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**Review of Integrated Pest Management of Alfalfa Hay Crop: A Successful Example at TADCO**

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**Abstract**

Alfalfa hay crop was grown at TADCO, mainly for dairy farms companies in Saudi Arabia on contract basis. This crop and due to the application of broad-spectrum contact insecticides lead to aphids' outbreak during spring and autumn and worms' outbreak during the summer month of each year leading to loss of hay quality and yield quantity. An Integrated Pest Management program was applied at TADCO in the period 2000 to 2010, and it succeeded to regulate the aphids and worms' insects' numbers on the alfalfa crop which resulted in a smaller number of sprays per season and lowered the cost of pest control over the years. This success was due to using selective insecticides which has little impact on the predators and parasites insects and allowed the company to produce high quality hay desired by the dairy farm companies and reduced the cost of production. Alfalfa was an ideal crop for applying integrated pest management program (IPM) as it is a perennial crop grown at each pivot for an average of two years, and this allowed the beneficial insects to stay on it and survive between the seasons feeding on insect pests.

**Keywords:** IPM; Predators; Parasites; Alfalfa Hay; Selective Insecticides

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**Introduction**

Alfalfa crop is considered globally an important crop and locally important in the Middle East countries, with water source in the form of current rivers or good quality ground-water sources, as the case in Egypt, Sudan, Saudi Arabia and some of the countries in the middle east [1,2]. Alfalfa was grown at TADCO, Saudi Arabia on contract basis with the dairy farm's

companies during the period 1990 to 2016 with an irrigated area of 2000 to 3500 Ha. /Year, see Figure 1. Alfalfa hay is used to feed livestock and horses, and it is also a proven crop for the reclamation of soil as it increases soil fertility and therefore is grown in new reclaimed lands because it is of medium salt tolerance to water and soil salinity. It fixes air nitrogen on the roots of the crop which increases soil fertility. It also provides farmers and agricultural companies with good income throughout the

growing season. Alfalfa was grown at TADCO after grain crops in the crop rotation for the purpose of combating cereal cyst nematode in

grain crops and to combat hard to control narrow leaf weeds in wheat crop such as rye grass and downy brome grass [3].



**Figure 1:** Alfalfa crop grown in center pivot at TADCO, Saudi Arabia.

The alfalfa crop is exposed to many pests, and the most important of which are aphids and worms, as well as the infection with leaf enation virus, which is transmitted by the cowpea aphid *Aphis cracovora*, in addition to competition from some broad leaf weeds and grasses such as fleabane, purslane, love grass and rashidi. This situation required the preparation of an integrated pest management program (IPM) to control pests on this crop. IPM is defined as the practical control of pest's populations using any or all methods of control in a sound environmental manner [4-8]. They were a combination of several methods of pest control, including natural, agricultural, biological and chemical methods to prevent the spread of economically important pests and to reduce their impact on the crop. It is an environmental approach to control insect pests. The aim of this research work was to review the successful integrated pest management program at TADCO during the period 2000 to 2010 which can be considered a guide solution to other agriculture projects in the Middle East countries.

## Materials and Methods

**The components of Integrated pest control program:** The components of IPM in this study were as follows [4,8]:

- Monitoring the number of insects pests periodically through fields inspection to investigate the presence of insect damages.
- Collect samples of infested plants to identify insects' pests and count them, as well as counting the numbers of beneficial insects.
- Use pheromone traps to detect the spread of moths and butterflies in the field or use yellow sticky tapes to detect soft body insects such as aphids and thrips.
- Assessing the potential damages on the plants if the pest numbers reached the economic threshold of damage, and then take the decision to control the pest or not taking into account the numbers of beneficial insects.
- Apply selective insecticides or use low toxicity insecticides to preserve the beneficial insects (predators and parasites) to prevent the insurgence of insect's pests in the event of damage to beneficial insects

when use contact insecticides with a broad range effect.

- Test the performance of new alfalfa varieties under IPM program with the dominant alfalfa variety CUF 101. The following is a description of how samples were collected from 50-hectare alfalfa pivots.

**Monitoring alfalfa pivots Infestations with aphids [8,9]:** 10 individual stems were taken for each sample and the samples were replicated from 4 to 6 locations in each alfalfa pivot. Sampling sites should cover tower's locations 1-7 moving in a zigzag manner until all 10 stems were collected. Each sample should be beaten inside plastic tray as one unit, then count them. Samples should be taken from each pivot at least once a week and more than once if possible. Before treating the pivot, check if the aphid insects in the tray were dead or alive using a hand lens. When the numbers of insects reach the threshold 40-50 aphids per stem, then the decision is taken to treat alfalfa pivot with effective insecticide as soon as possible. The threshold for cowpea aphid was 20 Aphids per stem.

**Monitoring alfalfa pivots infestations with worms [8,9]:** Worm pests should be sampled using a standard insect network with a diameter of 38 cm: Perform 10 swaps moving the network at an angle (180 degrees) in at least 4-5 locations in each pivot of alfalfa when the crop reaches 15-25 cm. Count the worms inside a white tray. Get the total number and divide it

by the number of swaps to get the average number of worms per swap. Repeat the procedure at four other locations. Calculate the mean number of worms in each survey. Note that worms that can be sampled using this method are small alfalfa leaf worm (armyworm), big alfalfa leaf worm and tomato fruit worm: *Spodoptera exigua*, *Spodoptera littorales* and *Helicoverpa armigera*. When the numbers reach the threshold of economic damage 10 larvae with a length of more than 1.25 cm per survey or 5 - 10 worms with a length of more than 1.25 cm per square meter after the balling (manual examination), the decision is taken to treat alfalfa pivot with effective insecticide as soon as possible.

## Results and Discussion

### Survey economically important pests of alfalfa: [8-10]

**Alfalfa Insect Pests:** Aphids: several species: Spotted alfalfa aphid (*Therioaphis maculata*), blue aphid (*Acyrtosiphon spp*), Cowpea aphid (*Aphis cracivora*), Army Worm (*Spodoptera exiguae*), Big alfalfa worm (*Spodoptera littorales*), Cut worm (*Agrotis ypsilon*), Tomato fruits worm, (*Helicoverpa armidgera*), Alfalfa caterpillar (*Colias croceus*), Measuring worms (*Syngrapha circumflexa*), Leaf roll worm (*Aproprocrema alfafella*), Leaf minor (*Agromyza spp*), Alfalfa leaves weevil: *Hypera postica*, Thrips (*Limothrips credalism*), see figure 2.



a. Blue Aphid



b. Cowpea Aphid



c. Spotted Aphid



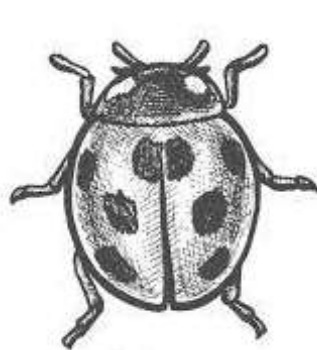
d. Army worm e. Big alfalfa worm Tom. F. worm g. Cut worm h. Leaf minor

**Figure 2:** Common pests of alfalfa hay crop: Aphids, worms, and leaf minor.

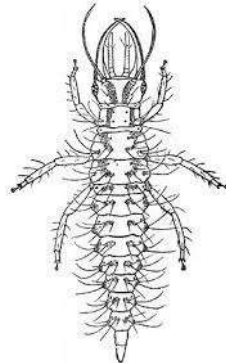
**Alfalfa diseases [11-13]:** Alfalfa enation virus, Alfalfa mosaic virus (calico), Witches broom, Downey mildew (*Perenospora trifoliorum*), winter leaf spots (*Pseudopeziza medicaginis*. Bacterial wilt disease, winter leaf-spot disease: *Pseudo peziza mediagenic*.

**Survey of beneficial insects (predators & parasites) [8,9,10,14].**

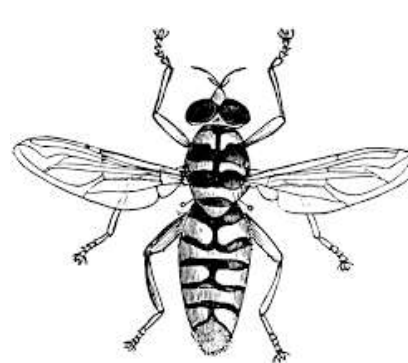
Predatory insects on aphids: Lady bird beetle with 11 points and: Lady bird beetle with 7 points, larvae of green lacewing, larvae of *Syrphid* fly, see figure 3.



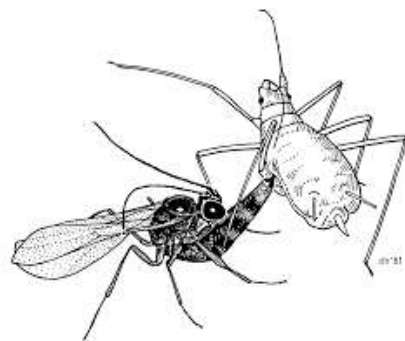
Lady Bird Beetle



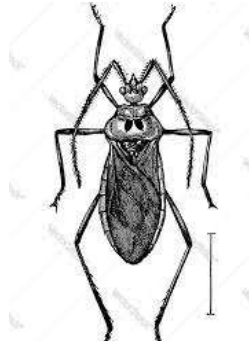
Green Lace wing larvae



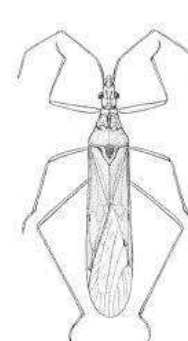
Syrphid fly



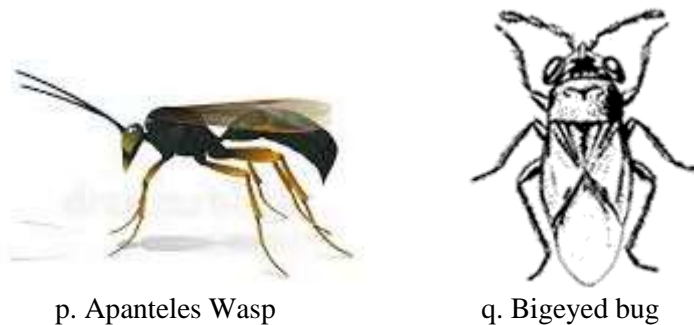
Aphidius wasp



Assassin Bug



Damsel bug



**Figure 3:** Beneficial insects (predators and parasites) found in alfalfa hay crop.

- Aphid parasites: *Aphidius wasp*, *Aphelinus wasp*.
- Predators of worms: Assassin bugs, damsel bugs, big-eyed bugs, green lacewing larvae, crab spiders.
- Parasites of worms: *Hyporsoter exigua larvae*, *Apanteles wasp*.
- Predators of alfalfa weevils: damsel bugs, big-eyed bugs, crab spiders

### Biology and Morphology of Alfalfa Insects Pests [8,10].

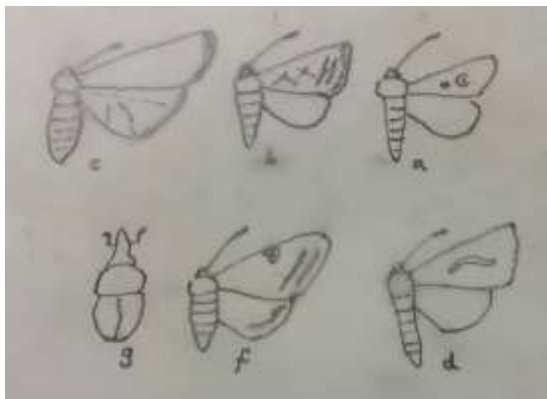
**Cowpea Aphid:** the color of nymphs is dark grey color and the color of adult insects is full bright black and the color of the legs whitish with its edges are black. The insect is present in the form of groupings on the tops of the plant, and needs to be fed on the infected plant for two hours to acquire the virus and incubation for more than 48 hours after which the insect becomes a vector of the disease for life. These insects transmit the disease of alfalfa enation virus biologically to healthy plants leading to the stunting of internodes and dwarfing of the plant and reduce the production, as the insect secretes the honey dew from the leaves sap which lead to the growth of black mold. The presence of honey dew leads to the appearance of the alfalfa as sticky which leads to harvesting difficulty of alfalfa. This aphid is active in spring and autumn.

**Spotted alfalfa aphid:** Aphid of small size, yellowish color with intermittent rows of dark spots on the top of the abdomen, this aphid is active in the summer leading to severe plants damages which inhibit the growth of the plant and may cause plant death, it reduces the yield and the nutritional value of hay. As the injury leads to the secretion of honey dew on the plants and growth of black mold, which reduces the ability of the animals to eat the hay.

**Blue aphid and peas aphid:** insects were of green color and similar to each other and can be distinguished from each other by the shape of the antenna where there are dark bands on the antenna of the pea's aphid while the antenna of the blue aphid is homogeneous with a black color. The injury leads to a honey dew secretion on the plant on which black mold grows, and this reduces the ability of the animals to eat the hay.

**Army Worm *Sopdoptera exiguae* [15]:** Green larvae with a smooth skin and presence of yellow strips on both sides of the abdomen. The larvae may appear with purple or black color accompanied with the presence of yellow strips. This species complete one generation in 4 to 6 weeks which may shorten to less than 3 weeks in hot summer months. The insect pupates inside a cocoon under the soil surface. This species has seven generation per year. The moth is with gray color and there are dark spots on the front wing. The moth lay egg masses (small and large) on the crop leaves and cover

them with cotton fluff. Eggs hatch after several days and begin feeding on the surface tissue of the leaves leaving the veins intact, the voracious feeding of larvae leads to the appearance of bleached leaves on the peripheral leaves in the form of flagging. The population density of the insect increases in summer and autumn. Causing extensive damage to the alfalfa crop, see figure 4 for the drawing of the different species of moths.



**Figure 4:** Drawing of common moth species of alfalfa worms: a. moth of army worm, b. moth of big alfalfa leaf worm, c. moth of cut worm, d. moth of measuring worm, e. moth of tomato fruit worm, f. alfalfa leaves weevil.

**Big alfalfa leaf worm *Spodoptera litoralis* [15]:** larvae is 4-5 cm, brown color and may be found with olive green color and black strips on both sides of the abdomen above the spiracles. The larvae are with grey spots on the thorax and the abdomen end and there is grey line on the top and the sides of the abdomen, The moth is with grey color and the presence of white strips on the front wings. It has about 8 generations in Egypt, completing one generation in 4 to 6 weeks in summer and extending in winter 7-12 weeks. It pupates in a similar manner of army worm. One of the most important factors of its survival is the presence of ground moisture, where it encourages them to lay eggs in the presence of the host, and the rise of humidity protects young hatched larvae from exposure to drought and death. The moth lay large egg masses on the leaves of the crop and covers them with cotton fluff. The eggs hatch within 3

to 5 days and start feeding on young leaves and its complete larval stage in 18 days then it develops to pupa for one week, then it develops to adult moth.

**Alfalfa Caterpillar *Colias croceus* [8]:** Green velvety surface larvae (hairy) with white strips appears on either side of the abdomen. Active from June to September, and it has 4-7 generations per year. The adult yellow butterflies appear in the fields in late spring and the beginning of summer where they lay their eggs individually on the upper surface of the leaves of short plants (15 cm). The eggs hatch after 3-5 days into small black-headed larvae. The larvae grow for two weeks, then develop to pupa like a boat hanged on the plant and it develop to the adult butterfly in less than a week.

**Tomato fruit worm [8]:** The multicolored larva is green or brown with light longitudinal strips on both sides, the head is brown, and there are black spots on the abdominal segments from which thorns come out. There are dark spots on the moth forewings, The duration of one generation is five weeks and it last in autumn to eight weeks. It has eight generations per year. The larva is large in size at the instar of five and is difficult to combat.

**The cut worm [15]:** larvae with smooth skin, brown or green grey. There is black sheet on the first thorax segment. Larvae are found under the surface of the soil near the plants and when contacted by hand they arch with up to 4-5 cm length. It feed at night and stay hidden during the day in disintegrated soil and under the vegetation. The moth body color and front wings are dark grey with black horizontal strips on the outer third of the front wing. The moth lay egg masses (white to green) randomly on the leaves or plant stems near the plant base. This species is found all the year round and numbers are increased in May and November as it causes economic damage on the plants. The larvae cut the new seedlings near its base or it cut the newly developed stems (at the surface or



below the soil surface) as alfalfa grows after the cutting or it feed on the new vegetative growths. This pest can be seen after irrigation at the sites of the absent areas due to insect feeding.

**Measuring worms:** there are several kinds of green and purple color ones, and the larva walks by lifting the front of its body upwards and then arching in the middle as if it measures the distance due to the loss of a couple of pseudo-abdominal legs.

**Alfalfa leaves folder:** small larvae in a black purple color that combine the top leaves of the plant.

**Leaf minor:** It belong to order Diptera, the larvae live between the skins of soft leaves and damage them, which leads to the inhibition of alfalfa growth and reduce the quality of the crop.

Most of the damage on alfalfa is determined by the first three insects followed by the tomato fruit worm.

**Alfalfa leaf weevil [15]:** The entire insect is a weevil of about 8 mm long, light brown color and has a long proboscis, see figure 4. The larvae are a curved worm with no legs and replaced on each ring of the body with appendages resembling false legs. The larvae color is green with a black head, and a light-yellow strip extends on its back; the larvae is wide in the middle and pointed on both sides. The young larvae feed on the green material inside the leaves, so it becomes transparent and then dry. The large larvae feed on the leaves and show rectangular holes, and they attack the buds and the developing tops. The edges of the plants appear dry and broken, and then it eats the stems from the bottom, therefore many sticks are seen in the field dry and dead. Weevils can be seen clinging on the plants or hidden under the soil surface in large numbers near the plants and enter into summer aestivation. The adult insects activate in the next winter and early spring producing large

numbers of larvae which appear in February and March, then pupate inside a silk cocoon on the plants, then develop into adults, The adults emerge from the cocoons and after mating, the females lay eggs on the plants which after hatching repeat the life cycle, this weevil probably has one generation a year.

## Field Observations on IPM program

We observed in the seasons before the application of integrated pest management program (IPM) on alfalfa crop during the 1993 - 2000, the need to spray insecticides after each cut due to the transfer of insect's infestations from advanced growth pivots to the recent cut pivots through insects' migration by flying or through harvesting equipment. The application of karati in Primo K insecticide to control aphids and Dursban 48% EC to control worms had resulted in the insurgence of aphids in the cold months and worms in large numbers in the hot months of summer July and August. Several army worms' outbreak was occurred in the summer months of the seasons before the start of IPM program, we observed high numbers of the 2<sup>nd</sup> to 4<sup>th</sup> instar larva of army worm at K-area pivots before the end of July 1996, and the number of worms per 10 swaps ranged 71 to 122 worms with an average 98.3 larvae. It was feeding voraciously which led to the appearance of large area of plants chewed partially or completely. Another heavy army worms attack occurred at J3 area in the same period, as the new grown alfalfa after cutting were removed by the worms in addition to the purslane weed. A third and very heavy worms' numbers breakout at F-area and the average worms per 10 swaps reached 127.4 larvae and it produced white patches of flagged plants partially or completely damaged. We were enforced to stop these heavy infestations by the injection of Chlorpyrifos 48% EC 1.5 liter + karate 5% EC 0.25 liter as it was difficult for tractor sprayers to enter. On August 1997 worms attack occurred at J11 pivots and adjacent pivots of F-area as they were subjected to heavy infestation by the big alfalfa worm

*Spodoptera littoralis* which resisted all chemical sprays, and this enforced us to apply lannate insecticide to stop the worms' outbreaks. The alternative shift to IPM through the application of selected insecticides such as Dimethoate EC 40% to control aphids during normal conditions and Malathion 57% EC in close to harvest situations as it is safe [16]. For worm control, it was shifted to the application of antimolt insecticides such as Nomolt 15 SC: 0.3 L/Hectare, or Cascade 0.3 L/Hectare, or Alsystane 0.5 kg/ Hectare, or Dimilin 25% WP: 0.7 kg/ha, and in the case of mixed populations with tomato fruit worm *Helicoverpa* and alfalfa worms *S. exiguae*, *S. littoralis*, we used a mixture of Nomolt (half dose) with Cascade (half dose). Due to the application of selected insecticides, the number of annual sprays was reduced significantly after two years of IPM program due to the preservation of beneficial insects (predators and parasites) which attacked the aphids and worms and reduced their damage to the alfalfa crop. As per field observations, the productivity of the cultivar CUF 101 was significantly superior to the Siriver variety under the conditions of the Integrated Pest Management program at TADCO fields [16], and this enforced the company to grow tolerant variety like CUF 101 during the IPM program and exclude the sensitive varieties. To follow up IPM program completely, attention was directed to control volunteer alfalfa plants growing inside surrounding wheat and potato pivots to prevent infestations of the main alfalfa crop since these volunteer plants harbor aphids and virus diseases.

## Conclusion & Recommendations

- Alfalfa was an ideal crop for applying integrated pest management program (IPM) as it is a perennial crop with deep roots, so it can compensate its normal growth if it was damaged by pests or harsh environment like frost or drought. Actually, it is grown in each pivot for an average of two years, and this allowed the predators and parasites insects to stay on it and

survive between the seasons feeding on insect pests.

- Recommend the farmers to follow up integrated pest management program in alfalfa and other crops in the Middle East countries through the application of selected insecticides with low mammalian toxicity to preserve beneficial insects, so the farmer could reduce the cost of crop production and produce healthy food.
- Recommend the farmers to test new varieties of alfalfa and other field crops which can perform better under IPM program.

## Acknowledgment

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