IRRIGATION INDUCED CHANGES IN INSECT POPULATIONS IN ISRAEL

by

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CONFERENCE ON THE
ECOLOGICAL ASPECTS OF
INTERNATIONAL DEVELOPMENT
AIRLIE HOUSE, WARRENTON, VA. DEC. 9-11, 1968

INTRODUCTION: IRRIGATION IN ISRAEL

When discussing the changes in insect populations induced by irrigation it is of interest to review changes in the extension and methods of irrigation that have taken place in Israel during this century and some of the developments in agriculture as a result of these changes. It should be born in mind, that small as the country is, it has zones of aridity of all degrees, beginning with the extremely arid and arid (the desert in the southern Negev), semi arid, (in the northern Negev), and semi humid in the central and northern part of the country. In the northern zones irrigation is carried out in the summer only, in the southern parts irrigation must be carried out in varying amounts even in the winter.

For centuries the sources of water for irrigation were springs, rivers and wells in which only upper level (table) water was exploited. Distribution of water was in open canals, and irrigation was made in lands lying lower than the pool of water. The raising of water was often by manual labour. From wells, the water was raised also by a chain of buckets rolling over a large wheel, going down into the well empty and coming up filled with water. This was collected into an elevated pool, from which open canals ran in all directions. The power behind the wheel was a horse. The areas that could be watered by these methods were limited. On small tracts of land were sown or planted egg-plants, tomatoes, peppers, okra, cucumbers and squashes of various kinds. These were watered in furrows. The fruit trees watered were mainly oranges, lemons and quinces, etc. All were watered in basins around the trunks. The summer field-crops in dry farming

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were sorghum, sesame and watermelons.

Pumps driven by petrol engines were introduced early in this century; these worked also at night to make up for their small output. During the third decade deep drillings were made and improved pumps were introduced, this made the collection pools unnecessary since the water was pumped in closed pipes from long distances. These new sources of water made possible the expansion of areas under irrigation. During the fourth decade permanent pipe lines were laid in large fields in which summer field crops under irrigation were sown. Corn, alfalfa and fodder beets were grown. The area of citrus groves increased and stone fruit were grown under irrigation.

In that decade a large irrigation enterprise was accomplished. A pipe line was extended from the springs of the Yarkon river to the semi-arid north western Negev, water was driven there by a pump, and the land under irrigation made possible the establishment, in 1939, of 11 new settlements in the midst of the desert.

During the fifth decade, after World War II, light portable irrigation pipes were introduced. At the beginning perforated pipes were employed for overhead irrigation then sprinklers of all kind took their place. The light portable pipes gave a boost to enlarging the areas under irrigation. Field crops, vegetables and trees covered now large tracts of land. Where sprinklers were not desirable, openings were cut in the pipes from which water in regulated streams ran in furrows, irrigating both trees or field crops. During the sixth decade, (after the establishment of the state of Israel), cotton, peanut, and sugar beets occupied large areas. Also commercial plantations of the tropical fruits, avocado, mango and others were planted. During that decade another irrigation enterprise on a large scale was undertaken, namely the draining of the Hula lake and swamps and the transfer of some of the Jordan waters to parts of the country where water was needed.

The gradual development of irrigation in Israel, the increase in irrigated areas, and, as a result, the introduction of crops hitherto not grown or grown a little, in the country, brought changes in the environmental conditions. These changes affected the many organisms living as an integral part of the ecosystems that make up the agricultural communities. The effects of these changes for the pests of some crops of agricultural importance will be discussed in the paper presented herewith.

I. CREATING AN OASIS IN THE DESERT

"When irrigation is introduced into a desert an oasis is made which will soon be invaded by pests specific to the crops raised". This statement was made by Uvarov at the 12th International Congress of Entomology in London 1964.

This situation occurred in Israel in several sites. At Nitzana about 40 kms from the nearest agricultural land, a tract of land was converted by irrigation into a truck crop farm. It did not take long before aphids attacked the plants, (Alper et Lobenstein, 1966). Aphids often develop into dense colonies on the plants and their sucking of the sap may weaken the host plants and cause a reduction of the crop. A 40% loss of yields of vetch or beans is a common event. However, even single individual aphids may cause damage by infecting the plants with virus. Alpert & Loebenstein (1966) were in search in the desert for a possible Aphis free area in order to grow virus free potatoes. How disappointed they were with their findings! During the winter the sources of these aphids were no doubt plants of the local flora, but as these dried, in April, the sources were from remote places.

The tendency of winged aphids is to leave the plant upon which they developed and rise upwards with the currents of air (Johnson, 1954); when at higher altitudes, they are carried by the wind, and may be dropped long distances away. Thus, when Dickson (1959) placed alfalfa plants in pots in the mojave desert, the plants soon became infested with aphids. The nearest field from which they could have originated was 130 kms away.

In the midst of the Negev desert, at Avdat, a small parcel of land was irrigated and sown to cotton, 50 kms from the nearest cotton field. The bolls were attached by the spiny boll worm, Earias insulana Boisduval. The female lays its eggs on the fruiting bodies of cotton and the ensuing larvae bore into them. As a result flowers and bolls drop; older bolls deteriorate on the plant. In Israel, if no measures

(p. 5a follows)

of control are practiced, the entire crop of a field may be destroyed. In 1956, when adequate control measures were not available, 80% of the fields in the upper Jordan valley were destroyed. This moth is not a true migrant because it is not absent from a country at a certain season, for a length of time in all its stages, as is the case with true migrants. During the cooler season it is quiescent. In its flights in search of host plants it may wander long distances, even hundreds of kms in one season. Rivnay (1966) made a study of the flights of this moth in the Negev Desert, South in Israel. At Nitzana, the first appearance of the boll worm occurred at the end of July; at Avdath, farther south it occurred during the last third of August; by the end of that month 28% infestation occurred, and 12 days later every boll was infested. At Eilat - the coast of the Red sea, and 180 kms south of the agricultural area, light trapping showed that the moth reached there by the end of September.

In the truck crop farm at Nitzana also Agrotis ypsilon larvae were found. In its latter stages the larvae of Agrotis ypsilon live in the ground feeding on root crowns of various plants. Many kinds of hosts may be attacked such as beets, cotton, potatoes, clover etc.. As a result of its attack many seedlings in the field are destroyed especially those adjacent to roads, or in fields in which weeds had been growing before the planting of the crop. Agrotis ypsilon is a true migrant (Williams, 1930). A hypothesis as to its course of migration in the Near East was promulgated by Rivnay (1964). This hypothesis was based on data of its occurrence in upper Egypt (Bishara, 1932), upon flight records (Williams, 1930) and upon light trapping in various sites of Israel (Rivnay, 1964). According to this, moths migrate in the spring from upper Egypt northward, through the Sinai peninsula and the Gulf of Akkaba, through Israel to the Lebanon and Mt Hermon elevations. A southward migration occurs in the autumn. Along their routes of migration moths will oviposit if vegetation is available. One of the routes of migration according to eye witness reports is in the neighbourhood of the Nitzana

farm - (The "White Canyon" - Rivnay, 1964). This explains the presence of cut worms - Agrotis ypsilon in that oasis in the midst of the desert.

(p. 6a follows)

II. EXTENSION OF AREAS UNDER IRRIGATION

The Cotton Leaf Worm - Spodoptera littoralis Boisduval

Spodoptera littoralis, formerly known by the name Prodenia litura is a notorious pest in Israel. It is of foreign origin, and entered this country probably early in this century. It spread to Israel apparently from Egypt where it appeared for the first time in the seventies of the past century.

Conditions in Egypt were favourable and within a short period this pest assumed a role of primary importance to Egyptian agriculture. In Israel the rise of this pest was far slower. It was hardly known before the twenties of this century. During the late twenties damage was recorded only during June-Aug., when population of this moth reached its peak. After that a decline in the population took place (Bodenheimer, 1930). For over two decades its status changed only a little. From the late forties the populations of this pest increased, the period of activity and recorded damage extended till October and November. The host list increased to include grape vines and apples which had not been attacked before.

The reason for this change in the status of this pest in Israel lies, among others, in the irrigation-induced changes in agricultural practices.

a. The Alfalfa areas increased due to the use of the portable irrigation lines, which facilitated the watering of large areas, and the initiation of the manufacture of alfalfa meal, which opened new markets for the crop.

b. New crops were introduced into the country on large areas.

Peanuts, cotton and sugar beets which had not been grown before, became key crops in the agricultural economics of the country. These four industrial crops which could exist in the arid summer only because of irrigation, offered food to the multivoltine[1] polyphagous[2] Spodoptera on a large scale, continuously

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1. Multivoltine - capable of raising more than one generation annually.

2. Polyphagous - feeding on many host plants.

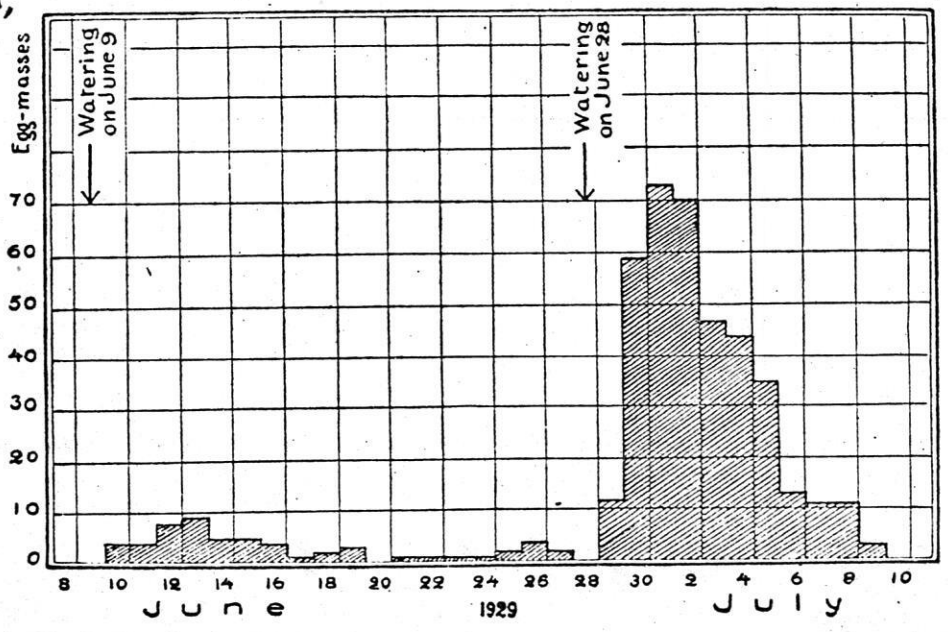
from May till late in November; when one kind of crop dried out, another was still fresh only a short distance away.

The lands upon which the irrigation crops grow now, were covered in the past with dry farming crops. These did not attract Spodoptera moths. In June, when the population of the pest had become active, the crops of wheat, chickpeas, lentils and others had matured and dried. Those that were still fresh, like sesame, had not been watered and therefore did not attract moths. As is the case with other moths of the Noctuid family, the females of Spodoptera are attracted in greater numbers to recently irrigated fields. The extent of damage depends upon the density of the population which differs every year; but in years of outbreaks, the entire crop may be destroyed. It is of interest to quote in this respect the observations and counts made by Bishara (1934) in Egypt.

In a cotton field of half an acre, egg masses were counted and removed every day. This was done for several days before and after irrigation. The number of egg masses counted are presented in Fig. 1. As may be seen, the maximum number of egg masses was laid on the third and fourth day after irrigation; after this the number decreased, and dropped to the pre-irrigation level on the ninth day after the stand had been watered.

Fig 1. (after Bishara, 1934)

Prodenia litura: *Relation of Egg-mass laying to Irrigations given to a Cotton field*



The extension of areas under irrigation caused also the increase of monophagous[1] pests. The weevil, Hypera variabilis Herbst, a pest of alfalfa, which in Israel was hardly noticeable in the early thirties, became a pest against which measures of control are practiced now. (Melamed, 1963). This holds true also for the beet weevil Lixus junci Boheman whose rank as a pest changed after sugar and fodder beets began to cover large areas under irrigation (Rivnay et al., 1956). Formerly vegetable beets were grown in restricted areas only.

1. monophagous - feeding on one kind of host plant.

(p. 8a follows)

III. PROLONGATION OF SEASON OR PERIOD OF HOST PLANTS

In their efforts to supply fresh succulent food to the dairy cattle during the dry period, farmers sow corn repeatedly and in succession in small areas throughout the arid summer. By the time one area had been cut and consumed, the following has grown to the proper stage, and the third is seeded. The need of seedling at various dates in the early summer is felt, and is also practiced with sorghum. Truck crop growers, in order to supply to the market fresh cucurbit vegetables throughout the summer sow these plants at various dates throughout the spring and summer.

These practices became possible only with the improved method of irrigation. Thes improvements in farming which are so valuable to the economy of the country, also favour the development and increase of some insect pests.

The Oriental Corn Borer - Chilo agamemnon Bleszynski

The oriental corn borer, Chilo agamemnon, can raise one generation in one summer month. The larva of this moth bores into the heart of the plant and before pupating girdles the stem from within. The plant as a result, weakens, its growth stunted and becomes easily breakable. At Beer Tuvia, in the coastal plain, the standard yeild of corn fodder was 4-5 tons per dunam (aprox. 1/4 acre) after the invasion of this pest the yield dropped to 1/5-2 tons per dunam.

In view of its quick development and presence of food all summer long, the corn borer raises six generations from May to early November (Rivnay, 1967). In the dry farming system, only two, at the most three generations of the moth could have been raised, as by August the stand has dried and become unsuitable for the larvae.

With an insect which spends half a year in dormancy, and which is active only during the vegetative period of its host, a situation of a continuous food supply is made also by sowing the host crop year after year in succession in the same time. An attempt to grow rice was made in the drained Hula area; with plenty of

water in that area rice was grown a few years in succession. In order to exploit the area which is so rich in water, it was planned to introduce a crop which was not cultivated before in the country. But this pest prevented it. At first the stand was beautiful, bearing fine yields. However, it did not take long before an entomological factor brought an end to this enterprise. This Chilo species. which had not been known to exist in the area before, attacked this crop. During the first year the percentage of infestation was bearable - 10-15%; the following year it was 33%; the infestation grew in subsequent years, and reached a stage when it became evident that it was not worth cultivating this crop since no adequate cheap control measures were available.

(Figure 2 follows)

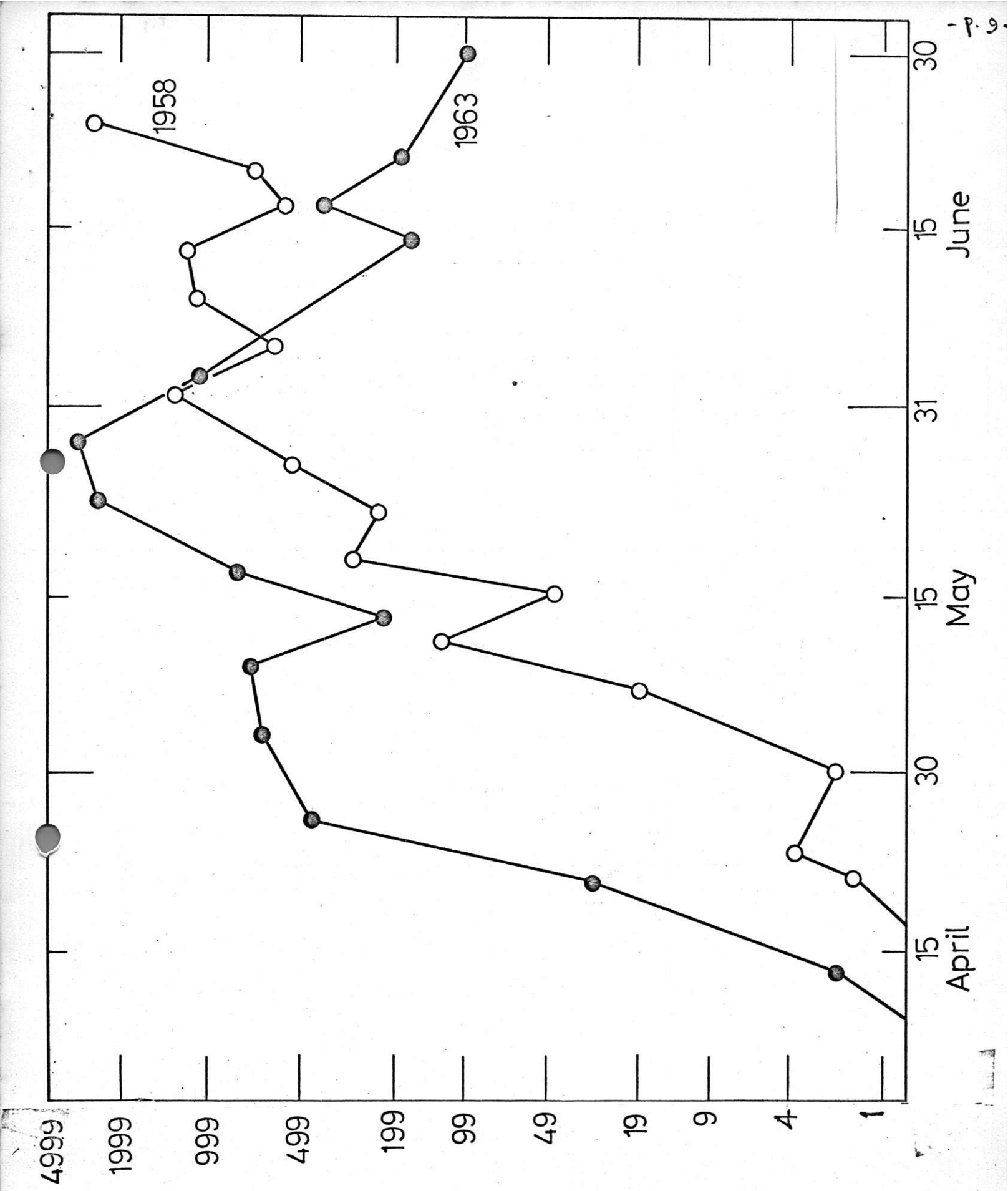


Fig. 2. Trend of population of Atheryona varia soccata, at Beit Dagan in a field where young sorghum plants were available till June. After Yathom, 1965. The lines show the continuous increase in the number of flies in the area till there were no more host plants of the proper age available.

The Sorghum Shoot Maggot Atherigona varia soccata Rond.

The sorghum shoot maggot Atherigona varia soccata attacks only young sorghum plants. From sprouting till the age of two - three weeks, plants may succumb to the attacks of this fly. After this the plant had becomes resistant. The neonate maggot works its way to the interior of the crown, there it scratches the surface and feeds upon the soft tissue of the innermost rolled leaves. As a result the central blade dries up and withers. Side tillers develop, the formation of grain is retarded, reduced or failing altogether.

When sorghum was grown in dry farming, this fly was hardly known in Israel. Bodenheimer (1930) who has made an inventory of all plant pests known to exist in the country at that time does not mention it at all. If the fly existed in the country (on wild sorghum plants) the cultivated sorghum probably escaped its attack, having grown to the resistant stage before the fly became active. With the cultivation of sorghum under irrigation the status of the fly has changed into a pest of importance. Atherigona varia soccata may raise one generation every summer month, and as long as young plants are available its population increases and remains high throughout the summer. Fig. 2 presents the number of flies per jar trapped on a farm where young sorghum plants were available throughout the early summer (Yathom, 1965).

Under conditions today sorghum cannot be sown late in the spring or in the summer without suffering losses incurred by this fly or applying measures of control. Farmers, as a rule sow early to escape the attack of the fly.

As a rule no records are kept of damages by insects, which in this case are hard to estimate. From the adopted practice to sow early in order to escape the damage one may surmise the importance of the pest. In experimental plots sowing later in the season, infestation reached 40-70%.

The Cucurbit Snout Beetle Baris granulipennis Tournier

Availability of cucurbit fruit all summer encouraged the increase of the melon weevil Baris granulipennis. It is still uncertain whether this pest entered the country recently from Egypt whence it had been described first, or it had been here before. But it is certain that in the late fifties of this century it increased to the extent that measures were taken against it especially in fields where melon was grown for export.

The snout beetle oviposits in the young melon fruit. Its larvae develop within the fruit feeding on the soft seed. After two, three weeks they mature and pupate within the peel which had in the mean time become dry. The growth of the fruit is stunted due to the girdling of its stem by the female prior to oviposition. Quite often, "by mistake", the petiole of the adjacent leaf is girdled instead. Oviposition is then made in a fruit which continues to grow. An infested fruit may be recognized by the oviposition scars.

The natural host plant of this beetle is Citrullus colocynthis. This plant and melon Citrullus vulgaris cultivated without irrigation yield young fruit till July or early August. After this, emerging beetles may not find suitable host fruit to oviposit. With the extension of the cucurbit season, due to irrigation, fruits, melon and cucumbers, are available till late in the autumn, and two more generation can be raised.

The percentage of survival from the long hibernation depends upon the generation to which the beetle belongs and its age. The earlier the beetles enter hibernation the less individuals survive. Development of late generations have an important bearing upon the strength of the generations of the following years (Rivnay, 1960).

Today, due to continuous preventive measures and extensive insecticide applications against other pests, the beetle has become quite rare.

The Onion Fly, Hylemyia antiqua Meigen

Before irrigation was extended in Israel, onions were grown in the winter by planting sets of previous years. Rains supplied the necessary moisture, and the bulbs matured and were harvested in June. Today as a result of irrigation, seed is used which is sown in September - October. The soft seedlings are re-planted in the field. The onion season was thus lengthened; onions already are in the fields by October - November.

The onion fly was considered until two decades ago a pest of least importance; no insecticides were necessary, as its damage was hardly felt (Bodenheimer, 1930). Now with the new methods of cultivation as a result of irrigation, this fly has became conspicuous thereby necessitating measures of control.

This fly raises in Israel two or three generations annually, as is the case in colder European and North American countries. The difference is however, that in Israel that fly is active during the winter and enters a diapause* during the summer, which is the other way round in northern countries.

According to Yathom (1963), the aestivating generation of the fly emerges from diapause in November - December. The offspring of this - the autumn generation matures in the middle of the winter, and gives rise to the winter generation which enters diapause in the pupal stage. The early individuals of this brood may continue to reproduce and only their offspring enter dispause.

Record of appearance of the generations are given in detail because in our efforts to explain the cause for the increase of the fly population due to irrigation we should point to the synchronization between availability of host plants and the awakening of the fly from dispause.

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* diapause - the period of arrested development which insects go through, which enables them to overcome adverse conditions of drought, temperatures too high, or too low, and helps them to synchronize their active period with availabilty of food. When the period occurs in the winter it is hibernation; in summer ,aestivation.

In the case of the dry farming when the flies of the aestivating generation emerged from dispause, there were no host plants upon which to oviposit; many, especially the earliest, perished before ovipositing, only those that emerged in December and early January could find hostplants. In this connection it is worth mentioning that the life span of the female may be as long as fifty days (Yathom, 1963). In the case of farming under irrigation the awakening flies in November find plenty of host plants; most of the flies lay, and thus give rise to a strong generation to further attack the onion fields.

It should also be mentioned that the onion sets which are used in dry farming are more resistant to the maggots than the soft seedlings which sprout from the seeds that are used under irrigation.

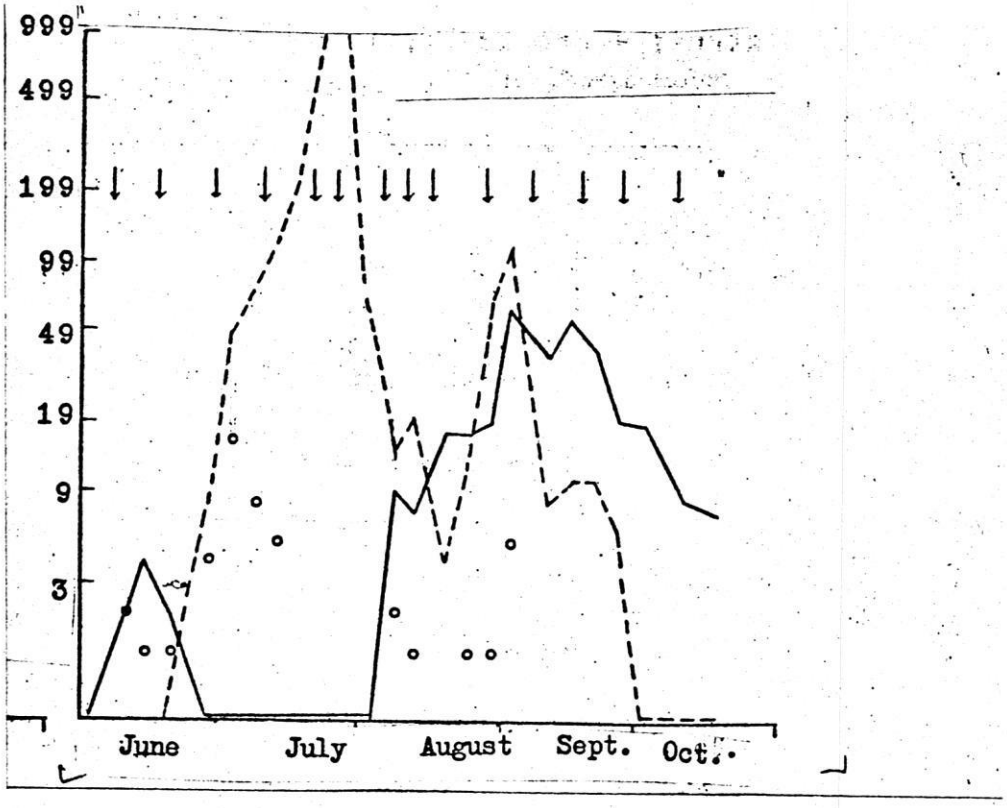

Fig. 3. Fluctuations of Populations of Spodoptera littoralis (broken line) and Earias insulana (straight line) in an irrigated cotton field in the coastal plain in Israel. After Rivnay & Yathom 1958.

(p.16 follows)

The Spiny Boll Worm Earias insulana Boisduval & The Cotton Leaf Worm Spodoptera littoralis Boisduval in Cotton

In the examples given above it was shown how insect populations increased due to the prolonged season of the host plant caused by repeated sowings at subsequent dates.

The period of a single stand may also be prolonged by irrigation as long as the temperature permits. Cotton for instance, when grown without irrigation in Israel is harvested during August; under irrigation this crop in the same locality is harvested during September and October. In the Beit Shean Valley (near the Jordan river) the vegetative period of the stand is extended till November. Here this prolongation is essential, because in the too warm days of July and early August, there is a general blossom drop, which ceases in the middle of August, the prolongation allows the fruiting of the late blossom to make up for the loss due to the drop in July.

These prolongations accentuate the infestations by the spiny boll worm Earias insulana Boisd., and the Egyptian cotton leaf worm Spodoptera littoralis Boisd. As may be seen from the accompanying graph, Fig. 3, the cotton leaf worm, whose population has its climax in July, may raise one generation in September and if fresh food is available in the Beit Shean Valley also one in October. The population of the spiny boll worm is at a very low level during July and early August. It begins to rise in the second half of the latter month. Dry farming cotton may escape the attack of the renewed wave of its population, since the bolls have dried and are ready for harvest. However, in irrigated fields the period August-October is the most crucial as far as the attack of Earias is concerned.

III IRRIGATION INDUDED CHANGES IN MIEROCLIMATES

The Seed Corn Maggot Hylemyia cilicrura Rondani

The seed maggot which is cogeneric[1] to the onion fly differs from it in being polyphagous[2]. Yathom (1961) who studied this fly in Israel, states that until the early fifties this fly was hardly felt as a pest, although it existed in this country . Bodenheimer (1930) mentions it as a predator of locust eggs. Its first discovery as a seed pest in 1935 was recorded much later in a publication called "Rare pests of truck crops" (Schweig, 1951). Today preventive measures must be taken against it when sowing cucurbits, peanuts, beans, cotton or corn, in order to avoid the necessity of reseeding once or twice.

In discussing the factors that have changed the status of the fly from an unknown insect to a pest of primary importance Yathom states that irrigated fields or those that have been ploughed recently attract flies for oviposition. In her own work this author demonstrated how hardly any females of this species laid on dry soil, whereas hundreds of eggs were laid on moist soil by the same number of females, which had been interchanged from time to time.

In dry farming the growing of summer crops is based on exploiting the moisture which had accumulated in the ground from rains during the winter. Some crops are watered afterwards in their furrows. Such conditions do not encourage egg laying nor the development of the species as is the case in agricultural practices today where the field is seeded and then watered by over-head irrigation. A small field experiment carried out near Rehovot demonstrated this significantly. One plot was well irrigated and two days later seeded with beans. The other was first seeded and then irrigated. The latter was strongly attacked by the seed corn maggot; whereas the other was hardly infested. In the first case the soil remained moist enough to cause germination of the beans but the surface became too dry to attract the ovipositing flies.

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(1) Cogeneric - belong to the same genus
(2) explained on page 6.

In our effort to explain how the population of H. cilicrura increased in Israel, we should consider the chances in April of synchronization of the presence of many gravid adults with ecologically favourable conditions for oviposition - namely irrigated fields. Such fields were not available on dry farming when sesame, sorghum, melons were sown in moist soil without subsequent irrigation. Such fields are plentiful today when large areas of peanuts, cotton, corn and others are sown and subsequently watered by overhead systems. Today farmers employ preventive insecticides; if not it is necessary very often to reseed the entire field once and twice.

The Red Pumpkin Beetle Rhaphidopalpa foveicollis Lucchese

On emergence from diapause, Rhaphidopalpa beetles feed on the leaves of the young cucurbit seedlings. When numerous they may inflict severe damage necessitating reseedling of entire fields.[1] However, the more important injury is caused by the larvae which feed upon and bore into the roots. Bacterial rot develops then, the plant succumbs suddenly and entire fields may thus be destroyed. The damage is aggravated because this often happens a week or two before the fruit is picked for marketing.[2] Injury of a third type may be caused by the larvae when they emerge to the surface and feed upon the nearly mature fruit. In recent years the situation of this pest has become quite serious, and the reason for this is the change from furrow to overhead irrigation (Rivnay, 1954).[3]

The eggs of Rhaphidopalpa foveicollis need contact moisture for development (Melamed, 1960). Eggs deposited near plants growing under ditch irrigation may not have the necessary moisture so that many eggs perish. In case of overhead irrigation the entire area is uniformly watered offering thus ideal conditions for the eggs to hatch. The larvae enter the soil and feed upon the roots. As they grow larger they penetrate the main root.

Unlike the eggs mature larvae are susceptible to excessive moisture. When the field becomes saturated with water supplied by the sprinklers the mature larvae leave the soil and seek shelter under the fruit upon which they also fed. (Fig-) In fields irrigated in furrows this does not happen. In fields where overhead irrigation was not too copious the infestation may be limited to the lower sites of the field where more moisture is accumulated.

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1. Farmers from Raanana, Ra le and other villages in the coastal plain, complain every season about destruction of 20-50% of the seedlings in spite of the dusting with insecticides. Only recently more effective insecticides were introduced.

2. At ashdod, for instance, the writer witnessed the destruction of the entire crop of a 15 acre field of melons. About a year later, that farmer appealed to the writer to testify about it in order to be exempted from income tax.

3. It is a well known fact that no such mishaps occur in dry farming, or in furrow irrigated melon fields like we find in the Arab villages.

The Almond Borers Capnodis Spp.

Early this century, the jewish settlers in Palestine, in their endeavour to improve their Agricultural economy, planted, along with other crops, almonds on large areas. This enterprise was sponsored by Baron Rothschild of France who financed it, and who also sent a french horticulturist to supervise the plantations. Naturally, the methods of cultivation practiced in the western Mediterranean basin were followed. The trees developed nicely, and began to bear fruit, after a few years of their existance they began to deteriorate, and gradually the plantations were uprooted.

There were several causes responsible for the failure of this tree in that period, but the major one was Capnodis spp. . Two species C. Carbonaria Klug. and C. tenebrionis L. attacked the trees.

The adults of these beetles usually feed on the bark of the soft twigs and upon the leaf petioles of various stone-fruit trees. The eggs are deposited in nooks and crevices near the root collar and the neonate larvae work their way to the main roots into which they bore. When several such larvae feed on the Cambium of the main roots, the tree weakens and finally succumbs.

In a study on the ecology and physiology of these insects it was found that the eggs were quite resistant to desiccation, and quite susceptible to a high degree of humidity (Rivnay, 1944). The egg shell is covered with hygroscopic salts which absorbed moisture around the egg, to render them resistant to dryness. Thus most eggs hatched even at a very low relative humidity. On the other hand, at high relative humidities the percentage of mortality increased as the humidity was higher, and as the time of exposure to it was longer Fig. 5. presents the mortality of eggs at various degrees of relative humidity, and Fig. 6. the percentage of mortality when exposed to a R.H. of over 90% for various lengths of time. One should bear in mind th at a temp. of 26-30°C the incubation period lasts 10-15 days.

When a tree is watered the soil remains moist for several days; the upper layers may dry faster, but the air spaces in the soil and the space between the soil

and trunk, where the eggs are deposited, remain humid for a longer period. Under such conditions the percentage of hatching eggs is reduced.

With the increase of water resources during the thirties stone-fruit trees began to be watered. The purpose was to obtain more and better fruit.

However, it was noticed that the major pest of the stone-fruit tree, Capnodis, began to diminish; less trees succumbed than it was before irrigation of the trees, had been introduced.

Today almond plantations are not watered, or are watered with long intervals between the irrigation. Under such conditions Capnodis larvae may survive and become injurious. Farmers use preventive measures by dusting around the trunks with contact insecticides. As a result of the situation discussed above Capnodis is hard to be found in Israel in comparison to the situation that existed before.

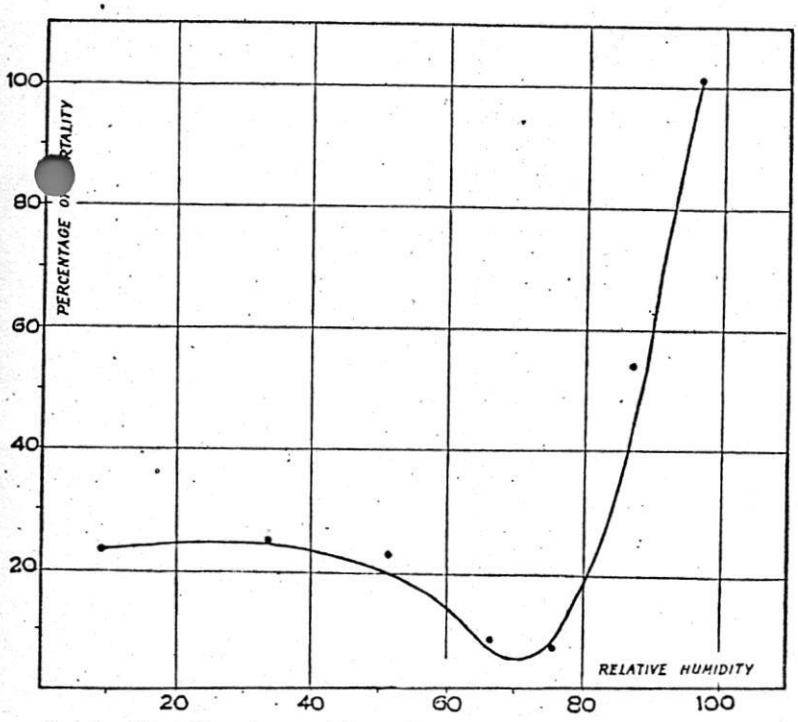

Fig. 4. Mortality of eggs of *Capnodis tenebrionis* at various degrees of relative humidity.

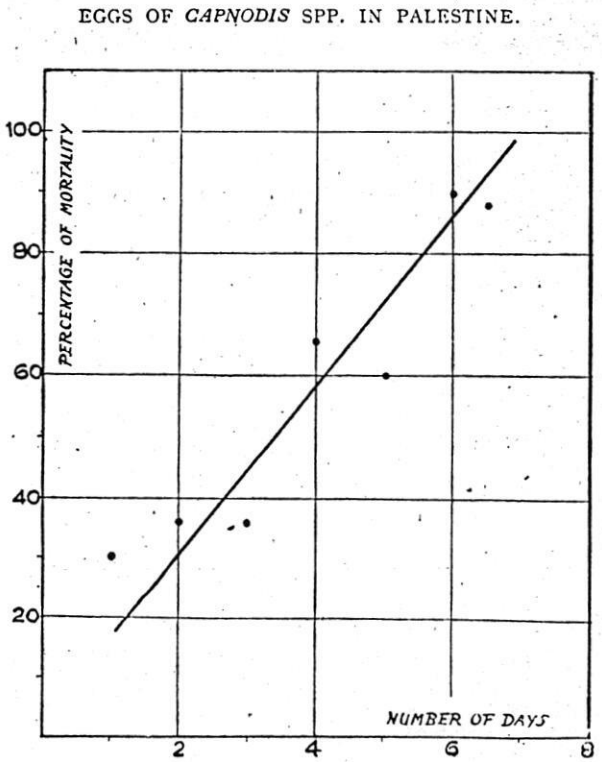

Fig. 5 Mortality of eggs of *Capnodis tenebrionis* when exposed to a high relative humidity.

(p. 21a follows)

V. IRRIGATION INDUCED CHANGES IN PHYSIOLOGICAL STATE OF HOST PLANTS

Aphids

In Israel the population of aphids reach their peak in March. A sharp decline in the number of species and individuals takes place towards the end of April (Bodenheimer, 1940). Some species are active also during the summer. In a study on the aphids occurring on fruit trees in Israel, Swirski (1954) found that Aphis pomi DeGeer ~~D.G.~~ remained on irrigated apple trees a longer period and were more numerous than on non-irrigated trees. Also Aphis punicae was more abundant on irrigated pomegranates than on non-irrigated trees.

The reason for this lies in the fact that irrigated trees continued to produce new growth and young leaves are available throughout the summer. That young leaves are attacked by aphids more than mature ones, was pointed out by Kennedy et al., 1950, who noticed that young and senescent sugar beet leaves were more infested with Aphis fabae than mature leaves. Also Sokolov and Sokolov (1952) found that young leaves of apples are more attacked by Aphis pomi D.G. than mature ones, and that their infestation varied inversely with the osmotic pressure. Also Harpaz (1953) explained it by the difference in the osmotic pressure in the leaves of different ages.

The Aphid secretes saliva into the spaces between the cells. Osmotic pressure of the cell sap being less than that of the saliva, the latter permeates into the spaces, and is ~~being~~ sucked by the Aphis, but in the case of old leaves, during the arid period, the osmotic pressure of the sap is greater than that of the saliva and it does not permeat into the spaces, and no food can be obtained by it.

Another theory in this respect was advanced by Kessler et al., 1959, namely, the proportion of soluble nitrogen in young as compared with senescent leaves is different. Since Aphids usually prefer to feed upon young leaves, assuming that the proportion of cytoplasm to the nucleus increases with the age of the leaf it was thought of interest to induce these changes experimentally. Young apple leaves, of about 1/4 to 1/3 of their final size were sprayed with 25, 50 and 100 ppm. caffeine in water. Twenty days later they were analyzed for ribonucleic acid and deoxyribonucleic acid. For comparison young, mature, and senescent leaves were also analyzed. When experimental leaves were infested with Aphids, and allowed to reproduce for about one month, it was seen that the increase in Aphid population was approximately inversely proportional to the caffeine concentration. Aphids increased to a much less extent equally on mature leaves and on leaves pretreated with caffeine.

The authors came to the conclusion that the soluble nitrogen which is greater in young than it is in mature leaves, and also the RNA/DNA, which is smaller in young leaves than it is in mature ones, may be responsible for the more increased infestation by Aphids in young leaves.

The Olive Black Scale - Saissetia oleae Bern.

In Israel the Olive Black Scale S. oleae, among others attacks olives and citrus. As a rule it raises one generation a year (Bodenheimer, 1951). Ovipositing females appear in April - May and crawlers settle mainly in May. The larvae, after developing a little, enter a state of diapause which lasts till the middle of November when they awaken and resume development. They mature in March - April.

In 1961-62, a survey on black scale infestation in various localities of the Esdraelon plain, both on citrus and olives trees, was carried out by Peleg (1965). From this survey it became apparent, that in citrus and non-irrigated olive trees the development of the scale insect follows the pattern described above. However, in irrigated olive trees the development of the pest follows a different pattern. According to this, a small percentage of the larvae follow the pattern described above, whereas the majority does not diapause but continues to develop. As a result, ovipositting females appear already in November. The offspring of these also develop continuously and mature in the spring. Thus, on the same tree there are individuals of one and two broods. In trees in which two broods develop there is no uniformity in the hatching. A similar situation was reported also from the coastal areas in Southern California where the lack of uniform hatching was termed "off hatch" in contradiction to the normal hatch in the one-brood scale insects which is prevalent in the interior, more arid parts of California. Naturally the population of the insect should be denser in trees where two broods develop. This was demonstrated by our counts of the population of this insect in irrigated as compared in adjacent non-irrigated trees in the Esdrealon valley.

On 10 twigs picked at random, in each of the sections of the grove, 115 insects were found on the irrigated as compared to 16 found on the non-irrigated trees.

When we try to find the cause for this phenomenon, we cannot help but think of the changes in the cell sap induced by irrigation. There are reports where in changes in the food of some insects induced diapause. Thus a large percentage of larvae of the pink boll worms Platyedra gassypiella Sand, entered diapause when fed on seeds containing a large percentage of fat and only 20% of water. When feeding on softer seeds containing a little fat and 70-80% of water diapause was averted (Squire, 1939). A similar report was given by Urbahns (1920) on the alfalfa seed chalcid Bruchophaggus gibbus Boh.

It is quite possible that in June, (about 3 months after the rain period) the olive tree sap is too concentrated; this, in combination with the high prevailing temperature induces diapause in the soft olive scale. In irrigated trees the sap may be very dilute and diapause is averted.

SUMMARY AND DISCUSSION

When land is irrigated in an arid zone an enclave of a different biocoenose,[1] an oasis, is created. Insects typical to this biocoenose, and to the plant grown therein will invade it. This invasion may be by drift, as illustrated by the aphids, by dispersal as happened with Earias in the Negev, and by migration as did Agrotis ypsilon.

It is quite natural that larger and more numerous fields of a certain crop will provide larger quantities of food for the insect that depend upon this crop, and larger populations of these insects will develop; this is what happened with Spodoptera littoralis in Israel.

The prolongation of the vegetative period of a certain crop, by repeated sowings will increase the insects depending upon it, provided biological habits, e.g. voltinism,[2] permit it. This happened in Israel with Chilo agamemnon in corn, Atherigona varia soccata in sorghum and with Baris grannulipennis in cucurbit plants. Also, the prolongation of the vegetative period of the stand will increase insects depending upon it. This was illustrated by Spodoptera littoralis and Earias insulana in cotton and by Hylemayia antiqua in onions.

In certain plants irrigation may cause changes in the composition of the cell sap. Such changes may cause the increase of aphids and prolong their activity period; such changes may also avert the dispause period in sucking insects as the olive black scale Saissetia oleae.

Overhead sprinkling surely has its advantages. Otherwise it would not have become so wide-spread and universal. In Israel its advantages are: 1) Saving expensive labour. 2) Possibility to employ labour unskilled in agriculture, and 3) Possibility to irrigate areas and slopes where furrow irrigation is impossible or difficult.

However, there are also some disadvantages to this kind of irrigation. In a comparative study between overhead sprinkling and furrow irrigated plots

1. Biocoenose - the association of organisms (plants, and animals) living together under the same determined conditions of existence.

2. Voltinism - the quality of raising more than one brood annually.

in Israel, it was found that overhead sprinkled tomatoes yielded less fruit than furrow irrigated plots. Often the yield was $^1/_3$ to $^1/_2$ less than the yield in the furrow irrigated plots. (Rotem et al., 1966, - Yagev et al., 1965).

Also some diseases develop more in overhead sprinkled plots. It was pointed out that overhead sprinkling created a microclimate over the stand which favours development of diseases. According to Rotem et al., 1966, the change of the microclimate in the stand consists of a higher relative humidity 30-40% above that of the surroundings, and the lowering of temperature 2-8°C. However, this occurs only during the sprinkling period and for an hour or two after this period; also, these changes occur only on extremely warm and dry days, and dry but windless nights (see Fig. 7.). Only organisms that are associated with excessive moisture the fungus like Stemphylum botryosparius f. Lycopersici on tomatoes could develop under the conditions created by sprinkling. Others like Oidipsis Gaurica developed better in furrow irrigated plots (Rotem & al., 1966). As to differences regarding insect infestations Yagev et al., 1965 claim that sprinkled plots were slightly more infested with Spodoptera eggs than furrow-irrigated plots. Perhaps this is also the reason for a lesser infestation of irrigated potato fields by the potato tuber moth Gnorimoschema operculella which thrives better under conditions at lower relative humidity. Possibly the changes in the microclimate of the stand are of too short duration and at too long intervals to allow drastic changes in insect populations.

The situation is different with the changes in microclimatic conditions created in the soil. Overhead sprinkling covers the entire surface of the soil, and the changes are of longer durations. Insects that need contact moisture for development will thrive better in overhead dprinkled soil as happened with

the eggs of the red pumpkin beetle Hraphidopalpa foveicollis. Insects that can not stand too much moisture will leave the soil as did the larvae of the same pest. The moisture over the soil, as a result of overhead sprinkling will attract moisture-loving insects like the seed corn maggot Hylemyia cilicrura in greater amounts. The development of the eggs and larvae in such soil will be more successful. On the other hand, irrigated soil proved to be detrimental to Capnodis eggs.

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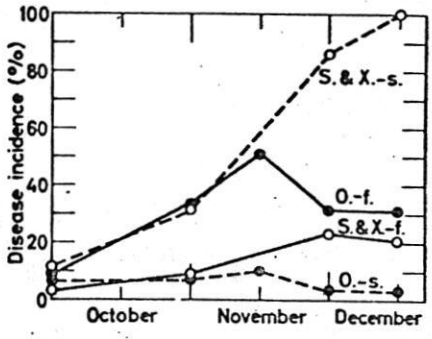

FIGURE 6. (Top) Disease incidence of Stemphylium botryosum f. lycopersici and Xanthomonas vesicatoria, and of Oidiopsis taurica in overhead-irrigated and furrow-irrigated fields. S. & X. - s.: Stemphylium and Xanthomonas in sprinkled plot. S. & X. -f.: Stemphylium and Xanthomonas in furrow-irrigated plot. O. - s.: Oidiopsis in sprinkled plot. O. - f.: Oidiopsis in furrow-irrigated plot.

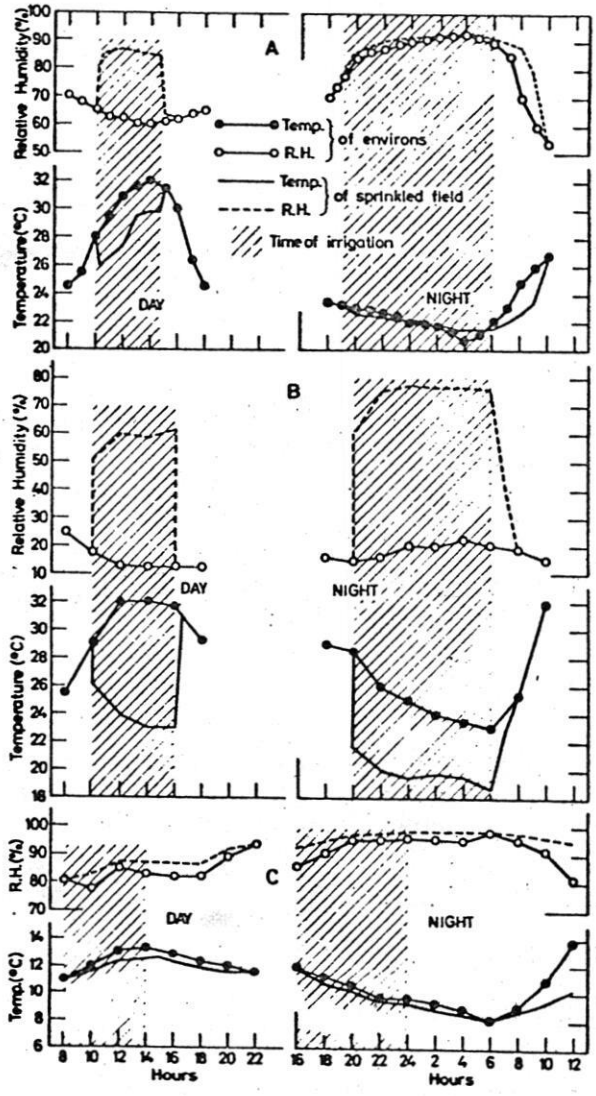

FIGURE 7. (Right) Temperatures and relative humidities of overhead-irrigated fields as compared with surrounding environment. A -- During a typical moderately windy summer day and windless night. B -- During an extremely hot, dry and windy day and a hot, dry but windless night. C -- During a cool, humid, cloudy and windless day and night.

(after Rotem et al., 1967)

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