco-friendly way

- Raise cowpea as a bund/border crop to encourage the activities of Natural enemies
- Monitor the crop regularly at least once in a week.
- Look for the ant activity / shiny leaves / yellowing , presence of sooty mould (advanced stages)
- Look for the predatory coccinellids, *Chrysoperla* and encourage their activities and avoid using synthetic insecticides when the natural enemy activities are more.
- Microbial Bioagents like *Beauveria* and *Verticillium* are found to be effective but takes some time to control the nymphs and adults, but this method is ecofriendly and sustainable.
- Crawlers (Early stage mealybug nymphs) can be controlled by spraying neem oil 2% or fish oil rosin soap 25g/l of water (to get effective control, thorough coverage is essential).

Diseases of Cotton and their management

Disease and cause	Control measures
Seedling disease *Rhizoctonia, Fusarium and Pythium spp*	Plant only high quality seed. Plant in warm, well-drained soil. Avoid crop stress due to a lack of fertilizer, excess water or excess herbicides. Plant on raised beds
Boll rots	Prolonged periods of high humidity or water on the boll surface are necessary for infection. Rank growth promotes boll rot. Avoid practices that result in a rank dense canopy.
Bacterial diseases *Xanthomonas campestris pv. malvacearum*	Most varieties have some resistance. Crop rotation will control this problem.
Leaf spot *Alternaria macrospora* *Cercospora gossypina* *Ascochyta gossypii*	These leaf spot diseases are of minor importance and specific controls are not recommended. They appear more frequently on stressed plants.
Fusarium wilt *Fusarium oxysporum f. sp. vasinfectum*	Most varieties are somewhat resistant. Maintain soil pH at 6.0 to 6.5, and use sufficient nutrients for plant growth.

Integrated Pest/Disease Management Package for Organic Vegetable Ecosystem

Vegetables being a rich and cheap source of vitamins and minerals, occupy an important place in the food basket of Indian consumers. The country is producing about 98 million tonnes (MT) of vegetables from an area of around 6.07 million ha. Not withstanding the advantages of vegetables, farmers confront a number of problems particularly of insect pests, diseases, nematodes and mites which limit their production. Among the vegetable crops okra, brinjal, tomato, cabbage and cauliflower are important and together occupy an area of 1.65 m ha with an annual production of 22.17 MT and they are infested by several pests at various stages resulting in a yield loss of about 25-30%. Pest management is thus important with a view to reduce undesired use of pesticides.

Integrated Pest/Disease Management package for Organic Tomato Ecosystem

Mechanical control methods

- Collection and destruction of damaged fruits, early instar and grownup caterpillars of *Helicoverpa armigera* and *Spodoptera litura.*

- Collection and destruction of virus affected plants.

Cultural control methods

- Grow simultaneously 45 days old American tall marigold and 25 days old tomato seedlings @ 1:16 rows so that both will come to flowering at the same time and *Helicoverpa armigera* adults will be attracted to marigold for oviposition.
- Grow 50 castor plants / acre as a trap crop for tobacco cut worm and the egg masses and early instar larvae in clusters on castor crop should be periodically collected and destroyed.
- Remove alternate weed host of whitefly, *Abutilon indicum.*
- Apply press mud @ 5 kg/m^2 for nematode disease complex.
- Installation of T shaped bird perches @ 15-20 / ha.
- Deep summer ploughing (tobacco cut worm and nematode).
- Flood irrigation to bring out the hiding larvae (tobacco cut worm).
- Grow sorghum or bajra as border crop (sucking pests and viral diseases transmitted by them)
- Ploughing the nursery area, uniformly spreading paddy husk @ 20 kg / m^2 (about 15 cm thickness) burning it and ploughing back facilitates production of nematode free seedlings.
- In nursery apply 200 g of neem cake / sq m (nematode).
- Crop rotation with marigold, gingelly, mustard, maize, wheat etc. (nematode).

Biological control methods

- Spray *Bacillus thuringiensis @* 2g/l. (*H. armigera* and *S. litura).*
- Release *Trichogramma chilonis* @ 50000/ha/ week (up to 6 weeks) coinciding with flowering time and based on ETL (*H. armigera* and *S. litura).*
- Application of NPV: For *H. armigera: H.a.*NPV 250 LE / acre
- For *S. litura*: *S.l.* NPV 250LE / acre along with 1 kg jaggery and 100 ml teepol at 10 days interval.
- Treat the seeds with antagonistic fungi, *Trichoderma viride* @ 4 g/kg seed (nematode)

Botanical control methods

- Spray Neem Seed Kernel Extract 50 g/l (serpentine leaf miner).
- Spray fish oil rosin soap 25 g/l. Add wetting agent (whitefly).

Behavioural control methods

- Set up pheromone traps @ 12/ha (*H. armigera* and *S. litura*). When the trapped moths are 8 / day necessary action may be taken.
- Install yellow sticky traps to attract the adult whiteflies.

Major Insect Pests of Tomatoes

Name	Damage	Control
Aphid	Sucks sap; Vectors disease; Creates honeydew which attracts sooty mold; Misshapen foliage, flowers, and fruit	Insecticidal soap; Beneficial insects (ladybugs, lacewings, etc.); *Beauvaria bassiana*; Pyrethrum; Rotenone
Armyworm	Feeds on foliage and fruit	Beneficial insects; Bt on larvae; Superior oil
Blister beetle	Feeds on foliage and fruit	Larvae are beneficial. For severe infestations, use pyrethrum, rotenone, or sabadilla
Colorado potato beetle	Feeds on foliage	Bt on larvae; Encourage beneficials; Neem; Pyrethrum; Rotenone
Cutworm	Cuts plant stem	Apply parasitic nematodes to soil; Wood ashes around stem; Moist bran mixed with Bt scattered on soil
Flea beetle	Many small holes in foliage	Row covers; Sanitation; Apply parasitic nematodes to soil; Neem; Pyrethrum; Rotenone; Sabadilla
Fruitworm	Feeds on foliage, flower, fruit	Destroy infested fruit; Bt; Row covers; Neem; Ryania
Hornworm	Feeds on foliage and fruit	Bt; Pyrethrum if severe
Pinworm	Fruit has narrow black tunnels	Destroy infested fruit; Till at season end to prevent over wintering
Stink bug	Deformed fruit with	Control weeds near

	whitish-yellow spots	plants; Trap crops; Planting late-maturing varieties; Attract beneficials by planting small-flowered plants; Sabadilla
Whitefly	Distorted, yellow leaves; Honeydew which attracts sooty mold	Insecticidal soap; Yellow sticky traps; Beneficial insects; Garlic oil; Pyrethrum; Rotenone; *Beauveria bassiana*

Tomato Diseases and their management

Tomato diseases are rarely fatal, if the proper management is employed. It is important to catch any tomato disease early, before it spreads to all of tomato plants and possibly other plants in the same family, such as potatoes, eggplants and peppers. Here are some common tomato diseases and their management.

Early Blight: Early Blight fungus overwinters in plant residue and is soil-borne. It can also come in on transplants. Remove affected plants and thoroughly clean fall garden debris. Wet weather and stressed plants increase likelihood of attack. Copper sprays can prevent further development of the fungus.

Gray Leaf Spot: Gray Leaf Spot affects only the leaves of tomatoes, starting with the oldest leaves. Warm, moist conditions worsen gray leaf spot problems. Remove all affected plants and fall garden debris. Selection of resistant varieties prevents the disease infection.

Late Blight: Late blight affects both the leaves and fruit of tomatoes. Late Blight is the disease responsible for the Irish Potato Famine. The Late Blight fungus can overwinter in frost free areas. Cool, wet weather encourages the development of the fungus.

Septoria Leaf Spot: Septoria Leaf Spot is sometimes mistaken for Late Blight. With septoria leaf spot, the papery patches on the leaves develop tiny, dark specks inside them. Older leaves are affected first. Copper sprays are somewhat affective at halting the spread of symptoms.

Verticillium Wilt: This name can be misleading, as sometimes the leaves will turn yellow, dry up and never appear to wilt. Verticillium wilt is caused by a soil-borne fungus and it can affect many different vegetables. The fungus can persist in the soil for many years, so crop rotation and selection of resistant varieties is crucial. Remove affected plants and choose resistant varieties.

Integrated Pest/Disease Management Package for Organic Brinjal Ecosystem

Mechanical control methods

- Collection and destruction of the beetles, grubs and pupae of Epilachna beetle.
- Removal and destruction of dried and withered shoots of shoot and fruit borer to arrest the spread of the pest.
- Remove the affected fruits and destroy (shoot and fruit borer).
- Remove the little leaf affected plants.
- Collection and destruction of aphid infested twigs.
- Removal and destruction of webbed leaves (leaf webber).

Cultural control methods

- Application of press mud at 5 kg/m^2 at the time of sowing.
- Application of 200 kg neem cake / acre as basal (shoot and fruit borer, nematode and ash weevil).
- Maintain the correct spacing (shoot and fruit borer).
- In nursery apply 200 g of neem cake / sq m (nematode).
- Crop rotation with marigold, gingelly, mustard, maize, wheat etc. (nematode).
- Deep summer ploughing (nematode).
- Transplant healthy seedlings.
- Avoid rationing of brinjal crop since woody stem is preferred by stem borer larvae.

Botanical control methods

- Spray neem oil 3% plus teepol (1 ml/l) or spray neem seed kernel extract 5 % (whitefly, Epilachna beetle, aphid).
- Spray neem seed kernel extract 5 % or neem oil 3% starting from one month after planting at 15 days interval (shoot and fruit borer).
- Pour 4% NSKE to soak the severely affected plant’s root system by making 2-3 inch holes (ash weevil).
- **Biological control methods**
- Seed treatment with antagonistic fungi *viz. Trichoderma harzianum* or *T. viride @* 4 g/kg seed (nematode).
- Apply *Pseudomonas fluorescens@* 10 g / m^2 for nematodes.

- Release 1st instar larvae of green lace wing, *Chrysoperla carnea* @ 10,000 per ha (aphid).

Behavioural control methods

- Monitor the whitefly with yellow sticky trap @ 12/ha.
- Installation of pheromone traps (shoot and fruit borer).

Diseases of Brinjal and their management

Alternaria Leaf Spot: *Alternaria melongenae, A. solani*

Bacterial Wilt: *Pseudomonas solanacearum*

Cercospora Leaf Spot: *Cercospora solani -melongenae, C. solani*

Collar Rot: *Sclerotium rolfsii*

Management

- Pant samrat variety is tolerant.
- Crop rotation with cruciferous vegetables such as cauliflower help in reducing the disease incidence.
- Fields should be kept clean and effected parts are to be collected and burnt.
- The diseases are more prevalent in the presence of root knot Nematodes, so control of these nematodes will suppress the disease spread.
- Seed treatment with 4 g of *Trichoderma viride* formulation per kg seed will help in reducing the diseases.
- Collection and destruction of diseased parts and portions of the plant.
- Spray Copper fungicides to control the diseases

Integrated Pest/Disease Management Package for Organic Bhendi Ecosystem

Mechanical control methods

- Collection and destruction of damaged buds and flowers and distorted fruits (fruit borer).

Cultural control methods

- Application of neem cake 400 kg/ha at sowing (nematode).

Botanical control methods

- Spray Neem Seed Kernel Extract 5 % or neem oil (3%) (fruit borer, leafhopper, mites and whitefly).

Biological control methods

- Release of egg parasite, *Trichogramma @* 1.0 lakh/ha (fruit borer).
- Release of 1st instar larvae of green lace wing bug, *Chrysoperla carnea* @ 10,000/ha (fruit borer).
- Spray *Bacillus thuringiensis* 2 g/l (fruit borer).

Behavioural control methods

- Set up pheromone trap at 12/ha (fruit borer)
- Installation of yellow sticky traps to trap whitefly adults.

Diseases of bhendi and their management

Cercospora Leaf Spots: *Cercospora malayensis C. abelmoschi*

Fusarium Wilt Of Okra: *Fusarium vasinfectum*

Powdery Mildew: *Erysiphe cichoracearum* and

Vein-Clearing/Yellow Vein Mosaic

Management

- Once the disease becomes destructive, it is advisable to find clean fields even if such a plan involves renting additional land.
- A better plan is to use a 6-year rotation before the fungus is destructive; this permit many years of okra growing without too much loss.
- For sowing during the summer season, when the whitefly activity is high, the susceptible varieties should be avoided.
- By selecting varieties resistant to yellow vein mosaic like Parbhani Kranti, Arka Abhay, Arka Anamika, Co3, and Varsha Uphar, the incidence of the disease can be minimised.
- Even in these varieties, when a plant starts exhibiting symptom of the disease, it should be pulled out immediately and burnt by which the spread of the diseases can be prevented.

Integrated Pest/Disease Management Package for Organic Chilli Ecosystem

Mechanical control methods

- Collection and destruction of damaged fruits and grownup caterpillars (fruit borers).
- Collection and destruction of the dropped flowers and fruits (midge).
- Collection and destruction of virus affected plants.

Cultural control methods

- Raise 2 rows of maize or sorghum for every 5 rows of chilli crop against wind direction (chilli mosaic).
- Crop rotation with maize, soybean, green gram, black gram etc. (*H. armigera* and *S. litura*).
- Deep summer ploughing (*H. armigera, S. litura* and root worm).
- Raise 2-3 rows of maize or sorghum as border crop to prevent the attack of *H. armigera* and *S. litura* from surrounding fields and enhances the activity of lady bird beetle.
- Plant the trap crops for *H. armigera* (marigold) and *S. litura* (castor) @100 plants / acre and periodical destruction of egg masses and larvae found on trap crops.
- Provision of bird perches @ 15-20 / ha and also provide water pots around them.
- Application of well composted farm yard manure along with neem cake (root worm)
- Don't crop the chilli in the fields where tomato and brinjal were raised previously.
- Intercrop onion 1 line after 10-12 lines of chilli to enhance the natural enemy population especially, coccinellids and syrphids.

Botanical control methods

- Spray neem oil and NSKE (mite, thrips, fruit borers, whitefly).
- If the infestation is severe, spray the botanicals at weekly intervals.

Biological control methods

- Spray *Bacillus thuringiensis* at 2 g/l (fruit borers).
- Apply TNAU formulation of VAM (containing 1 spore/g to control root knot nematode in nursery).
- When *H. armigera* is in egg stage, release *Trichogramma* @ 60000 / acre two to three times.
- Spray *H.a* NPV and *S.l* NPV @ 200 LE / ha + 500 g jaggery + 100 ml teepol in evening hours.

Behavioural control methods

- Set up pheromone traps for *Helicoverpa armigera* and *Spodoptera litura* at 12 /ha.
- Installation of yellow sticky traps (whitefly).

Diseases of chillies and their management

Disease	Stage Important	Factors favouring infection	Management
Damping off	Seedling (nursery)	Moist soils poordrainage 90-100% R.H soil temperature 20°C	Partial sterilization of soil by burning trash in the surface helps in checking the disease Follow cultural practices such as thin planting (600 - 750g seed per cent) on raised seedbeds. Use of light textured soils provides better drainage and aeration. Use of well decomposed manure. Seed treatment with 4g *Trichoderma viride* formulation
Anthrac-nose /Die back /Fruit rot	Fruiting	Infected seed airborne wind - blown rains	Use disease free seed. Seed - borne infection is controlled by seed treatment
Frog eye leaf spot	Nursery	Prolonged period of wetness Seed and infected crop residues	Crop rotation Use of resistant varieties
Powdery mildew	Any stage of growth in main field	Warm climate both dry and humid More leaf shedding at low humidity	Crop rotation Use of resistant varieties
Fusarium wilt	Nursery & mainfield	High temperatures Wet soil conditions	Use of wilt resistant varieties
Bacterial leaf spot	Main field all stages of crop	Cloudy weather	The bacteria are seed - borne and the seeds can be treated with corrosive sublimate. It is also soil-borne and hence crop rotation is essential
Leaf curl	Main field all stage of crop	Virus generally transmitted by white-fly	Crop rotation Use of resistant varieties
Mosaic Viruses	Main field at all	Virus transmitted by insect vectors.	Crop rotation Use of resistant varieties

	stages of crop	(Sucking pest)	

Eco-Friendly Methods for Stored Grain/Seed Insect Management

Ever since the advent of stabilized Agriculture, storage of produce has remained an issue of utmost concern. Unless the problem of storage is solved satisfactorily the problem of hungry millions may continue even with substantial increase in production. There are a number of estimates of post harvest losses. Most conservative estimates for the post harvest losses in food grains in India even put at about 10%, a quantity good enough to feed at least 60 million people. Out of the total production, about 70% is retained and stored by farmers for consumption, as seed, feed and payment of wages and only about 30% is marketable surplus. Insects are responsible for enormous spoilage in storage they feed on grain, bore the kernel, and destroy the germ portion, cause heating and deterioration in stored produce. As per the Pause committee report, the storage losses due to insect pests of stored grain are 2.55%. In addition they are also responsible for the qualitative losses in food grains.

Sources of Infection

- Field infestation, insects fly from stores to fields and lay eggs upon the maturing grains.
- These eggs hatch out to larvae in favourable conditions when grains reach the stores. They can crawl/fly to fresh stocks and infest them is called cross infestation.
- It has been a general practices, specially with farmers, that they keep without cleaning the empty food grain bags for use in the next season only.
- Eggs and larvae of insects remain hidden and feed on the grain fragments in the off season. Whenever the grains are filled up in such bags, infestation reappears.
- The insects, which may be present in the joints or corners of the carriers, migrate to the food grain lots and cause infestation.
- The scientific storage of grains helps in minimizing the damage by insects, and microorganisms.
- The following methods can help in safe storage of grains.
- Preventive measures
- Curative measures

Preventive measures

- Cleaning the storage structures, sealing of cracks, crevices and holes present in the floors. Cleaning of the Sheller before their use.
- Storage structures/godowns/gunny bags should be disinfected with approved residual insecticides preferably with Malathion 50% EC, with dilution 1 : 100.
- Proper stacking of the filled bags for proper hygiene and sanitation prevents insect damage in the godowns.

Curative measures

The infestation of stored grain insect pests can be minimized by different methods

Physical control measures

- Heat treatment of stored grain at 55-60°C
- Mixing of inert dusts with grain makes entry of insects a difficult task. However here grain has to be washed before consumption.

Mechanical measures

- These measures are practicable and include sieving of grains.

Ecological measures

- Temperature, moisture content of grain and availability of oxygen have to be suitably manipulated by designing and constructing the storage structures which create unfavourable ecological conditions for insect attack.
- Food grains kept in airtight sealed structure remain insect free. Eg. Pusa bin.
- Grains with moisture content less than 10% are not suitable for multiplication and survival of most of the insects (except Khapra beetle which can survive but it is susceptible to reduced oxygen content)

Apart from this TNAU have developed various ecofriendly techniques for controlling stored products and are given below.

i. TNAU Insect Probe Trap

The use of trap is relatively a new method of detecting trapping insects in stored grains. The basic component of a TNAU probe trap consists of three important parts: A main tube, insect trapping tube and a detachable cone at the bottom. Equispaced perforations of 2 mm diameter are made in the main tube.

Concept

Insects love “AIR” and move towards air. This behaviour of the insect is exploited in this technology.

Method of working

The insect trap has to be kept in the grain like rice, wheat etc., vertically with the white plastic cone downside as shown the figure. The top red cap must be with the level of the grain. Insects will move towards air in the main tube and enter through the hole. Once the insect enters the hole it falls down into the detachable white cone at the bottom. Then there is no way to escape and the insects are trapped forever. The white detachable cone can be unscrewed once in a week and the insects can be destroyed.

Salient Features

No chemicals; No side effects and No maintenance cost.

Significance

- Commercialized during 2002. Around 1, 00,000 units have been sold so far across the country. The trap has been included for popularization under Canadian International Development Agency (CIDA) and Mc Gill University Project on "**Food Security in South India"** at TNAU, Coimbatore and UAS (University of Agricultural Sciences), Dharwad during 2003-2007.
- **CARE (Co-operative for Assistance and Belief Everywhere)** world's largest independent, non profit, nonsectarian, non government international relief and development organization with its internal secretariat at Brussels, Belgium is using the TNAU probe trap technology under integrated child development services in Madhya Pradesh.
- Won Best Creative product award from Chamber of Commerce, South India, 2002.

Recent achievements

- A good response from tribal regions of Adilabad district of Andhra Pradesh for the trap. Women are purchasing the trap and using them to control insects in rice / sorghum. They say that the traps are useful in reducing the drudgery of cleaning their grains through frequent sieving.
- Recently M/s. TATA Chemicals Ltd., Kolkatta has taken up marketing of TNAU probe trap, through TATA Kissan Sanchar in Gorakpur area of Uttar Pradesh after detailed field studies independently by them.

Efficiency

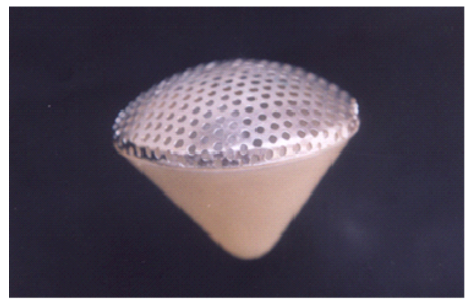
TNAU Insect traps are excellent insect detection devices in food grains and more effective in the detection of stored grain insects namely *Rhyzopertha dominica* (F.), *Sitophilus cryzae* (L.) and *Tribolium castaneum* (Herbst) in stored food grains both **in terms of detection** as well as **number of insects caught** than the standard normal sampling method (by spear sampling). The detection ratio (trap : normal sample) is higher in trap than of normal sampling method by factors ranging from 2 : 1 to 31:1. The insects catch is also higher in the probe trap than the normal sampling method by factors ranging from 20: 1 to 121: 1.

They are also good mass trapping devices when used at 2 - 3 numbers / 25 kg bin (28 cm dia and 39 cm length). They should be placed at top 6 inches of the grain, where the insect activity is seen during early period of storage. They can remove > 80% of the insects within 10 - 20 days.

ii. TNAU Pit Fall Trap

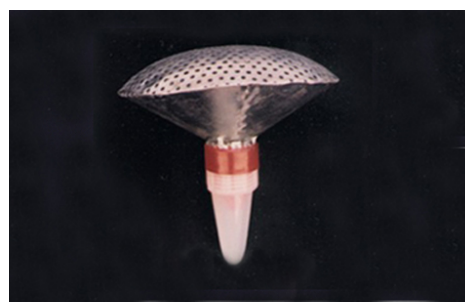
Pitfall traps are used for capturing insects active on grain surface and in other layers of grain (Monitoring and mass trapping tool).

Standard Model



- Standard model of pitfall trap has 2 parts, perforated lid (2 mm (or) 3 mm) and a cone shaped bottom portion.
- Application of special coating with sticky material on the inner side of cone to hold trapped insects is necessary
- This procedure is tedious.

TNAU Model



- TNAU model has perforated lid, cone shaped bottom which tapers into a funnel shaped trapping tube.
- Hence sticky coating is dispensed with
- Commercial model is in plastic, simple and economical.
- Easy to handle.

Significance

- Commercialized very recently and product launched on 18 September 2006 by TNAU and available in food grade plastic materials.
- Cost is only Rs.25/-
- Around 1000 units have been distributed to KVK's for popularization of the technology
- Because of easy handling and low cost, there is great scope of this model to spread fast across the country.
- No such cost effective and durable device is available so far in any part of the world. Twenty five Rupees investment will be worth to collect plenty of stored grain insects.

iii. TNAU Two-In-One Model Trap

The probe trap containing the components namely the perforated tube, pitfall mechanism, a collection tube and the cone shaped pitfall trap with a perforated lid and the bottom tapering cone were combined as a single unit. Combination of probe and pitfall increase the trapping efficiency of insects. Best suited for pulse beetles as they are seen only on grain surface wandering here and there. It does not require tedious procedures like coating the inner surface of pitfall cone with sticky materials before trapping to hold pulse beetles. Beetles are captured alive in this trap, which may facilitate release of pheromone and there by attract more insects.

Significance

- Commercialised and commercial launching was held on 30.12.2003.
- Around 100-200 used of farmers of Tamil Nadu and Karnataka units have been dispatched to UAS, Dharwad for popularisation
- This trap technology is one of the promising technologies commercialised under National Agricultural Technology Project funded by World Bank (Rainfed eco system)
- Spreading fast across the country.

iv. Indicator Device

It consists of a cone shaped perforated cup (3mm perforation) with a lid at the top. The cup is fixed at the bottom with a container and circular dish, which are to be smeared with sticky material like vaseline.

Farmers, before storing their pulses, should take 200 g of pulses to be stored and put them in the cup. When the field carried over beetles start emerging, due to their wandering behaviour, they enter the perforations and get slipped off and fall into the trapping portions. As they stick on to the sticky materials, farmers can easily locate the beetles and can take out the bulk-stored pulses for sun drying. The device with 2mm perforations can be used for cereals. This will help in eliminating the initial population, which acts as the major source for further build up. Thus, timely detection will help the farmers to preserve their valuable pulses during storage. The device is being popularised.

v. TNAU Automatic Insect Removal Bin

TNAU insect removal bin can remove insect automatically. The structure has 4 major parts namely outer container, inner perforated container, collection vessel and the lid. The model exploits wandering behaviour of stored product insects as well as the movement of these insects towards well aerated regions. The grains are held in the specially designed inner perforated container. The space between inner and outer container provides good aeration for the insects. Insects, while wandering, enter the perforation to reach the aerated part and while doing so, get slipped off and fall into the collection vessel through a pitfall mechanism provided in the collection vessel. In order to quickly collect the insects, as and when they emerge from grains, perforated (2 mm) rods are fixed in the inner container.

The container will be useful for storing rice, wheat, broken pulses, coriander etc. The insects such as rice weevil, lesser grain borer, red flour beetle, saw toothed beetle, which are commonly found attacking stored grains can be removed automatically by storing grains in this container. Within a very short period of 10 days a majority of the insects (more than 90 per cent) can be removed from the grains. The containers are available in 2 kg, 5 kg, 25 kg, 100 kg and 500 kg capacities.

Efficiency

Grains (paddy and sorghum) stored in Automatic insect removal bin (100 kg and 500 kg) recorded only 1 - 4% damage by insects compared to 33 to 65% damage in ordinary bin after 10 months of storage. The population of insects (*R. dominica, S. oryzae)* ranged from 0 - 2/kg in grain stored in 100 kg Automatic insect removal bin compared to 5 - 191 / kg in ordinary bin after 10 months of storage.

Significance

- The technology was popularised of the Avinashilingam deemed University through a project from Department Science and Technology, Government of India.

- Tamil Nadu State Council for Science and Technology sanction Rs. 10,000 during 1998 for popularisation of Gadgets to women folk.

- **Suitability for developing countries**

No granaries can be filled with grains **without insects** as the harvested produce contain, egg (or) larvae (or) pupae in them because of 'field carryover infestation' which cannot be avoided in developing countries like India (known scientific fact).

So the aim of stored product insect researcher should target on this field carryover population (which is generally < 1%) which emerge has adults 15 to 20 days after harvest in granaries.

In this field carryover population is not cared then the insect will multiply and contaminate the food grains and complete damage can even be expected within 4 months of storage.

Here comes the role of **automatic insect removal bin** which can remove substantial number of emerging adults and sometimes free living larvae also.

Significant achievements have happened in popularization of Automatic Insect Removal bin Technology.

vi. UV - Light Trap for Grain Storage Godowns

The UV light trap mainly consists of a ultra-violet source (4 W germicidal lamps). The lamp produces ultra-violet rays of peak emission around 250 nano meter. The light is fitted at the centre of a funnel of 310 mm diameter at the top and 35 mm diameter at the bottom. The bottom end of the funnel is attached with a transparent plastic container for collecting the trapped insects. To hang the unit at desired points, three hooks have been provided at the periphery of the funnel. The unit is also provided with a tripod stand.

The UV light trap can be placed in food grain storage godowns at 1.5 m above ground level, preferably in places around warehouse corners, as it has been observed that the insect tends to move towards these places during the evening hours. The trap can be operated during the night hours. The light trap attracts stored product insects of paddy like lesser grain borer, *Rhyzopertha dominica,* red flour beetle, *Tribolium castaneum* and saw toothed beetle, *Oryzaephilus surnamensis* in large numbers. Psocids which are of great nuisance in godowns are also attracted in large numbers. Normally 2 numbers of UV light trap per 60 x 20 m (L x B) godown with 5 m height is suggested.

The trap is ideal for use in godowns meant for long term storage of grains, whenever infested stocks arrive in godowns and during post fumigation periods to trap the resistant strains and left over insects to prevent build up of the pest populations. In godowns of frequent transactions the trap can be used for monitoring.

Efficiency

It has been found that two traps kept at the corners of the warehouse (60m x 20m x 5m) can catch around 200 insects/day even from a godown where normal sampling did not show any insect presence, thus indicating its effectiveness as a monitoring and mass trapping device. It has been recorded around 3000 *Rhyzopertha dominica* on a single day from single trap kept in a paddy godown.

Significance

National

- The Food Co-operation of India has entered into MOU with TNAU for popularisation of this trap. Already 25 officers of all has been trained on this line.
- M/s. Bannari Amman sugars Limited uses the UV light trap technology under the consultancy project with TNAU for management of stored grain insects in their godowns.

International

- M/s. Madaus Pharmaceuticals Pvt. Ltd Goa, (German Firm) has adopted the UV trap technology to detect/mass trap cigarette beetle infestation in their export produce, senna pods/seeds (*Casia augustifolia*).
- M/s. Saraf Trading Corporation Pvt. Ltd., Cochin which exports herbal tea to Europe uses the UV- light trap technology for detection/mass trapping of *Lasioderma serricorne*.
- In Ayurvedic and Siddha Medicine factories UV-light trap will be used for detection of insects in the plant product ingredients used for medicines.

vii. TNAU Stored Grain Insect Management Kit

Food grains are stored for varying periods to ensure proper and balanced public distribution throughout the year. Among the biotic and abiotic factors which affect grains / seeds in storage, insect plays a major role in the deterioration of grains / seeds causing both qualitative and quantitative losses. Often the presence of insects in store houses are felt only when they are hovering and flying around, by which time enormous loss and population build up of insects might have occurred. Hence, timely detection of the stored grain insects will help to prevent heavy losses.

TNAU is one of the pioneering institutes in India in the development of detection devices for stored grain insects. These devices exploit the wandering behaviour of the insects and help in timely detection of insects in stored produce leading to timely control. These include TNAU probe trap, TNAU pit fall trap, two in one model trap, indicator device, Automatic insect removal bin and UV-light trap technology. These devices have been widely used in many places and have received State and National recognitions.

Hence, the Department of Agricultural Entomology, Centre for Plant Protection Studies, TNAU, Coimbatore has developed a "KIT" named as **TNAU-Stored Grain Insect Pest Management Kit** containing prototypes of all the devices along with a CD-Rom about the devices and how to use them. This kit will be of great use in popularization of the technologies across the country. The kit will be an ideal "hands - on training" tool for Education, Extension centers (KVK, Plant clinic, save grain centers) and also for private ware housing. This TNAU kit is the first of its kind in the world.

Significance

- The kit has been commercially launched by TNAU through MOU with M/s. KSNM Marketing, Coimbatore.

- Good response from Agrl. Colleges, KVK's, PHT's Centers across the country. So far around one hundred units have been sold by the firm.
- For the benefit of the students and staff of Agricultural College and Home Science Colleges of our country the entire information on above kit is hosted the website under TNAU-Mc-Gill CIDA Project.

www.agrenv.mcgill.ca/agreng/india/files/pest%20trap

- ICAR - Agricultural Engineering Regional Center (ICAE) at Coimbatore has taken up TOT of this technology and spreading this technology through Income generation project.

viii. A Device to Remove Insect Eggs from Stored Pulse Seeds (Patent No. 198434)

Pulses are more difficult to store than cereals as these suffer a great damage during storage by pulse beetle *Callosobruchus* sp. The main source of infestation by pulse beetle is it's carry over damage from field to stores which is well known. The present invention is a prototype of a gadget which can successfully crush the eggs of pulse beetle, *Callosobruchus chinensis* and *Callosobruchus maculates* which attack stored pulses. The gadget has outer container and an inner perforated container with a rotating rod having fixed with plastic brushes on all sides. The seeds with eggs are to be stored in the perforated container and the rod has to rotated one full circumference clockwise and anti-clockwise for 10 minutes 3 times a day (morning, noon and afternoon). Due to the splashing action of the brush in rotating rod, the eggs get crushed and thus the damage is prevented. The treatment does not affect the germination of seeds.

Advantages of the invention

- The device is useful in removing the eggs without affecting the germination
- Once the eggs are removed there will not be further build up of population during storage of seeds.
- Removing the eggs laid by the beetles will have a significant impact in arresting the population builds up in storage.
- Farmers generally fear to store pulse seeds because of the pulse beetle damage during storage. The device of the present invention

can remove this fear from the farmers mind and thus motivate them "to have their own seeds".

- The patent has been recently commercialized.

ix. Trap for monitoring stored product insects in warehouse

(Patent Application No.1733/CHI/2008, dt.24.7.2008)

The invention disclosed in this application relates to a device for detecting stored grain insects in bagstacks which comprises a main hollow tube having a diameter in the range of 1.8 to 2.0 cm with equispaced perforation in the range of 1.8 to 2 mm on its upper portion with a bend at one end which ends in a transparent collection unit to collect the insects falling down from the bend, the other end of main tube being closed.

Advantages of the invention

- The device is useful in detecting stored grain insects in bag stacks of the food grain warehouses without any damage to sacks.
- The device does not require any bait materials to trap insects.
- The device is useful in studying the distribution pattern of stored product insects in various layers of bag stacks.
- The device will be useful to validate the effect of fumigation by using it immediately after fumigation, in different layers of the fumigated stacks.
- The device will also be useful at farm level when farmers store their produce in bags.

TNAU`s Contribution in Biological Control of Pest and Diseases

Tamil Nadu Agricultural University is a highly recognized organization making great inroads in the field of agrotechnology. Tamil Nadu Agricultural University's consistent efforts in contributing to this field involves the efforts of various agriculture and horticulture experts includes *Trichoderma viridi* and *Pseudomonas flouroscens*

Trichoderma viride

Advantages

- Environmentally Safe
- Economically Cheaper
- Easy to use
- No Residual Toxicity
- No Development of Resistance by Pathogens
- Incraesed multiplication in the soil
- Protect the crops
- Broad spectrum of action
- Enhances plant growth
- Compatible with other Bio fertilizers
- Not harmful to beneficial soil microbes

Recommended Crops

- Black Gram
- Green Gram
- Bengal Gram
- Red Gram
- Groundnut
- Sunflower
- Gingelly
- Cotton
- Chilli
- Tomato
- Turmeric

Dosage:

- 4g/Kg of Seed as dry Seed Treatment

- Soil Application: 2.5Kg/ha

Pseudomonas fluorescens

Features of ***Pseudomonas fluorescens***

- Cost Saving
- Improves the growth and Yield of the Crop
- Controls Seed born and Soil born fungal diseases
- Improves the disease resistance power of the crop
- Improves uptake of minerals
- Eco-Friendly
- Saves Earthworm and other Micro organisms in the soil

Recommended Crops:

- **Cereal Crops**
  - Paddy
  - Ragi
- **Oil Seeds**
  - Ground Nut
  - Gingelly
  - Sun Flower
- **Cotton**
- **Pulses**
- **Vegetable Crops:**
  - Tomato
  - Brinjal
  - Chillies
  - Bitter Gourds
  - Cabbage
  - Cauli Flower
- **Fruit Crops:**
  - Banana
  - Mango

Dosage

- *Pseudomonas fluorescens* @ 10g / kg to control seed born Pathogens
- Soil Application: 10 Kg/ha

Do's and Dont's in Organic Farming

Do's in Organic Agriculture

Climate

Appropriate to avoid pests and diseases

Soil Type

To match with the crop cultivated. Ex: Deep well drained soils.

Crops

With inbuilt disease, pest & other biotic resistance.

Acceptability for markets

Quality, yield potential

Adaptability to varying environmental conditions

Climate, soils, crops - Appropriateness and suitability are the key factors to be considered

Pesticides and organic agriculture

No processed chemical pesticide is approved for use.

Instead of chemical pesticide the following can be used

Botanicals

Neem based products

Pongamia based product

Any botanical with pesticidal property

Biocontrol or biological control agents such as

Bacillus thuringensis (BT) Natural enemies of pests can be used

Adopting natural biocontrol measures such as

Mixed cropping

Trap crops etc.

(Panchakavya, agnihotram,homeo medicines, vrikshayurveda are also projected as effective

No chemical pesticide is the major requirement for O.A.

Do not use Agrochemicals

Fertilizer

Agrochemicals such as pesticides, herbicides, fungicides, plant growth promoters (synthetic hormones) Antibiotics for crop production.

Do not use products like

Antibiotics, pest control chemicals, hormones, disinfectants, urea etc for Livestock production

Any processed input considered to be a potential environmental hazard is prohibited

Specific items banned in organic crop production

Sewage, sludge

Genetically engineered crops

Ionizing Radiation for food processing

Chemical preservatives

Land for organic agriculture should NOT have used prohibited products/ substances for minimum three years.

Banned items in the "Specifics" list should be checked with standards and certifying agencies as they change from time to time

Thus, organic way of pest and diseases management plays a significant role in organic farming. The knowledge intensive and farmer based management approach that encourages natural control of pest populations by anticipating pest and disease problems and preventing from reaching economically damage levels will definitely help achieving the target yield without causing serious damage on environment and contaminating the food.

For Your Thinking

World Food day

Bonn, Germany, October 16th 2007 - On this World Food Day 2007, with the theme of the Right to Food, which was recognized as a universal human right in 1948 in the Universal Declaration of Human Rights, over 850 million people around the world, particularly in least developed countries, suffer is the right of every person to have regular access to sufficient from hunger and malnutrition. For IFOAM, the Right to Food nutritionally adequate and culturally acceptable food for an active, healthy life. It is the right to feed oneself in dignity and to produce healthy and culturally appropriate food through ecologically, socially and economically sound methods, defining one's own food systems, rather than the right to be fed. This counts for each and every individual, as well as for communities and regions.

Soil - The Living Dynamic System

Soul Of Infinite Life

Upon this handful of soil our survival depends. Husband it and it will grow our food, fuel, our shelter and surround us with beauty

Abuse it and the soil will collapse and die taking man with it

"We need to make our farming practices and our food economy subject to standards set not by the industrial system but by the health of ecosystems and human communities"