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Economic Thresholds for Central European and North American Wheat Insects

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ECONOMIC THRESHOLDS FOR CENTRAL EUROPEAN AND NORTH AMERICAN WHEAT INSECTS[1]

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ABSTRACT

The economic thresholds for implementing control of 24 wheat insect pests from Central Europe and North America are discussed. Additional studies on wheat pests are necessary to better define the existing thresholds.

Wheat (*Triticum aestivum* L.) has played a major role in human economic and social development, and provided more nourishment than any other food crop (Inglett 1974). Much information has been published about the relationship of insects to losses in wheat and their control. A primary task of many entomologists is to evaluate insect damage to a crop relative to its yield and biomass loss; from these data economic thresholds can be established to reduce future losses. For wheat, however, the situation is more complex than just described because insects usually are not the sole or primary consideration causing yield reduction, and often it is difficult to correlate the economic losses directly to insect numbers and their damage. Many other factors influence wheat yield, e.g., the genetic potential of the cultivar, or cumulative environmental and biological effects during the growth and development of the plant including diseases, weeds, and mineral and water deficiencies or excesses.

Boyer (1982) suggested that U.S. wheat productivity falls far short of the potential of the crop and noted the following wheat data from the USDA (1965): record yield, 14,500 kg/ha; avg. yield, 1880 kg/ha (or 13.0% of the record yield); loss from diseases, 336 kg/ha (2.3%); insects, 134 kg/ha (0.9%); weeds, 256 kg/ha (1.8%); other unfavorable environmental conditions, 11,900 kg/ha (82.0%). The major losses in wheat are attributed to climate and soil conditions and include drought, excess water, hail, and wind. Pesticide usage in 1955 equalled 1% of the total crop value, and this had risen to 4.6% by 1968 (Neumeyer et al. 1969). About 3.8% of all insecticides used in the U.S. in 1985 were used on wheat pests (USDA 1985). This percentage is low relative to the value of the crop and is due, in part, to compensation of wheat to insect attack by tillering.

In this paper, we compare the recommended thresholds for control of wheat insects in the United States and Central Europe (primarily the German Democratic Republic). Since the climate and some pests from the two regions are similar, evaluating the differences in small grain insect control in the two regions should bring about a better understanding of economic thresholds.

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CEREAL YIELDS AND QUALITY

The world's wheat acreage is concentrated in the Northern Hemisphere with over 90% of the acreage in Eurasia and North America (Reitz 1967). Cereal losses are typically determined by the components of yield, i.e., the density of heads per unit area, the number of seeds per head ("ear" or "spike"), and the seed weight often expressed as the weight/1000 seeds. The corresponding loss percentages relative to total yield are 48% with respect to the density of the stand, 29% with respect to the seeds per spike, and 23% with respect to the weight/1000 seeds (Damisch 1970). In addition, the straw of wheat is also an important article of commerce. Cereal feeding insects may affect the quality as well as quantity of the grain. Wratten (1975, 1978) and Freier and Wetzel (1976) found a reduction of grain protein of wheat and assumed that it was probably due to nitrogen depletion by aphids feeding on the heads.

INSECT PESTS OF WHEAT

Many factors must be considered before reaching the decision that insecticides should be used to control an insect pest. The following are perhaps the most important criteria that should be considered when evaluating pest damage of a crop: (1) the stage of growth at the time of the infestation (spring or fall plants, tillering or heading); (2) the size and expected duration of the infestation; (3) the transmission of diseases or the injection of toxins that injure the crop more than nutrient removal; (4) other pests attacking the crop; (5) the vigor of the plants and their ability to tolerate or withstand attack; (6) the nature of any host plant resistance; (7) the presence of predators and parasitoids to suppress the pest; (8) the yield potential or value of the crop under present light, soil, and moisture conditions; and (9) the cost of control (the insecticide and application) relative to other expenditures already incurred during the development of the crop and relative to the future anticipated monetary return.

Many insect pests of North America were introduced unknowingly by immigrants. Since most immigrants came from Europe, it is appropriate to compare and contrast the thresholds for insect control of wheat insects of North America with European thresholds. We selected only those insects that are more important pests, although other insects are occasionally classified as pests. In addition, both areas are quite large; thus we used the most typical thresholds for both continents.

Table 1 provides information on the number of insects per unit area or plant that serve as thresholds before initiating chemical control. No specific insecticides are recommended because these vary from region to region and tend to change as new products become available. Of the 24 pest groups or species listed in Table 1, eight are from both continents, and eight are each from Europe or North America. The recommended thresholds are quite similar for the species that occur on both continents.

CEREAL LEAF BEETLES

Control measures for *Oulema* spp. are recommended when three or more eggs or larvae, or both, are present per plant, or one larva or more per flag leaf. These leaf-feeding insects often prefer to attack wheat in one or two fields in an area, and their populations then may warrant insecticidal control. In the 1960's and early 1970's, the cereal leaf beetle, *Oulema melanopus* (L.), was frequently controlled in North America with insecticides. In the 1970's, four species of Europen parasitoids were established in North America, and the need for insecticidal control was greatly reduced from 1975 to 1985. These leaf feeding insects, *Oulema* spp., are considered sporadic pests in Europe.

Table 1. Current thresholds for control of common wheat pests in Central Europe and North America

Insect Pest	Central Europe (CE)	North America (NA)
	ROOTS	
COLEOPTERA		
Phyllophaga spp.	N/A[a]	32–43 larvae/M^2[b,c]
Agriotes spp.	2–3 larvae/0.05 × 0.15 M core causes 10% loss[d]	N/A
Melanotus spp.	N/A	Occasional pests
Eleodes spp.	N/A	do.
HOMOPTERA		
Rhopalosiphum insertum (Walker)	Occasional pests	N/A
	STEMS AND BLADES	
ORTHOPTERA		
Grasshoppers	N/A	8/M^2 on small plants[e]
LEPIDOPTERA		
Pseudaletia unipunctata (Haworth)	N/A	4/0.3M of row[e]
COLEOPTERA		
Zabrus tenebroides Goeze	1–2 larvae/M^2 in autumn[f]	N/A
Oulema melanopus (L.)	1 or more eggs or larvae/flag leaf[f]	3 eggs or larvae/plant or 1 or more larvae/flag leaf[e]
Oulema lichinis (Voet)	1 or more eggs or larvae/flag leaf[f]	N/A
HEMIPTERA		
Blissus leucopterus Say	N/A	Occasional pest
HOMOPTERA		
Schizaphis graminum Rondani	15–25 aphids/plant between flowering and milk stage[g]	10–15 cm, 50 aphids/plant[h] 15–25 cm, 200 do. 46–51 cm, 300 do. > 76 cm, 800 do.
Sitobion avenae (Fabricius)	do.	Occasional Pest
Rhopalosiphum maidis Fitch	do.	do.
Rhopalosiphum padi (L.)	do.	do.
Sitobion fragariae (Walker)	do.	do.
Metropolophium dirhodum (Walker)	do.	N/A
DIPTERA		
Delia coarctata (Fallen)	125 larvae/M^2 in soil Jan.–Mar.[i] 60–90 eggs/M^2 in soil Sept.[f]	N/A
Mayetiola destructor (Say)	1–6 larvae/plant[f]	20% stems infested[j]
HYMENOPTERA		
Cephus pygamaeus (L.)	30 larvae/M^2 in stubble (indicator for popln. next year)[f]	Occasional pest
Cephus cinctus Norton	N/A	70% tunneling – 10% loss in grain[g]
	HEADS	
HOMOPTERA		
Sitobion avenae (Fabricus)	3–5 larvae/head at flowering and 60–80% infestation[f]	Occasional pest
DIPTERA		
Sitodiplosis mosellana (Gehin)	1 ♀/3 heads just before flowering (ca. 13 larvae/head)[k]	1 ♀/head at flowering[k]
Contarina tritici (Kirby)	1 ♀/head at start of flowering[f]	N/A
Haplodiplosis equestris (Wagner)	5 larvae on culm on internode below the head (13% loss)	N/A
Meromyza americana Fitch	N/A	Control when infestation > 15%[m]

[a]N/A = not applicable
[b]Painter et al. (1954)(NA)
[c]Coppock et al. (1984)(NA)
[d]Griffiths et al. (1967)(CE)
[e]Ruppel and Bird (1981)(NA)
[f]Wetzel and Freier (1981)(NA)
[g]Bonnemaison (1980)(CE)
[h]Daniels (1962)(NA)
[i]Maskell and Gair (1961)(CE)
[j]Hill et al. (1943)(NA)
[k]Basedow and Schutte (1973)(CE,NA)
[l]Nijveldt and Hulshoff (1968)(CE)
[m]Kieckhefer and Morrill (1970)(NA)

CEREAL APHIDS

Rabbinge and Coster (1984) noted that cereal aphids cause direct yield loss through assimilate consumption and changes in the nitrogen balance, and indirect yield loss through honeydew excretion affecting photosynthesis, senescence, and pythotropic fungi. In addition, their ability to transmit various cereal diseases must always be considered when evaluating the need for control.

Aphid control recommendations are more variable, with insecticidal control being implemented when aphid numbers per plant in Europe are 15–25 near flowering or in the milk stage. The guidelines for aphid control in North America typically use crop height while Europeans use host maturity, and both use number of aphids per plant or linear foot of row. Although the current recommendations are not species specific, greenbugs, *Schizaphis graminum* (Rondani), whose saliva is much more phytotoxic than the saliva of the other aphids listed in Table 1, usually cause more cereal damage (Wadley 1929). Cramer (1967), summarizing statistics for 1965 from the USDA (1965), listed the greenbug as causing more wheat yield loss (23.3%) than any other insect. Coppock et al. (1984) noted that parasitoids occasionally attack enough greenbugs in the field to reduce infestations below economic levels, and that mummified greenbugs can be used to evaluate the presence of the parasitoid. In Europe the English grain aphid, *Sitobion avenae* (Fabricius), requires control on wheat heads; in North America other aphids attack small grains, but generally only greenbugs require control. In general, economic thresholds are less precise for aphids than many other insects because of the low correlation between aphid numbers and yield loss (Rabbinge and Mantel 1981). Although the transmission of diseases by insect vectors has not been mentioned specifically, some aphids may become more mobile after receiving sublethal or slow killing insecticides (Broadbent 1969). The aphids may move more frequently from plant to plant feeding on many more plants, thus innoculating them with viruses that are transmitted mechanically on their stylets in less than 1 min. of feeding time, in contrast to the less mobile untreated insects. Fortunately, the most important insect-transmitted disease of wheat, barley yellow dwarf, is not transmitted as rapidly, and insecticidal control may be helpful, but a definitive study on barley yellow dwarf transmission is still pending. The situation becomes more complex when one notes that the barley yellow dwarf viruses (or strains) exhibit varying degrees of specificity among grass feeding aphids (Sylvester 1980).

HESSIAN FLY

The Hessian fly, *Mayetiola destructor* (Say), of European origin, is not a major pest there, but is a very serious wheat pest in North America. Insecticidal control is typically not used, but control is warranted where the percentage of stems infested is about 20% (Hill et al, 1943). The use of resistant varieties in combination with the fly-free date are the principal control methods. The causative biotype is identified based on its survival on wheats having different genes for resistance, and the proper resistance is incorporated into commercial varieties by plant breeders to suppress the infesting biotype(s). In 1974, 16 million acres in North America were planted with Hessian fly resistant varieties (Gallun 1977).

WHEAT BLOSSOM MIDGES

The orange wheat blossom midge, *Sitodiplosis mosellana* (Gehin), was not considered a major pest on either continent until 1983, when a $30 million loss to spring wheat occurred in northeast Saskatchewan, Canada (Olfert et al. 1985). They found that one, two, three, or four larvae per kernel resulted in an infestation level of 38, 58, 78, and 96%, respectively. In addition, infestations of 30, 60, and 90% reduced spring wheat yields by 40, 65, and 79%, respectively. Usually fewer than 10 larvae are present per wheat head (ear), and seed weight may be significantly different between infested and noninfested heads. Although the midge is not dependent upon the presence of glume blotch, *Septoria nodorum* (Berk.) Berk., to attack, Wellso and Freed (1982) found that a positive association exists between the insect and glume blotch with more larvae present in those heads infected with glume blotch. In Europe, the lemon wheat blossom midge, *Contarinia tritici* (Kirby), appears to be more abundant than the orange wheat blossom midge, and its larvae feed on the wheat flower, killing the stigma and preventing pollination and grain development. Control in Europe is recommended when one or more adults are present per ear (head) when sampled throughout the field.

WHEAT STEM SAWFLIES

The European wheat stem sawfly, *Cephus pygmaeus* (L.), attacks spring wheats more than winter wheats and is a more important pest in Europe than North America. In North America, it is found only in northeastern United States and adjacent Canada, while its European distribution is greater. Another species, the wheat stem sawfly, *Cephus cinctus* Norton, is economically more important in North America as it attacks wheat west of the Mississippi River, primarily in North Dakota, Montana, and western Canada. Solid stemmed cereals are resistant to *C. cinctus* and deter oviposition and larval development. Insectidical control has not been very successful, and burning the straw and deep plowing have helped reduce sawfly populations (Bonnemaison 1980).

OTHER WHEAT PESTS

The other pests listed are from either Europe or North America, and, even within these areas, may be economically detrimental in only part of the wheat growing area. In some years, grasshoppers in North America may be very important pests, especially west of the Mississippi River. They are more important in years that are drier than average, as egg hatch is often reduced in moist years by soil-inhabiting fungi. Grasshoppers require control when 6–12 nymphs/m^2 are present. Various cutworm species and the armyworm, *Pseudoaletia unipuncta* (Haworth), may be important pests occasionally. The cyclic nature of these pests in the past seems to be related to favorable environmental conditions. With greater emphasis on minimum tillage practice, these insects may become more important economic pests. Chinch bugs, *Blissus leucopterus* Say, are only an occasional pest on small grains in Kansas and adjacent states. This insect may develop in wheat or grasses, stunting some plants or causing them them to die in small areas. This insect may become a serious pest to corn and sorghum after the wheat is harvested. The wheat stem maggot, *Meromyza americana* Fitch, damages spring wheat more than other cereals with losses ranging from a maximum of 9% with averages of 1–3% in South Dakota (Kieckhefer and Morrill 1970). The larvae feed within the culm and may cause the heads to die. Wireworms, including *Melanotus* sp., *Eleodes* sp., and *Agriotes* sp. may live in the soil from 2 to 6 years with the remaining larvae moving very far from the oviposition site. They feed on the wheat roots and may cause spotty damage in the field. Like armyworms and cutworms, these insects may become more abundant under minimum tillage practices. June beetles, *Phyllophaga* spp., like wireworms, may occasionally damage the roots of cereals.

Wheat bulb fly, *Delia coarctata* (Fallen), larvae move through the soil in Eurasian cereal fields and penetrate the underground stem (crown). The larvae move upward through the culms and feed upon the terminal buds, and may cause as much as 10% crop loss (ABMAC 1965).

We have described and compared the major damage to wheat by Central European and North American insect pests. Most entomologists agree that the current recommended thresholds need to be improved and that this will occur only after we better understand the insect-plant interactions. Since environmental stresses cause the major losses, the relationship of insects, weeds, and diseases to each other and during these various stresses must be more clearly defined relative to crop loss. We are improving our biological and environmental monitoring and sampling, and this, together with a better understanding of the tolerance of plants to withstand insect attack, will bring about a better understanding of yield losses.

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