THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

COMBATING AGRICULTURAL PESTS AND DISEASES THROUGH CULTURAL MEANS

ABSTRACT

Cultural practices are commonly known as simplest, cheapest and safest approaches for combating pests and diseases of agricultural crops. These involve modification of the environment governing the relationships between phytophagous fauna and their host plants. The main components targeted by such practices may include the soil, plant and climatic factors, besides the relevant regulatory measures. The physical and chemical properties of a soil have a great role on the status of soil biodiversity which ultimately affecting the biological activities in the plant rhizosphere. Since there are interactions between the soil, plant and the surrounding environment (biotic and abiotic), hence soil characteristics mainly interfere with the occurrence and severity of several pests and diseases. Therefore, soil manipulation through cultural means may have significant influence either in suppressing or enhancing such biotic stresses on plants. Moreover, certain cultural practices may also play an important role in modifying the micro-climate within the crop canopy, and therefore more or less affecting the performances of plants and phytophagous species. In this paper, the impact of some soil features and various cultural practices on the occurrence of plant pests and diseases were reviewed, with special reference to indigenous experiences accumulated in Sudan. Significant results were obtained through different measures; and in some instances full pests controls were achieved relying merely on cultural approach. The collected results encouraging more research on these neglected fields, which are potentially important in ecological pest and disease management.

KEYWORDS: Cultural practices; soil properties; pests; diseases; control; Sudan.

INTRODUCTION

A complex of many factors is always known to influence the status of a plant pest/disease, and consequently its damage and effect on crop yield. Some of these factors are ecological, but others may be of economical origin. Therefore, pest population densities are ecologically regulated within certain limits by the interaction of several biotic and abiotic factors. The former may include for instances; a practice of monoculture, quantity and quality of food available, intra-specific and inter-specific competition, and host-natural enemy relationship. On the other hand, abiotic factors are principally dependent on weather conditions, which affected by climatic elements (e.g., temperature, relative humidity, rainfall and wind), besides the soil conditions (i.e., physical and chemical properties of soil and its micro-climate). The above features are known to operate regularly in nature in a harmonious way to keep the sustainability of natural balance. But, the upset of this balance is the primary causes of unchecked population development of an organism. Although, such abnormal condition can be emerged through natural catastrophes, it is well known that the interference of man is the important factor causing the disturbance of ecosystems and environmental degradation. This can be exemplified by the extensive irrational usage of broad spectrum pesticides and other synthetic chemicals, and their well recognized negative impacts on the environment worldwide.

Accordingly, scientists are resorted again to the nature in recent years seeking for compatible ecologically sound measures suitable for crop management. Among recognized measures, cultural practices were considered as one of the important components in crop husbandry and integrated pest management, due to their dual positive roles in plant growth and pests' control[2]. These practices generally involved manipulation of soil and/or plant population, so as to make the environment more favourable for plant growth and

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY
ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

beneficial fauna, but unfavorable for the occurrence of pests and diseases. Also, legislation and quarantine regulations may have great impact as supportive measures, especially for combating invasive or alien species. Moreover, the soil structure (its physical and chemical properties) is considered as the main determinants of its function (biological activities). These ultimately affect the plant development directly, but also indirectly through interferences with pests and diseases.

There is an accumulated knowledge found scattered in literature concerning the impact of soil properties and cultural practices on phytophagous species, need to be collected, analyzed and evaluated as baseline data for future studies. This paper attempted to summarize the main points in this field, emphasizing the effects of soil characteristics and some important cultural practices on the prevalence of pests or diseases, with especial reference to indigenous knowledge experienced in the Sudan.

EFFECTS OF SOIL CHARACTERISTICS

The characteristic of a soil is an outcome of complicated physical and biological interactions undertaken over a period of time between so many factors within and outside the soil. These factors including mainly the physical (kind and texture), chemical (e.g., availability of organic matter and soluble elements) and climatic (e.g. temperature and humidity) status of a soil and its faunal and floral constituents, which keep nutrients cycling and natural balance. Cultural control, therefore, should make use of all these factors without detrimental disturbances to the natural systems.

Physical properties

The effect of soil physical properties on pest prevalence seems to be apparent in the case of root knot nematodes. Three species of these parasites are found in Sudan, namely Meloidogyna srenaria, M. incognita and M. javanica, with the last two species are economically important. Tomato and tobacco are greatly affected by M. javanica in northern part of the country, whereas M. incognita threatened tomato and eggplant in southern part. However, an important fact is that the occurrence of these plant parasitic nematodes are highly restricted to the light clay and sandy soils, and almost completely absent under heavy clay soils. Thus, root knot nematodes are always problems in silt soils along the banks of rivers, and in light alluvial soils of western and southern Sudan[3]. In these areas susceptible solanaceous plants are avoidable, but only resistant cultivars can be fit, though are rarely found. However, changing the physical properties of a soil may be somewhat difficult, but suitable solutions through cultural means are waiting for further studies.

Chemical and climatic properties

Numerous examples are detected showing the effects of soil chemical properties on plant pests and diseases. For example, the chocolate spot disease caused by Botrytis fabae/ Botrytis cinerea (Family: Moniliacae) is considered one of the important diseases of broad bean. This crop is generally prone to infection when it is grown in soils deficient in phosphate and potassium[4]. Therefore, the easiest way of controlling the disease is the addition of such elements. In this respect, the practice of putting increasing level of boron fertilizer in soil was found to affect its microbial population positively[5]. On the other hand, addition of certain chloride salts to the soil was found to reduce the severity of brown leaf rust (Puccinia recondita f.sp. tritici) on seedling and mature winter wheat plants. Salts like lithium, sodium or potassium chlorides, applied to the soil surface at the rate of 0.5g of pure chemical per plant, seven days before inoculation with P. recondita gave good control of the brown rust disease[6]. Moreover, an important parasitic weed in hot dry areas is the Orobanche racemosa. This weed is usually worse in alkaline soils.

The main climatic factors affecting soil properties may include the humidity and temperature. Regarding soil moisture, millet head worm Heliocheilus albipunctella, one of the destructive pest of pearl millet in western Sudan, was found to spend a long period of its lifecycle (10 months) as diapausing pupae in soil. Termination of diapauses is found to occur with the onset of the rainy season, at

ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

about 47-49 days from the start of the effective rain. Sharp decrease of pupation was noticed to be coupled with the increase in moisture content of the soil[7]. Such conditions were considered when cultivating millet in these areas through avoidance of peak infestation.

Temperature is a very critical factor for living organisms in soils. Saremi and Burgess (2000) indicated that temperature had a significant influence on the population levels of five Fusarium species. Although, some of these species showed noticeable reduction of population at warm temperatures, the population of F. solani and F. compaction were higher at high temperatures[8]. Therefore, high temperatures and relative humidity, in addition to high levels of nitrogen in soils are known as predisposing conditions for the appearance and multiplication of Fusarium wilt disease in Sudan. These and other soil characteristics can be manipulated though various cultural practices, as explained in the coming section. For instances, the addition of organic materials such as animal manures, green manures and plant residues plays an important role in this aspect. Hence, the addition of "dura straw" (i.e., sorghum straw) rich in carbon and poor in nitrogen to Fusarium infested soils, was found to reduce this disease, while green manuring and straw rich in nitrogen, increased infections by the disease[9,10].

EFFECTS OF CULTURAL PRACTICES

Pests and diseases control can be realized directly or indirectly by making use of the advantages associated with different cultural practices. Cultural control is one of the major and oldest control methods adopted by man which predated the appearance of synthetic pesticides. It is simply the use of farming practices associated with the crop production to make the environment less favourable for survival, growth or reproduction of pest species. Certain practices can be directed straight forward to kill some pest species. For proper application of cultural control thorough knowledge on biology and ecology of the intended pests, and predisposing conditions of diseases should be provided. The results of applying different cultural approaches for pests and diseases control, stressing available literature in Sudan, were summarized as follows:

Sanitation and removal of alternative hosts

Sanitation or hygiene is a vital operation in pests' containment for different crops. It involves destruction of crop residues following harvesting. These measures eliminate the breeding and sheltering opportunities and prevent the carryover of phytophagous species from one season to another. An outstanding example is the introduction of a cleanup campaign in the Gezira cotton since 1935. This campaign is carried out annually, and involved collection and burning of crop residues after cotton harvesting, followed by soil cultivation during April-May when temperatures are maximum to get rid of any source of infection from the surface and inside the soil. Such practice helps particularly in combating the pink boll worm (Pectinophora gossypiella Saund.), the cotton bacterial blight (Xanthomonas campestris pv. malvacearum) and the cotton leaf virus disease[11]. However, sanitation is equally performed during the growing season involving removal of diseased plants and infested parts or infested fruits, a practice which adopted in mitigating a number of major diseases and insect pests like damping off diseases, bollworms and fruit flies on various field and horticultural crops.

The program of sanitation also involved the removal of weeds that act as alternative hosts for pests and/or diseases. This may includes self sown seedlings (volunteers) or wild host species. Removal of these alternative hosts especially during the dead season of cotton in the Gezira scheme (April-June), helps in cutting the "green bridge" between successive seasons, hence preventing population buildup of several notorious pests such as the flea beetle (Podagrica spp.), cotton whitefly (Bemisia tabaci), cotton jassid (Jacobiasca lybica), African bollworm (Helicoverpa armigera), spiny bollworm (Earias insulana), pink bollworm (Pectinophora gossypiella) and cotton seed bug (Oxycarenus hyalinipennis). The major alternative hosts targeted are the "Hambouk" weeds (Abutilon spp.) and Hibiscus plants, members of Malvaceae, which harbour all the foregoing pest species[11]. There are several examples in Africa and elsewhere of

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE

Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

sanitation practices, including for instances the suppression of groundnut rosette disease and its main aphid vector, Aphis craccivora, in Tanganyika[12], and the control of cotton pests in Egypt[13].

Laws/ Legislative measures

Laws applied for crop protection either consist of those regulating quarantine measures at the inlet ports of the country to prevent introduction of exotic pests and diseases, or those enforced inside in form of domestic quarantines and localized legislations in certain farms. The latter is quite important for certain practices to be performed. However, a cotton ordinance was enforced in the Sudan Gezira since 1926, and accordingly certain things were prohibited included the growing of okra between 1st June and 15th September, and store of un-ginned cotton, cotton stalks and untreated cotton seed. The process reduced the carryover of various cotton pests and diseases especially the pink bollworm and bacterial blight[11,14].

Tillage operations

A part from its various agronomical benefits, tillage can be effective in smothering weeds and suppressing insect pests that spend part of their lifecycle in the soil. It can kill some pests, burry some and expose others to sun heat or to their natural enemies. Generally, the more soil manipulation, the greater the insect mortality. In the Gezira scheme, land is cultivated after the cleanup campaign. This operation is found to be very potent in killing the pupae of Sudan bollworm (Diparopsis watersi), pupae of African bollworm and adults of flea beetles[11]. Similarly, the emergence of the pink bollworm in the USA was also reduced from increased tillage[15].

On the other hand, the mechanical tillage or hand harrowing, known locally as “Azeeg”, are also used to manipulate the soil during the growing period for several purposes, i.e., to eliminate soil cracking, mowing weeds, amend ridging or to bury plant bases or tubers. The control of potato tuber moth (Gonrimoschema operculella) in Sudan is almost completely dependent on such practices which help to bury exposed tubers to be protected from the egg laying moth.

Sowing and harvesting time

Because of their critical influences on infestation, sowing and harvesting times should be carefully selected based on scientific research. It should be indicated in a way that enabling the crop vulnerable stage to avoid the period of pest invasion. Both sowing and harvesting dates were indicated for different crops in Sudan as well as in other countries to escape infestation by certain serious pests or infection by destructive diseases.

Sowing between July and August is being enforced for the Gezira cotton so as to avoid early sowing pests (flea beetles and bacterial blight), and those of the late sowing ones (pink bollworm). Also, the potato tuber moth and onion thrips (Thrips tabaci) are managed in central parts of the country by integrating many cultural practices including early sowing dates. Sowing of onion in between July and October so that seedlings can be well transplanted before December generally helps in escaping the peak infestation by thrips during January-March. Moreover, studies on sorghum midge (Stenodiplosis sorghicola) in rain fed at El Damazine area during 1998-2001 showed that the density and damage of the pest were low when the sowing date of sorghum performed between the first and the third week of July, after which the population of the pest increases rapidly depending on the onset of the effective rains[16]. A similar study was conducted to see the effect of three sowing dates (15th and 30th July, and 15th August) during 2000-2004, on the same pest infesting rainy sorghum at Gedarif area. Early sowing dates reflected in significantly low incidence of the pest and high yield for some varieties, compared to the late sown (15th August) crop which sustained the highest midge infestation and the lowest yield[17].

THE EXPERIMENT
INTERNATIONAL JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN-2319-2119

REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

Considering plant pathogens, root rot/ wilt disease complex of faba bean was found to be decreased with late sowing of the crop. The high disease incidence reported in early sowing was attributed to the relatively high soil temperature and reduced soil moisture, as predisposing factors for the disease[18,19]. Looking abroad, results of study conducted in Yemen on sesame phyllodae disease caused by mycoplasma like organism showed that the incidence of the disease decreased significantly in early sowing between February-March, compared with the late sowing (May-July). The disease incidence ranged between 15.2-19.9% and 24.5-86.8% for early and late sown crops, respectively. The corresponding seed yield obtained ranged between 1.7-1.8 tons/ ha and 0.31-0.93 tons/ ha, in the same order[20].

Indicating optimum harvesting times can be of prime importance in minimizing post harvest damage especially of vegetables and fruits. In Sudan, it was determined that sweet potato and Irish potato should be harvested as soon as they are mature so as to minimize damage by the sweet potato weevil (Cylas puncticollis) and the potato tuber worm, respectively. It was reported that late harvesting of sweet potato, 6-7 months after transplanting, subjected the crop to more damage by C. puncticollis[21,22]. Moreover, earlier observations revealed that shortening intervals between okra pickings and guava harvestings, greatly minimized the damage induced by Earias spp. and fruitflies on the two crops, respectively.

Clean seed materials

Seeds or vegetative propagating materials such as tubers, cuttings, offshoots, seedlings ...etc., are of basic importance in obtaining healthy crops. Seed quality is the major determinant of crop potentiality. Many factors determined the quality of seed, among which are; seed maturity, inherited characters, cleanness from injury, pests and diseases. Therefore, seeds supposed to be diseased or infested can be treated through cultural means. For instances, cotton seeds are treated with heat/ hot air in Egypt and Sudan to kill the larvae of the pink bollworm diapausing inside the seeds[13,14]. But in Sudan, pests of cotton seeds are sometimes exposed to sun heat for 24 hours during the hottest time of the year[14].

Plant population (Thinning) and stands

Plant population density (inter-rows and inter-holes spacing, and the number of plants per hill) is very important agronomically for each crop, because it enables optimum utilization of climatic and soil resources by the plant. When considering crop protection, such population density should be adjusted in a way to be suitable for plant growth, but creates less favourable microclimatic conditions for pests and diseases. After germination, thinning is important to optimize plant population, and to remove weak and diseased seedlings. Such practice enables farmers to minimize sympathetic microclimate within cotton canopy for whitefly, and to get rid of stem canker diseases in the Gezira scheme[11]. Contrarily, reducing faba bean population (16.6 plants/ m²) significantly buildup infections by the root rot/ wilt disease, compared with high population (49.9 plants/ m²)[19]. Also in Nigeria, Akinkunmi et al. (2012) showed that narrow spacing in sunflower crop (65 cm x 75 cm) was resulted in significantly higher populations of major pests and higher damages of leaves, stems and flower heads than wide spacing (100cm x 75cm) which reflected in the lowest infestation and the highest seed yield[23].

Plant stands is another agronomical factor influencing biotic stresses in crops. According to Oji and Ali (2005), staking (trelling) of tomato plants significantly reduced the whitefly infestation as well as sunscald, fruit rotting and other fungal diseases in the crop, and hence increased marketable yields by 95.3%[24].

Irrigation practices

Quantity and frequency of crop watering generally govern the microclimatic conditions in the soil and within plant canopy. Therefore, good irrigation management can eliminates predisposing conditions for several plant diseases and make the environment unsuitable

ISSN-2319-2119

REVIEW ARTICLE

Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

for some insect pests. In the Gezira scheme, heavy watering or flooding of cotton crop was practiced to discourage microbial infection (e.g., bacterial blight) and to kill numerous pests, especially those spend part of their lifecycle in the soil, e. g., thrips (Caliothrips spp.), Sudan bollworm, African bollworm and flea beetles[11]. However, in field experiments at Shambat, Khartoum North, during 1998/99-1999/2000, frequency of irrigation was tested against onion thrips (Thrips tabaci) on a local onion cultivar (Saggai). The results proved that the shorter irrigation intervals (every 7 days) sustained the highest nymphal population, while the longer intervals (14 days) harbour the lowest. More watering also resulted in better onion growth that masked off the negative impact of thrips on yield[25]. Also, field experiments were conducted at Shambat during 2001/02-2002/03 to study the effect of three irrigation intervals (7, 14 and 21 days) on sweet potato damage caused by the sweet potato weevil (Cylas puncticollis). Plots received the longest irrigation intervals (21 days) manifested serious damage by the pest compared with those of the shortest intervals (7 days). It is concluded that water stressed sweet potatoes suffer higher level of insect damage than unstressed crop[22]. Also, different watering intervals (4, 8, 12 and 16 days) were evaluated on the incidence of pink root rot disease of onion. It is proved that the disease is aggravated with an increase in watering intervals[26].

Crop rotation

Crop rotation where by different non host plant species alternated with the host plant in the same land is found to be very effective in decimating various pests and diseases, especially those of monophagous and oligophagous habits. The rotation should be supported with good cultivation practices so as to get rid of volunteer plants and other wild alternative host species in vicinity, which may act as refuge and interfere with the rotation. Crop rotation and cropping sequences adopted for some crops help in controlling certain pests and diseases in different parts of the country. The cotton rotation managed to reduce the occurrence of flea beetles, cotton thrips, bacterial blight and Fusarium wilt[11]. Rotation is also found to be effective in mitigating some vegetable diseases like the pink root rot of onion and Fusarium wilt of tomatoes. Wiggins and Kinkel (2005) stated that potatoes grown in soil planted to corn or alfalfa the previous year had significantly lower Verticillium wilt and potato scab ratings as well as higher yields than potatoes grown in soil previously planted to potato[27]. Moreover, rotation can equally be important in controlling parasitic weeds and nematodes, especially those of limited hosts range. Results of three cropping sequences applied in Khartoum area during 1997-2003 managed to control Orobanche ramosa on tomatoes. These sequences, viz., wheat-onion-faba bean-tomato; onion-onion-onion-tomato, and onion-alfalfa-alfalfa-tomato, induced great reduction in the parasite infestation ranged between 75 to 98%[28].

Weeding

Since weeds compete with the crop for nutrients, water and sun light, they should be eradicated to leave the space for proper establishment of the crop to withstand adverse conditions. It is known that fit crop can tolerate pests and diseases attack. Although, weeds may act as alternative or alternate hosts for certain pests or diseases, but sometimes they may harbour beneficial species like natural enemies of pests and plant pollinators. Therefore, the removal of any weed plant should be based on sound experimental findings. Among the important weeds controlled in the Gezira is Hambouk, Abutilon spp., as it harbours cotton pests like Earias insulana[11].

Fertilizers

Fertilizers should complete the deficiency in soil nutrients to help in establishing vigorous plants that withstand attack of pests and diseases. But, sometimes fertilizers are known to interfere positively or negatively with certain phytophagous species. Addition of nitrogen to the cotton plants in form of urea was found to enhance the population buildup of whitefly in the Sudan Gezira. As mentioned before in the soil section, the fertilizer containing high level of nitrogen is one of the predisposing factors for increasing Fusarium wilt disease, while deficient of phosphate and potassium is conducive to Botrytis infection[4,9,10].

ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

Other rich sources for enriching soil nutrients are the organic fertilizers. These natural fertilizers are considered as the best additives that bring dead soils to life and make the plants healthier. They enhance biological activities, thus provide almost all the necessary fertilizing nutrients and food webs for natural enemies that suppress pests and diseases. In Sudan, soil amendment with organic manure followed by a fallow period and exposure to direct sunlight was found to suppress the black scurf disease of potato caused by Rhizoctonia solani Kuhn and to improve the tubers yield[29]. Use of green manure (buckwheat-treated soil) was found to reduce Verticillium wilt significantly and increase the yield of potato[27]. Organic rice was reported to have thicker cell wall, more tolerance and even more resistance to insect attacks than conventional rice[30]. Chau and Heong (2005) found that organic fertilizers and manure compost enhanced rice growth and significantly reduced insect pests and diseases such as brown plant hopper, stem borer, leaf folder, blast and sheath blight[31]. In contrast, sucking and chewing insect pests were reported to be significantly higher in crops grown with synthetic/ or inorganic fertilizers[32,33,34]. Application of organic fertilizer for two consecutive years in maize field was recorded to host fewer populations of aphid (Rhopalosiphum maidis) than maize grown with synthetic fertilizers[35].

Intercropping

The system of intercropping necessitates growing of different crops simultaneously on the same land. Such diverse community has fewer fluctuations in numbers of a given species and is stable. Several cultural practices are known to promote diversity and stability on the farm, including the intercropping[36]. This practice increased the distance between plants of the same species which leads to complicate migration of pests or transmission of diseases from one plant to another in the same field[37]. In crop protection generally there is a base crop and one or more associated plants grown within, acting as repellent or attractant for certain pests. Attractant species are mainly used as trap plants to reduce pest infestation on the base crop. Once pests are lured from the main crop on to the trap plants, they can be controlled in limited area with minimum cost.

It was reported that intercropping strips of alfalfa within cotton fields can act as a trap crop for lygus bugs. Experiences in Sudan also showed numerous examples of intercropping advantages in pest control. Field intercropped fenugreek (Trigonella foenum greacum) with muskmelon decreased various pests (B. tabaci, Aphis gossypii and Aulacophora Africana) and suppressed oviposition of Epilachna elaterii and its subsequent numbers[38,39]. Also, intercropping of millet with sorghum to disrupt egg laying of the millet head worm (Heliocheilus albipunctella), significantly minimized the pest infestation on millet compared to the sole crop[7]. Vegetable crops intercropped with Lablab purpureus, as a trap plant, significantly divert the population of Bemisia tabaci on to the latter crop. Because L. purpureus is a non host for the leaf curl virus, it contributes a lot in reducing the disease incidence when intercropped with some susceptible vegetables like tomatoes[40]. On the other hand, sowing of L. purpureus in alternating holes with sorghum on the same day, suppressed Striga weed population density by 88%, compared to sole sorghum crop[41].

However, recently both of repellent and attractant plants are utilized in pest management, an approach known as “Push-Pull” strategy. This was applied in controlling whitefly on Phaseolus vulgaris when intercropped simultaneously with L. purpureus and Coriandrum sativum. The latter crop acted as a repellent, while L. purpureus diverted the whitefly away from the main crop (P. vulgaris)[42]. Regarding diseases, Al-Heety and Al-Hadethy (2006) found that growing sorghum and maize as barriers around sesame significantly reduced the phytoplasma disease incidence to 0.46% and 1.95%, respectively, as compared with the control (5.68%)[43].

Mechanical and physical methods

Among the earliest and familiar economical practices of cultural control applied in several countries, is the hand collection and killing of pests. This was considered as a profitable method for removal of Papilio caterpillars from young citrus trees in some countries. Hand picking of Spodoptera littoralis egg masses from cotton fields in Egypt is a common practice applied[13]. In Sudan, hand collection and destruction of the melon bug (Coridius viduatus), a serious economic pest of water melon in western States, during the resting period in summer (15th May-15th July) was proved to be the most effective, easier and non costing control tactic ever known for this pest. Adoption of such control measure had encouraged farmers to expand the area under water melon by 93%, few years following the program commencement, hence significantly reflected in settlement of nomads, increase of animal production and water conservation (72.3%). However, the major environmental and economical benefit from the hand picking of bugs is the gradual reduction in the quantity of chemical insecticides used for the pest control, from 10 tons before the start of the program (2000) to nil in the fifth year (2004/05)[44]. Now, control of the pest is completely relies on cultural means.

This part of cultural control also may include banding, mechanical drags (crushing), burying and burning to get rid of insects. Destruction and burning of date palms infested by the red palm weevil (Rhyncophorus ferrugineus) is applied to eradicate the pest from localized new invaded areas. Banding of fruit trees especially to kill flightless moths, caterpillars, ants and other resting insects, is found to be effective. Among earliest approach of locust control was to herd hopper swarms into large pits to be buried with soil. However, in western Sudan, there are some persons known as "Danbari", exploiting certain ecological and behavioral features of the desert locust, cut the way for several migrating swarms of the pest and divert them to already prepared ditches or deep holes where locusts kept to be sold as human food during other seasons. But, ditching is sometimes used to control insects resting in large clusters on trees, such as the sorghum bug (Agonoscelis pubescens) during November-July. The trees are shaken vigorously to drop large number of insects in the holes beneath, which then buried. The mechanical drags or crushing of insects on the ground, though experienced against some pests like Spodoptera littoralis, but the practiced has already been abandoned. Moreover, a physical method of insect destruction is shown in the control of cotton stainer bugs (Dysdercus spp.) in western Sudan. This late season pest affected seed quality and contaminated cotton lint causing economic loss. The habit of pest hibernation in big clusters on some trees (e.g., Adansonia digitata) during the dead season was exploited in its control through burning of clustering bugs in these sites by utilizing blow flames[11,45].

CONCLUSION AND RECOMMENDATIONS

The paper conveyed prominent examples of partial and complete control of some crop pests/diseases based on ecologically sound cultural operations.

The properties of soils and crop micro-climate which can be manipulated through cultural means are the important factors that need to be studied carefully for managing predisposing conditions of phytophagous species.

Future cultural control should be focused in view of its broadest sense accompanying recent trends that exploiting ecology and biodiversity in various strategies (habitat manipulation, ecological control, Push-Pull strategy, .etc) of crop management.

REFERENCES

1. Afresh-Nuamah K 1984 The neglected aspects of agriculture in the third world: Research in insect control practices. African Journal of Agricultural Sciences 11 (1+2): 124-125.
2. Hill DS, Waller JM 1982 Pests and diseases of tropical crops. Principles and methods of control. 1, 52-59.
3. Yassin AM 1986 Problems of plant parasitic nematodes. In: Bashir, S., El Tigani KB, El Tayeb YM and Khalifa H (eds.). Crop pest management in the Sudan, Proceedings of a Symposium held in Khartoum, February 1978. Published by the Ministry of Agriculture and the University of Khartoum, Sudan. pp. 389-395.
4. Giha OH 1987 Plant pathology, an introductory Course. Willey Eastern Limited, India. 132 pp.
5. Bilen S, Bilen M, Bardhan S 2011 The effects of boron management on soil microbial population and enzyme activities. African Journal of Biotechnology 10(27): 5311-5319.

ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

6. Hashim LO, Russel GE 1982 Possible control of brown leaf rust on winter wheat by applying chlorides to soil. Cereal Rusts Bull., 10 (2): 29-34.
7. Bashir YGA, Eisa MA 2004 Studies on the ecology and the mechanism of resistance to the millet head worm, Heliocheilus albipunctella de Jo. (Lepidoptera: Noctuidae). The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
8. Saremi H, Burgess LW 2000 Effect of soil temperature on distribution and population dynamics of Fusarium species. J. Agr. Sci. Tech., 2: 119-125.
9. Abu Salih HS 1962 Annual Report of the Agricultural Research Division for the year 1961/62, Sudan.
10. Khalifa H 1966-68 Annual Reports of the Agricultural Research Division for the years, 1965/66; 1966/67 and 1967/68, Sudan.
11. Sharaf El Din N, Saleem MBA, Omer MEH 1986 Non chemical pest control practices. In: Bashir S, El Tigani KB, El Tayeb YM, Khalifa H (eds.). Crop pest management in the Sudan, Proceedings of a Symposium held in Khartoum, February 1978. Published by the Ministry of Agriculture and the University of Khartoum, Sudan. pp. 67-77.
12. Evans AC 1954 Groundnut rosette disease in Tanganyika. I. Field studies. Annals of Applied Biology 41:189-206.
13. Isa A, Attiah HH 1986 Integrated control of pests infesting the major crops in Egypt. In: Bashir S, El Tigani KB, El Tayeb YM, Khalifa H (eds.). Crop pest management in the Sudan, Proceedings of a Symposium held in Khartoum, February 1978. Published by the Ministry of Agriculture and the University of Khartoum, Sudan. pp. 219-228.
14. Kisha JSA 1986 Control of pink bollworm in the Gezira. In: Bashir S, El Tigani KB, El Tayeb YM, Khalifa H (eds.). Crop pest management in the Sudan, Proceedings of a Symposium held in Khartoum, February 1978. Published by the Ministry of Agriculture and the University of Khartoum, Sudan. pp. 79-90.
15. Watson TF, Moore L, Ware GW 1975 Practical insect pest management, a self instruction manual. pp. 2-48.
16. Fadlelmula AA, Nasr Edin I 2004 Strategies for sorghum midge (Stenodiplosis sorghicola Coq.) control in sorghum in rain fed areas. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
17. Suliman EH 2004 Effects of sowing dates and variety on the incidence of sorghum midge Contarinia sorghicola (Coq.) in Gedarif State. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
18. Ahmed EM 1987 Studies on wilt and root rot disease complex of faba bean (Vicia faba L.). M. Sc. Thesis, Crop Protection, University of Gezira. 105 p.
19. Salih FA, Ageeb OAA 1987 The effect of plant population, sowing date and pigeon pea shelter (shading) on the incidence of the root rot/ wilt disease complex and yield of faba bean. FABIS Newsletter, vol. 18, August 1987. pp. 18-20.
20. El-Saggaf SM 2006 Effects of sowing date on the incidence of sesame phyllodae disease and yield of sesame (Sesamum indicum L.) in Wadi Hadhramout, Yemen. Ninth Arab Congress of Plant Protection, 19-23 November 2006, Damascus, Syria.
21. Siddig SA 1990 Integrated pest management for potato in Sudan. Proceedings: Integrated Pest Management in Tropical and Subtropical Cropping Systems, December 1989, Frankfurt: Deutsche Landwirtschafts-Gesellschaft 1990. pp 281-291.
22. El Zubeir A, El Khidir E, Mowafi K 2007 Effect of irrigation intervals and sweet potato cultivars on infestation levels of the sweet potato weevil Cylas puncticollis Boheman. University of Khartoum Journal of Agricultural Sciences 15(3): 448-463.
23. Akinkunmi OY, Akintoye HA, Umeh VC, AdeOluwa OO 2012 Influence of spacing on the feeding activities of major pests of sunflower and their associated damage. Agriculture and Biology Journal of North America 3(6): 233-236.
24. Oji FL, Ali TE 2005 Integrated management of whitefly and sunscald: the major tomato yield reducing factors in Sudan. The 3rd International Conference on IPM Role in Integrated Crop Management and Impacts on Environment and Agricultural Products, 26-29 November 2005, Giza, Egypt.

ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

25. Dawood KH, El Khidir E, Abdelbagi AO 2004 Effect of irrigation intervals on onion thrips population and its impact on crop yield. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
26. Ali GHM, El Hassan HS, Fregon SO 1984 Effect of frequency of irrigation and cultivar on the incidence of pink root rot disease of onions. Acta Hort., 143: 427-432.
27. Wiggins BE, Kinkel LL 2005 Green manures and crop sequences influence potato diseases and pathogen inhibitory activity of indigenous streptomycetes. Phytopathology 95:178-185.
28. Dongola GM 2004 Effects of crop sequence Orobanche ramosa L., in tomato crop. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
29. Hamid EE, Himeidan YE, El Hassan SM 2006 Cultural practices for the management of Rhizoctonia disease in potato. J. King Saud Univ., Vol. 18, Agric. Sci. (2): 141-148.
30. Ramesh P, Singh M, Subba Rao A 2005 Organic farming: Its relevance to the Indian context. Current Scientist 88(4): 561-568.
31. Chau LM, Heong KL 2005 Effects of organic fertilizers on insect pests and diseases of rice. Omonrice 13: 26-33.
32. Kowalski R, Visser PE 1979 Nitrogen in a crop-pest interaction: Cereal aphid. Nitrogen as an ecological parameter, pp. 16–17. Blackwell Sci. Pub., Oxford. UK.
33. Altieri MA 1994 Biodiversity and Pest Management. Agro-ecosystem, p.185. Howarth Press, NY.
34. Myers D, Stolton S 1999 Organic cotton-from field to final production, p. 250. Intermed. Technol. Publication, NY.
35. Morales H, Perfecto I, Ferguson B 2001 Traditional fertilization and its effect on corn insect population in the Quatemalan highlands. Agric. Ecosys. Environ., 34: 145-55.
36. Ouma G, Jeruto P 2010 Sustainable horticultural crop production through intercropping: The case of fruits and vegetable crops. Agriculture and Biology Journal of North America 1(5): 1098-1105.
37. Magaguda GT, Haque I, Godfrey W, Fendu I, Masina GT 1979 Intercropping studies in Swaziland: Present status and future projections. Proc. Int. Workshop on intercropping 10-13 January 1979, Hyderabad, India, pp. 98-104.
38. Mahmoud AK 2000 Investigation in the use of intercropped fenugreek (Trigonella foenum greacum L.) and its extracts in control of muskmelon pests and assessment of their side effects on predators population. M. Sc. Thesis, Faculty of Agriculture, University of Khartoum/ Sudan.
39. Mahmoud AK, Abdelbagi AO 2004 Effect of intercropping of fenugreek and muskmelon on insect pest population of muskmelon. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
40. Satti AA 2008 Mixed cropping and intercropping as cultural means of control for some cucurbit pests. 23rd International Congress of Entomology, 6-12 July 2008: International Convention Centre, Durban, South Africa.
41. Dawoud DA, Ahmed EA, Abdalla NK, Sauerborn J, Babiker AGT 2004 Influence of intercropping of sorghum (Sorghum bicolor L.) (Moench) with hyacinth bean (Lablab purpureousL.) on Striga control and sorghum growth and yield. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
42. Oji FL, El Hag FA, Awad TI 2004 Whitefly management by exploiting biodiversity in a “Push-Pull” strategy on Phaseolus vulgaris. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
43. Al-Heety AA, Al-Hadethy ON 2006 Survey of weed and insects associated with Sesamum indicum L. crop and evaluation of transmission methods of the phytoplasma causing phyllody diesease to sesame crop. Ninth Arab Congress of Plant Protection, 19-23 November 2006, Damascus, Syria.

ISSN-2319-2119
REVIEW ARTICLE
Abdelrahim Satti, The *Experiment, December .2012 Vol. .5(4), 304-314*

44. Ibrahim RE 2004 The experience of mechanical control of water melon bug, Coridius viduatus (F.), and its impact on human beings and environment. The Second National Pest Management Conference in the Sudan, 6-9 December 2004. Faculty of Agricultural Sciences, University of Gezira, Wad Medani/ Sudan.
45. Satti AA 2006 Pesticides alternatives from local environment on light of traditional legacies and scientific research in Sudan - A supportive paper. The Development and Environment National Conference, 18-20 September 2006, Friendship Hall-Khartoum/ Sudan.

Abdalla Abdelrahim Satti

Environment and Natural Resources Research Institute, National Centre for Research
Khartoum/ Sudan;
E-mail: satisattisat@yahoo.com