Effect of Non-crop Vegetation on Insect Infestations and IPM in Reduced-Tillage Corn and Sorghum Production Systems in Low and High Technology Agriculture

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Abstract

Nan-crop vegetation in conservation tillage systems can influence the abundance and importance of phytophagous insects and plant diseases in contrasting ways in low and high technology agriculture. In Honduras, non-crop vegetation in fields of interplanted corn and sorghum may either increase or reduce damage to the crops by insect pests, depending on larval host food preferences, and the timing and efficacy of weed removal procedures. A complex of four lepidopterous species attacks broad leaf weeds and grasses in subsistence production fields prior to crop planting. The larvae move from this vegetation onto the seedling corn and sorghum and damage or destroy the crops. Weed removal from production fields is recommended to lower insect pest abundance and reduce damage to the crops. Corn production in the high input crop production systems in the southeastern United States can he used to illustrate the divergent roles of weeds in influencing insect vector abundance and incidence of two insect-borne diseases, namely maize dwarf mosaic and corn stunt. Johnsongrass, an early season host for maize dwarf mosaic virus and host for aphid vectors, is responsible, in part, for aphid population buildup during early spring and is a source of innoculum to the aphid vectors, particularly the corn leaf aphid. Removal of Johnsongrass would eliminate this host for aphids and the maize dwarf mosaic virus. Conversely, the incidence of corn stunt disease may he correlated directly with amounts of non-crop vegetation in production fields. Conservation tillage methods may help reduce losses to corn stunt disease by allowing weeds to develop in the field. The black faced leafhopper vectors prefer to feed on the non-crop grasses and remain on these weeds, feed less on corn and thus the incidence of corn stunt disease is lower in the field. Weedy corn fields have the highest number of leafhopper vectors, hut a lower incidence of corn stunt disease than weed-free fields.

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Introduction

Eighty-two percent of the world's population is found in developing countries. These countries occupy 62% of the world's land area. The needs of agriculture in developing nations can differ greatly when compared with developed nations, and the solutions to many of the agricultural problems in the former, must of necessity, be different from those of the latter (Mellor, 1988). In developed nations, agricultural production relies heavily on inputs of fuel, fertilizer, insecticides, fungicides, nematicides, and herbicides. Crop varieties are developed and chosen for optimal yield under these high-input conditions. Agriculture in developing nations has evolved differently, and remains more vulnerable to climatic and pest uncertainties. Here, human and animal power have not been replaced by fossil fuels (Oram, 1988). and agricultural chemicals are not in common use.

A major goal of high technology, mechanized agriculture is to optimize return on investment, or stated another way, the goal is to derive the maximum dollar return per dollar spent on production. The farmer's profit depends upon inputs, yield, and the value of his crop at the time of harvest or some future date after storage. Laws of supply and demand, global grain supplies, and governmental programs influence directly the value of the high technology farmer's commodity. The low technology farmer in a developing nation often faces different circumstances. His crop will usually be consumed on farm, and a portion may be sold for capital. Choice of crop and cropping practice is often determined by local needs and/or weather patterns (DeWalt and DeWalt 1984) and crops are often interplanted in order to minimize risk of total crop loss.

By addressing some aspects of corn (or corn/sorghum) production we will illustrate the divergent role of weeds in influencing insect abundance and associated feeding damage and/or incidence of plant diseases in low technology and high technology agricultural systems.

Low Technology Corn Production

Corn and sorghum are often grown intercropped together in low technology, subsistence farming systems in many areas of Latin America. In years of high corn yields, corn is used for human consumption and sorghum is often fed to livestock (Hawkins, 1982). In years of severe drought, corn often fails and sorghum is then used for human consumption.

In Honduras, a complex of lepidopterous species attacks corn and sorghum during both the first (primera) and second (postrera) growing seasons. These pests are collectively referred to as the "langosta" (Pitre, 1989). and they frequently destroy crop stands in the first plantings. The most damaging members of the langosta during the early growing season are the fall armyworm (FAW), *Spodoptera frugiperdu* (J. E. Smith), the southern armyworm, *S. eridania* (CRAMER), and *Metuponpneumata regenhoferi* Moschler. The grasslooper, *Mocis latipes* (Guenee), reaches pest status Some years.

The presence of non-crop vegetation near or within fields may either promote or reduce pest damage, depending on the pest and plant species involved, and the duration of feeding and extent of damage caused by the insects to the non-crop host plants (Pitre, 1989;Portillo, 1989 personal communication). Moths oviposit on non-crop vegetation and larvae move onto the crop after they have consumed the weeds. Broad leaf plants are more common than species in the Graminae. The lepidopterous larvae feed on seedlings and young whorl stage plants of the broad leaf weeds, including *Melumpodium divaricatum* (L.C. Rich) and *Portulaca aleraceu,* L. and grasses, including *Seraria* sp.. *Echinodea sp., Cynodon dactylon,* (L.) *Ixophorus unisetus* (Presl) Schlecht., *Punicum* sp. and other unidentified species. At least nine broad leaf weeds and six grass species (not all identified) were present in our study fields in southern Honduras (Pitre, unpublished). Knowledge of the biological and ecological relationships between the insect pests and non-crop vegetation in and around production fields is useful in developing cultural, non-chemical insect pest management practices. Pitre (1989) recommended the removal of non-crop vegetation from fields and field borders as a means of reducing larval numbers and damage to the corn and sorghum crops in the primera.

Of the many pests of corn and sorghum in Honduras, the FAW is one of the most serious. In southern Honduras, it is the major constraint to successful corn and sorghum production (DeWalt and DeWalt, 1984). Castroet al. (1989) found that FAW infestations were lowest in sorghum fields with a natural weed complex present compared with sorghum monoculture or sorghum intercropped with corn. Similarly, Altieri (1980) found that weed-free corn fields in monoculture in Florida had twice as many FAW larvae as weedy corn fields. His studies in Colombia also showed fewer FAW larvae in corn fields with weeds, compared with fields with good weed control. Castro et al. (1989) speculated that crops in weedy fields were stressed through competition with weeds, and hence were nutritionally less fit for the FAW than crops in other treatments. This is based on the fact that FAW lays more eggs on sorghum grown with adequate fertilization than sorghum grown under suboptimal nutrient conditions (Van Huis, 1981). Additionally, weedy corn or sorghum fields have fewer FAW larvae than fields with fewer weeds because the weeds may reduce the moths' host finding ability (Altieri and Whitcomb, 1980). Root (1973) proposed the "resource concentration hypothesis" for situations in which non-crop species associated with preferred crop species reduce the ability of a herbivore to detect and utilize its host plant. Such reduced responses by herbivores may result through masking cues that potential herbivores use to detect appropriate hosts, or may be due to a subtle alteration in the microclimate so as to encourage a pest's emigration from the field (Risch et al. 1983). An alternative hypothesis, the "natural enemies hypothesis" was proposed by Pimentel (1961). According to his hypothesis, increases in pest mortality are observed in more diverse fields. Consequently, fields with higher diversity and increased stability have more abundant natural enemies than fields with less diverse vegetation. There is obviously a practical limit to beneficial weediness in a field, and Risch et al. (1983) suggest that this point is reached when the positive effects of diversity are out-weighed by the loss in yield due to plant competition.

High Technology Corn Production

The high technology producer has a different set of tools with which to address a different set of problems. Subsistence farming is not his goal, rather, it is to maximize return on investment. Where the major risks faced by the low technology farmer may be weather and pests in producing enough food on a small amount of land to feed his family, the high technology farmer is more concerned with weather, commodity prices and the interest rate at his local bank.

One method of cost control in agriculture is the adoption of conservation (= minimum = reduced) or no-tillage crop production techniques. In general, conservation tillage reduces producer costs and soil erosion, preserves soil moisture, and may influence pest biology and behavior through reduced soil temperatures and altered vegetational structure within fields. This practice has been addressed in a recent review by Pitre and Porter (1989). Reduced tillage methods have become widely accepted in the U.S., but pest problems constitute a serious limitation to acceptance of these techniques in reduced-input agriculture.

While increased weed abundance in no-till fields can cause direct yield loss through weed/crop competition, this may not always be the major factor in yield reduction. Insects associated with crop and non-crop vegetation may transmit plant disease agents from plant to plant, and their role as vectors is usually more important than their direct feeding injury (Knoke, 1976). Two vector-borne diseases associated with corn serve here as examples of the contrasting role of weeds in the dynamics of insect pest populations and disease incidence in crop production systems utilizing high technology agricultural inputs. The corn/Johnsongrass *[Sorghum halapense* (L.) Pers.] /maize dwarf mosaic virus (MDMV)/ aphid vector interrelationship is one example of this situation. Johnsongrass, an important overwintering and early spring host of MDMV (Williams and Alexander, 1965), is commonly found in and around no-till fields, and is phenologically more advanced by several weeks compared with conventionally tilled fields. Weed growth in no-till fields is not delayed compared with that in conventionally tilled fields (All and Musick, 1986).

The corn leaf aphid, *Rhopalosiphum maidis* (Fitch) is one of several aphid vectors of MDMV (Gordon, 1976). and feeds preferentially on Johnsongrass early in the spring before and after corn is planted before moving to corn (Nault. 1976). Aphids acquire the MDMV from Johnsongrass and transmit the virus to corn.

Several tactics are used to control MDMV in high-input production systems, all of which seek to disrupt the virus/ vector/Johnsongrass/corn interaction. The most economically feasible options are the use of virus resistant corn varieties and early planting (Pitre, 1970). which allows corn to escape virus infection during its most susceptible stages and before large vector population build up. The use of conservation tillage in corn production may be impractical in areas with a history of MDM disease, large vector populations, and high density of insect vector non-crop host vegetation. However, rotation of soybean with corn allows for aggressive weed control to be implemented during the soybean portion of the rotation (All and Musick, 1986), which may be effective in reducing levels of MDM disease in the corn crop.

Thus, the presence of overwintering reservoir and early season weed host plants for virus disease agents and susceptible growth stages of the crop are requisites to the establishment of epiphytotics in corn production systems. Conversely, situations do exist where non-crop vegetaion can have a negative influence on crop disease severity and crop losses due to disease. Corn stunt disease, caused by the corn stunt spiroplasma, formerly recognized as corn stunt virus, was responsible for reductions in corn production in some parts of the southeastern United States in the 1960's (Gordon, 1976). The disease is transmitted to corn by several leafhopper species, including the black-faced leafhopper, *Graminella nigrifrons* (Forbes) (Boyd and Pitre, 1969).

Many grasses (weeds) serve as feeding host for G. *nigrifrons* (Table I. from Boyd and Pitre, 1969). Survival of adults varies depending on the host plant. Of the grasses encounttered in and around corn fields in Mississippi, survival was highest (20-33%) on orchardgrass *(Dactylis glomerata* L.) and crabgrass *(Digitaria sanguinalis* L.), and lowest (6-18%) on Johnsongrass, goosegrass *(Eleusine indica* L,), and lowest (6-18%) on Johnsongrass, goosegrass *(Eleusine indica* L.), bracharia *[Bracharia platyphylla* (Griseb.) Nasb.], Bahia grass *(Paspalum notafum* Flugge), common Bermudagrass *[Cynodon dactylon* (L.) Pers.], Dallisgrass *(Paspalum dilatatum* Poir.), and carpetgrass *(Axonopus affinis* Chase). Adult *G. nigrifrons* survival was generally poor on most of the plant species, including some cultivated crops tested by Boyd and Pitre (1969).

Corn is not a preferred feeding host of *G. nigrifrons.*

Table 1. Adult survival of and oviposilion by *G. nigrifrons* on various plant species after a 10-day confinement.*

Plant selection	No. eggs**	% survival**
Sorghum. Sweet Sioux	51.7 abc	33.1 a
Rice, Nato	54.3 ab	32.0 a
Ryegrass. perennial	10.3 def	31.0 a
Fescue, tall	5.0 det	27.4 a
Sudangrass, greenleaf	24.9 abcde	21.2 ah
Ryegrass. annual	9.3 def	27.2 ab
Barley. Colonial	27.5 abcd	27.1 ab
Millet. common pearl	67 2 a	24.5 ab
Orchardgrass	16.8 bcdef	24.2 ah
Sudangrass, sweet	19.1 abcdef	22.5 ab
Wheat. Anderson	14.9 bcdef	21.3 ab
Rye. Abruzzi	16.6 bcdef	20.7 ah
Crabgrass. large	14.9 bcdef	20.6 ab
Oat. Moregrain	56.1 ab	20.5 ah
Sugarcane	18.2 bcdef	18.0 ah
Johnsongrass	26.0 abcde	16.4 ab
Sorghum-Sudangrass hybrid. Suregraze	20.7 abcdef	16.1 ab
Corn, Mcurdy M-306	17.1 bcdef	16.1 ab
Coker 67	24.2 abcdef	15.7 ab
Seneca Chief	23.0 abcdef	15.4 ab
Funk's G-740	11.4 cdef	15.1 ab
Goosegrass	4.7 def	13.3 ab
Gamagrass, eastern	1.1 f	12.9 ab
Corn. Pioneer 309B	22.3 abcdef	12.9 ab
Bahiagrass. Pensacola	13.5 bcdef	12.6 ab
Bermudagrass, common	8.3 def	10.6 abc
Dallisgrass	21.9 abcdef	8.7 abc
Carpetgrass	2.3 def	8.2 abc
Brachiaria	3.0 def	5.5 bc
Alfalfa	1.5 ef	0.0 c

* Five males and five females per replicate.
** Average of 4 replicates; avg. % survial is the decoded arc sin mean and avg no. eggs is the decoded. square root + 0.5. mean.
Column means followed by the same letter are not significantly different at the 5% level of probability as determined by Tukey's w-procedure. Data modified from Boyd and Pitre (1969).

Where weed populations were regulated in small field plots in a corn field with a history of corn stunt disease in Mississippi, indigenous leathopper vectors were more abundant in weedy plots than in moderately weedy or weed-free plots (Table 2, from Pitre and Boyd, 1970). The influence of weeds on the leafhopper vector population was reflected in the disease incidence date (Table 3, from Pitre and Boyd, 1970). Disease incidence was higher in weed-free plots than in the other plots. Bracharia, goosegrass and crabgrass appeared to be the species of importance in the epidemiology of corn stunt disease in this field study in Mississippi. This fact suggests that the vectors showed preferential feeding on vegetation other than the corn crop. An increase in disease incidence can result in fields where vectors of disease agents have little choice in feeding. *G. nigrifrons* may feed on corn in weed-free fields because of the lack of a preferred food source. Thus, Pitre (1969) suggested that within-field weeds may be beneficial in reducing the incidence of corn stunt disease in corn in fields in Mississippi.

Both chemical and cultural methods are available to reduce crop losses due to corn stunt disease (Pitre, 1968). Although chemical control methods may be employed

Table 2. Number of *G. nigrifrons* collected from corn having received different weed-control practices. Yazoo City, Mississippi, 1968.

Treatment	Avg no. leafhoppers/ 125 linear row ft. May 29	June 4	June 11	Seasonal Avg
Weedy	12 a	400 h	375 b	262 h
Weed-free	5 a	74 a	207 a	95 a
Moderately weedy	6 a	57 a	213 a	91 a

*Average of 4 replicates. Means followed by the same letter arc not significantly different at the 5% level by Duncan's multiple range test. Data modified from Pitre and Boyd. (1970).

Table 3. lncidence of corn stunt disease and yield of corn having received weed control practices. Yazoo City, Mississippi, 1968.

Treatment	Disease Incidence July 9	August 5	Yield lb/5 plants
Weedy	10 a	13 a	2.6 a
Weed-free	21 h	24 h	2.8 a
Moderately weedy	11 a	13 a	3.0 a

* Average of 4 replicates: includes plants in both the 2 and 3 rating class. Means followed by the same letter are not significantly different at the 5% level as determined hy Duncan's multiple range test. Data modified from Pitre and Boyd (1970).

routinely to protect corn crops from insect pests, other approaches including cultural control methods are available. Cultural controls entail modification of habitats which can create or destroy ecological niches for either pest or beneficial species (Herzog and Funderburk, 1985). Thus, a single factor or combination of methods may be used to regulate insect pests and associated plant diseases.

Conservation tillage methods can help reduce corn stunt disease losses by allowing non-crop vegetaion to develop in the field (Pitre, 1969), since *G. nigrifrons* prefers to feed on weeds rather than on corn plants. In this case, the leafhoppers might remain on weeds, feed less on corn, and lower the incidence of corn stunt disease transmission. In support of this hypothesis, Pitre (1969) and Pitre and Boyd (1970) reported that while weedy corn plots had the highest numbers of *G. nigrifrons* , these plots had a lower incidence of disease than weed-free plots. They suggested that in weed-free fields, *G. nigrifrons* had little option but to feed on corn, a less preferred host: thus the incidence of corn stunt disease was highest where effective weed control practices were followed.

Conclusions

Non-crop vegetation in conservtion tillage and no-tillage systems plays an important role in the dynamics of insect pest and natural enemy populations. Weeds serve as refugia, oviposition sites and sources of food for insects (Hammond and Funderburk, 1985), as well as host reservoirs for plant disease causal agents. This non-crop vegetation will enhance the structural and trophic diversity of the crop agroecosystem and crop damage due to pests may be increased or decreased depending upon the spatial and temporal biological relationshops between the plant and animal communities. These conservation tillage systems commonly support higher species diversity and density of insects than conventionally tilled systems.

The levels of crop and integrated pest management practices employed in crop production are basically limited by financial constraints in low technology agriculture, and by social, environmental and limited agronomic constraints in high technology cropping systems. Whereas there are disadvantages to utilizing conservation tillage practices, there are obvious benefits to no-till agriculture. Although the advantages of weedy fields are apparent for control of certain insect pests (e.g., limited feeding by leafhopper vectors on crop plants) and associated diseases (e.g., reduced incidence of corn stunt), this management technique will not be easily accepted among agricultural scientists or producers (Herzog and Funderburk, 1985). However, interest in alternative cropping practices is increasing. New crop production techniques may be discovered principally through novel disruption of the agroecosystem (Litsinger and Moody, 1976).

References

All, J. N., and G. J. Musick. 1986. Management of vertebrate and invertebrate Pests. p. 347-387. *In* M.A. Sprague and G.B. Triplett (eds.) No Till and Surface Tillage Agriculture The Tillage Revolution. John Wiley and Sons, New York.

Altieri, M. A. 1980. Diversification of corn agroecosystems as a means of regulating fall armyworm populations. Florida Entomol. 63:450-455.

—— and W. H. Whitcomh. 1980. Weed manipulation for insect pest management in corn. Environ. Management 4:483-489.

Boyd. F. J., and H. N. Pitre. 1969. Greenhouse studies of host plant suitability to Graminella nignfrons, a vector of corn stunt virus. J. Econ. Entomol 62: 126-130.

Castro. M.T.. H. N. Pitre, and D.H. Meckenstock. 1989. Populations of fall armyworm, *Spodoptera frugiperda* (J.E. Smith), larvae and associated natural enemies in sorghum and maize cropping systems in southern Honduras. Trop. Agric. (in press).

DeWalt, W., and K.DeWalt. 1984. Socio-economic projects. p. 17-18. In D.T. Resenow, (ed.) INTSORMIL'S Next 5 Years, County Report, Honduras. INTSORMIL Principal Investigator's Conference, Scottsdale, Arizona.

Gordon, D. T. 1976. Maize virus diseases in the United States. p. 45-48. *In* L.E. Williams. D.T. Gordon, L.R. Nault (eds.) Proc. Intnl. Maize and Virus Disease Colloquium and Workshop.

Hammond. R. B., and J. E. Funderhurk. 1985. Influence of tillage practices on soil-insect population dynamics in soybean. p. 659-666. *In* R. Shihles, (ed.) Proc. World Soybean Res. Conf. III. Westview Press, Boulder, Colorado Hawkins. R. 1982. Reconmimiento de cultivos y sistemas de produccion en Centro America. Documento presentado en el curso de adiestramiento en investigacion sobre la eficiencia de los fertilizantes en los tropicos. E.A.P. Oct 3-22, 1982.

Herzog, D. C.. and J. E. Funderhurk. 1985. Plant resistance and cultural practice interactions with biological control. p. 67-88. *In* M.A. Hoy. and D.A. Herzog, (eds.) Biological Control in Agricultural Integrated Pest Management Systems. Academic Press, New York.

Knoke, J. K. 1976. Virus Disease epiphytology: developing field tests for disease resistance in maize. P. 116-122. *In* L.E. Willims. D.T. Gordon. L.R. Nault (eds.) Proc. Intni. Maize and Virus Disease Colloquium and Workshop.

Litsinger, J. A.. and K. Moody. 1976. Integrated pest management in multiple cropping systems. p. 293-316. *In* R.I. Papendick. P.A. Sanchez. G.B. Triplett (eds.)Multiple Cropping. Am. Soc. Agron. Spec. Pub. No. 27. ASA. Madison, Wisconsin

Mellor, J. W. 1988. Sustainable agriculture in developing countries. Environment 30(9):7.

Nau1t, L. **R.** 1987. Vectors of maize viruses. p. 111-114. In L.E. Williams. D.T. Gordon, **L.R.** Nault (ed.) Proc. Intnl. Maize and Virus Disease Colloquium and Workshop.

Oram. P. A. 1988. Moving toward sustainability: building the agroecological framework. Environment 30(9):17-36.

Pimentel. D. 1961. Species diversity and insect population outbreaks. Ann. Ent. Soc. Am. 54:78-86.

Pitre, **H.** N. 1968. Systemic insecticides for control of the hack-faced leafhopper. *Graminella nigrifrons,* and effect on corn stunt disease. J. Econ Entomol. 61:765-768.

——1969. Insecticide and weed control practices influence incidence of corn stunt disease. Miss. State Univ. Agric. Exp. Sta. Info. Sheet No. 1066.

—— 1970. Maize dwarf mosaic in corn related to corn leaf aphid population and date of planting. Miss. Agric. Exp. Sta. Info. Sheet No. 1101

—— 1989. A complex oflepidopterous defoliators on sorghum and maize in southern Honduras. CEIBA 29(1)12.

——, and F.J. Boyd. 1970. A study of the role of weeds in corn fields in the epidemiology of corn stunt disease. J. Econ. Entomol. 63: 195-197.

——, and R. P. Porter. 1989. Influence of cultural variables on insect populations in soybean. *In* A.J. Pascale. (ed.) Proc. World Soybean Res. Conf. Vol. 5. Argentina Soybean Assoc. Buenos Aires. Argentina (in press). Risch. S.. J.D. Andow. and M.A. Altieri. 1983. Agroecosystems diversity and pest control: data, tentative conclusions and new research directions. Environ. Entomol. 12:625-629.

Root. **R.** B. 1973. Organization of a plant arthropod association in simple and diverse habitats: The fauna of collards *(Brassica oleracea).* Ecol. Monogr. 43:95-124.

Van Huis, A. 1981 Integrated pest management in the small farmer's maize crop in Nicaragua. Meded. Landbuowhogeschool Wageningen 81-6. The Netherlands. 221 pp.

Williams, L. E.. and L. J. Alexander. 1965. Maize dwarf mosaic, a new corn disease. Phytopathology 55:802-804.