Pest Management Systems for Sugarbeets in the North American Central Great Plains Region*

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INTRODUCTION

The North American Central Great Plains region is one of the oldest sugarbeet production regions in the United States with main production in a five-state area east of the Rocky Mountain range. Climate of this region is semi-arid, and cultivated soils are alkaline and low in organic matter but fertile.

Representative elevations range from 980 m to 1400 m above sea level in Kansas and Wyoming, respectively. Annual rainfall ranges from 150 mm in northern Wyoming to 430 mm in Kansas. All sugarbeets in this region, which also includes areas in Colorado, Montana and Nebraska, are produced under irrigation. The growing season varies from 135 days in Wyoming to 165 days in western Kansas (27).

Sugarbeets, field corn, dry beans, malting barley, and alfalfa are commonly grown in rotation. Some vegetable crop production occurs. Most farmers in the region rely on 3- to 4-year cash-crop rotations. Average yield for sugarbeets approximates 44 metric tons per hectare.

Some of the major pests on sugarbeets in this region are: sugarbeet nematode (*Heterodera schachtii*), sugarbeet root maggot (*Tetanops myopaeformis*), rhizoctonia crown rot (*Rhizoctonia solani*), sugarbeet powdery mildew (*Erysiphe polygoni*), redroot pigweed (*Amaranthus retroflexus*),

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common lambsquarters (*Chenopodium album*), kochia (*Kochia scorparia*), black nightshade (*Solanum nigrum*), barnyard grass (*Echinochloa crus-galli*), green foxtail (*Setaria viridis*), yellow foxtail (*S. lutescens*), and wild oat (*Avena fatua*).

Main objectives of this treatise are: 1) to generally review the current pest management systems for sugarbeets; 2) to specifically identify some of the problems involved; and 3) to discuss possible strategies for future pest management systems. This review presents information from many sources of a specific nature as well as general concepts adaptable to any production region.

PEST MANAGEMENT CONCEPTS

Sugarbeets are vulnerable to attack by many insects, mites, nematodes, and pathogenic microorganisms. In addition, numerous weed species compete directly with sugarbeets for space, water, and nutrients. Nevertheless, there are only a few key pests in each group that are primarily responsible for the bulk of crop damage and loss. These key pests must be identified and included in the total pest management system. Key pests often vary from one geographical area to another because of differences in biotic (vegetation, natural enemies, other competing organisms, etc.) and abiotic (climate, soil, etc.) conditions.

Integreted pest management has been defined as a "pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible manner as possible and maintains pest populations at levels below those causing economic injury" (12). Numerous books and papers have been published in recent years on various pest management techniques and methods (1, 2, 3, 4, 6, 12, 14, 16, 18, 19, 20, 21, 22, 23, 26, 32). However, the techniques and methods described are not always applicable to all crops and pests. Each

scientist must choose the techniques or methods that are most effective, practical, economical, and environmentally sound for given pests and crops in a given area.

Pest management systems described in this report involve all suitable techniques and methods, and they also represent an interdisciplinary approach. Some important pest management tactics employed by the authors are listed below:

1. Pest resistant varieties
2. Cultural control
   a. Crop rotation
   b. Field sanitation
   c. Planting date
   d. Plant spacing
   e. Cultivation
   f. Irrigation
3. Biological control
4. Chemical control
   a. Selection of pesticides
   b. Formulations
   c. Pesticide mixtures
   d. Application techniques
   e. Plant growth regulators
5. Other supportive tactics
   a. Determination of economic thresholds
   b. Sampling
   c. Scouting and monitoring
   d. Education and training

CURRENT PEST MANAGEMENT SYSTEMS

Generally, sugarbeets planted early in the spring (late March and early April) are more tolerant to pests than fields planted later. Seedling diseases caused by *Phoma* and *Pythium* spp., however, are more prevalent under cool conditions. Monogerm hybrid seed is treated with fenaminosulf or maneb to protect the seed from seedling diseases. Planting sugarbeets to a final stand is encouraged whenever conditions permit, and plantings to final stand are increasing. Seedbeds often are irrigated to promote quick crop emergence.

Nematodes, particularly the sugarbeet nematode, are widespread in most sugarbeet growing areas in the region. A

4-year crop rotation is strongly recommended wherever nematodes occur. Soil samples are routinely taken for nematode counts. If the count shows 10 or more viable cysts per 473 cc (1 pint) of soil, a nematicide treatment is recommended (1). Fields infested with nematodes are fall- or spring-fumigated with dichloropropene compounds or treated with aldicarb at planting time. Nematicides are the most expensive pesticides used by sugarbeet growers.

For control of soil insects, such as the sugarbeet root maggot (*Diptera-Otitidae*), pale-striped flea beetle larva (*Coleoptera:Chrysomelidae*), and wireworm (*Coleoptera: Elateridae*), one of several approved soil insecticides is recommended at planting time. Whether to use an insecticide depends largely on past infestation levels in a given area. In areas where initial population suppression has been achieved, an insecticide is applied in the seed furrow at a reduced rate to minimize any undesirable side effects on the environment, rather than at a full dose in a standard 18-cm band. In marginal areas, bait traps containing sugar-trichlorfon solution are used to monitor the adult root maggot flies emerging from the soil. When 10 or more adult flies are caught per trap per day, an insecticide application is recommended.

Foliar insect pests are carefully monitored and an approved insecticide is applied only when a high level of infestation is anticipated. The effects of insect defoliation and stand loss on sugarbeet yield are well documented (7, 9, 10, 15, 17). Generally, insecticides are applied for control of mid-season foliar insect pests when about 10% of the foliage is consumed by a pest and the damage is expected to increase. This does not apply to insect pests with piercing-sucking mouthparts, particularly the virus vectors, the green peach aphid (*Myzus persicae*) and the beet leafhopper (*Circulifer tenellus*).

In general, a systemic soil insecticide applied at planting

time to control sugarbeet root maggot also provides sufficient crop protection against many other foliar insect pests. A typical side benefit is the near extinction of webworms (*Loxostege* spp.) in the region. *Loxostege* spp. used to be the most abundant and destructive foliar pest until about 1970. The reasons for the sharp decline in webworm populations in recent years are: 1) highly effective systemic soil insecticides; and 2) improved weed control techniques that destroyed weed hosts, namely common lambsquarters and Russian thistle (*Salsola kali*). The spinach leafminer (*Pegomya hyoscyami*), another common insect pest in the region, also is steadily declining.

Natural enemies undoubtedly play an important role in regulating various pest populations in sugarbeets. Numerous predators, parasites, and pathogens belonging to several orders and families have been described (4, 8, 16, 18) and they are listed in Table 1.

Table 1. Predators, parasites, and pathogens on sugarbeet pests.

	Predators	Parasites
Insects:		
Coleoptera -	*Carabidae* *Cicindelidae* *Coccinellidae*	
Neuroptera -	*Chrysopidae* *Hemerobiidae*	
Hemiptera -	*Anthocoridae* *Nabidae* *Lygaeidae* *Pentatomidae* *Phymatidae* *Reduviidae*	
Diptera -	*Asilidae* *Chloropidae* *Syrphidae*	*Sarcophagidae* *Tachinidae*
Hymenoptera -	*Pompilidae* *Scoliidae* *Sphecidae* *Vespidae*	*Braconidae* *Ichneumonidae* *Chalcidae* *Eulophidae* *Encyrtidae* *Mymaridae*
Strepsiptera -		
Thysanoptera -	*Thripidae*	

Table 1, cont. Predators, parasites, and pathogens on sugarbeet pests.

	Predators	Parasites
Mites:		
	Predaceous Mites	
Nematodes:		
		Mermithidae *Allantonematidae*
Fungi:		
Viruses:		

Under an outbreak or epiphytotic situation where a pest population increases rapidly, natural control of pest populations by biological control agents has been totally insufficient; thus, suppressive pesticides must be used to protect crops.

Two important virus diseases, beet yellows and curly top, occur sporadically in the Central Great Plains, but infestations are usually light. Some of the measures recommended to reduce viral incidence are field sanitation; maintenance of a full, uniform stand; use of virus resistant varieties; and application of systemic insecticides to kill insect vectors (3, 14, 16, 18).

Cercospora leaf spot (*Cercospora beticola*) also is considered a sporadic disease in this semi-arid region. The standard control recommendation is to use Cercospora-resistant cultivars and approved fungicides. Cercospora strains resistant to benzimidazole fungicides have been found in Texas and Arizona, and area growers are advised to use non-benzimidazole fungicides (24).

Two important diseases affecting sugarbeet production in Colorado and elsewhere are rhizoctonia crown or root rot and fusarium yellows (*Fusarium oxysporum* f. sp. *betae*). The only effective methods known to control these diseases include crop rotation and avoidance of covering the sugarbeet crown area with soil when cultivating (E. G. Ruppel

and R. J. Hecker, unpublished). No fungicides are registered for control of these diseases at the present time. In 1979, the Holly Sugar Company introduced the first commercial sugarbeet cultivar resistant to *R. solani*; however, level of resistance and productivity of this particular cultivar under commercial conditions is unknown at this time.

Sugarbeet powdery mildew is another major fungus disease affecting sugarbeets in the United States, including the Central Great Plains. Since 1974, the disease appears in our region in late July or early August, and infests the entire region by late August. The standard treatment for powdery mildew control is to apply sulfur as soon as the disease appears in the general area.

Post-harvest storage rot is a major cause of sugar loss in certain parts of the United States. *Phoma betae*, *Penicillium* spp., *and Botrytis cinerea* are considered the three major fungal organisms causing storage rot (5). The problem, however, is relatively minor in the Central Great Plains region, and no attempt has been made to treat commercial sugarbeet piles with fungicides. All beet piles are covered with chopped straw to protect the sugarbeets from fluctuating temperatures.

Weeds are considered the most prevalent pests in sugarbeets. Some minor species shifts are occurring due to use of herbicides and other causes. For example, in Montana and Wyoming, wild oat and kochia frequently coinfest fields, and they still remain troublesome due to short rotations and ecological adaptation of chemical-resistant plants (31).* Wild oat is economically controlled by diallate applied preplanting, often in mixture with cycloate. Ethofumesate is gaining in use since commercial

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release in 1978, due to longer residual action and effectiveness on both wild oat and kochia.

Russian thistle and kochia infestations are spreading in western Kansas and eastern Colorado production areas; fortunately, excellent control of these pests has been obtained by applying ethofumesate preplant.

Among all areas, including the Nebraska panhandle, the important annual weeds, including volunteer crop weeds, are listed in Table 2. In addition, perennial weeds infest sugarbeet fields, especially in Colorado, Montana and Wyoming, and the most troublesome are Canada thistle (*Cirsium arvense*), field bindweed (*Convolvulus arvensis*), perennial sowthistle (*Sonchus arvensis*), and quackgrass (*Agropyron repens*) (Table 2). Spot applications of glyphosate and dicamba, particularly in crops grown in rotation with sugarbeets, control these weeds.

Table 2. List of sugarbeet pests.

Classification	Common Name	Scientific Name
Disease:		
Fungus	*Damping-off	*Aphanomyces cochlioides* **Phoma betae* *Phytophthora spp.* ***Pythium spp.*** *Rhizoctonia solani*
	*Fusarium Yellows	*Fusarium oxysporum*
	*Crown Rot	*Rhizoctonia solani*
	Root Rot	*Aphanomyces spp.* *Phoma spp.* *Phytophthora spp.* *Pythium spp.* *Rhizoctonia solani* *Rhizopus spp.* *Sclerotium spp.*
	Rust	*Puccinia aristidae*
	Leaf Spot	*Cercospora beticola* *Phoma betae* *Ramularia beticola*
	Downy Mildew	*Peronospora schachtii*
	*Powdery Mildew	*Erysiphe polygoni*

Table 2, cont. List of sugarbeet pests.

Classification	Common Name	Scientific Name
Bacterium	Crown Gall	*Agrobacterium tumefaciens*
	Soft Rot	*Erwinia Spp.*
Virus	Beet Yellows (BYV)	
	Beet Western Yellows (BWYV)	
	Curly Top	
	Mozaic	
	Savoy	
Insects:		
Root Feeders	Cutworms:	
	Army Cutworm	*Euxoa auxiliaris*
	Pale Western Cutworm	*Agrotis orthogonia*
	Variegated Cutworm	*Peridroma saucia*
	*Pale-striped Flea Beetle Larva	*Systena blanda*
	Sugarbeet Root Aphid	*Pemphigus populivenae*
	*Sugarbeet Root Maggot	*Tetanops myopaeformis*
	Wireworms:	
	Sugarbeet	*Limonius californicus*
	Eastern Field	*L. agonus*
	Western Field	*L. infuscatus*
Foliage Feeders	Armyworms:	
	Armyworm	*Pseudaletia unipuncta*
	Beet Armyworm	*Spodoptera exigua*
	Blister Beetles:	
	Black Blister Beetle	*Epicauta pennsylvanica*
	Ashgray Blister Beetle	*E. fabricii*
	Carrion Beetles:	
	*Spinach Carrion Beetle	*Silpha bituberosa*
	Beet or Black Carrion Beetle	*S. opaca*
	Flea Beetles:	
	*Pale-striped Flea Beetle	*Systena blanda*
	*Potato Flea Beetle	*Epitrix cucumeris*
	Three-spotted Flea Beetle	*Disonycha triangularis*
	Grasshoppers:	
	Differential Grasshopper	*Melanoplus differentialis*
	Two-striped Grasshopper	*M. bivittatus*
	Red-legged Grasshopper	*M. femurrubrum*
	Migratory Grasshopper	*M. sanguinipes*
	Clear-winged Grasshopper	*Camnula pellucida*
	Leafminers:	
	*Spinach Leafminer	*Pegomya hyoscyami*
	Beet Leafminer	*P. betae*

Table 2, cont. List of sugarbeet pests.

Classification	Common Name	Scientific Name
Foliage Feeders	Lygus Bugs:	
	*Tarnished Plant Bug	*Lygus lineolaris* *L. hesperus* *L. elisus*
	Webworms:	
	*Beet Webworm	*Loxostege sticticalis*
	*Garden Webworm	*L. rantalis*
	Alfalfa Webworm	*L. commixtalis*
	Zebra Caterpillar	*Ceramica picta*
Virus Vectors	Curly Top:	
	Beet Leafhopper	*Circulifer tenellus*
	Beet Yellows and Beet Western Yellows:	
	Green Peach Aphid	*Myzus persicae*
	Bean Aphid	*Aphis fabae*
Nematodes:		
	*Sugarbeet Nematode	*Heterodera schachtii*
	False Root-knot Nematode	*Nacobbus batatiformis*
Symphyla:		
	Garden Symphylan	*Scutigerella immaculata*
Weeds:		
Broadleaf	*Black Nightshade	*Solanum nigrum*
	Buffalobur	*S. rostratum*
	Common Cocklebur	*Xanthium pensylvanicum*
	*Common Lambsquarters	*Chenopodium album*
	Common Sunflower	*Helianthus annuus*
	Common Purslane	*Portulaca oleracea*
	Giant Ragweed	*Ambrosia trifida*
	*Kochia	*Kochia scoparia*
	Prostrate Pigweed	*Amaranthus blitoides*
	*Redroot Pigweed	*Amaranthus retroflexus*
	*Russian Thistle	*Salsola kali*
	Shepherdspurse	*Capsella bursa-pastoris*
	Smartweed	*Polygonum pensylvanicum*
	Tanseymustard	*Descurainia pinnata*
	Wild Buckwheat	*Polygonum convolvulus*
	Wild Mustard	*Brassica kaber*
	Velvetleaf	*Abutilon theophrasti*
	Jimsonweed	*Datura stramonium*
	Fanweed	*Thlaspi arvense*

Table 2, cont. List of sugarbeet pests.

Classification	Common Name	Scientific Name
Broadleaf	Canada Thistle	*Cirsium arvense*
	Field Bindweed	*Convolvulus arvensis*
	Perennial Sowthistle	*Sonchus arvensis*
Grass	*Barnyardgrass	*Echinochloa crus-galli*
	*Green Foxtail	*Setaria viridis*
	*Wild Oat	*Avena fatua*
	Quackgrass	*Agropyron repens*
	*Yellow Foxtail	*Setaria lutescens*
	Field Sandbur	*Cenchrus incertus*
Volunteer Crops	Corn	*Zea mays*
	Barley	*Hordeum vulgare*
	Wheat	*Triticum aestiivum*

*Most troublesome

Most successful growers plant sugarbeets to final stand based on complementary herbicide selections among herbicides shown in Table 3. Growers keep weed populations in sugarbeet fields below the economic threshold by supplementing integrated practices, such as: crop rotation, seed-bed and field tillage, proper use of herbicides (in other crops and waste places), and hand weeding. Usually, one hand weeding removes weeds that escape cultural and chemical control. Thus, many fields are either weed-free at harvest or the density of weeds is below the economic threshold.

Table 3. Sugarbeet crop protection chemicals.

Classification	Common Name	Chemical Name
Fungicides:		
Arasan	thiram	*Bis(dimethylthiocarbamoyl) disulfide*
*Benlate	benomyl	*methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate*
Captan	captan	*cis-N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide*

Table 3, cont. Sugarbeet crop protection chemicals.

Classification	Common Name	Chemical Name
Fungicides:		
Demosan	chloroneb	1,4-dichloro-2,5-dimethoxybenzene
*Du-Ter	triphenyltin hydroxide	triphenyltin hydroxide
*Lesan	fenaminosulf	Sodium 4-(dimethylamino) phenyl diazenesulfonate
*Manzate	maneb	Manganese ethylene bisdithiocarbamate
*Mertect	thiabendazole	2-(4-thiazolyl)-benzimidazole
*Sulfur	sulfur	Sulfur
Terrachlor	PCNB	pentachloronitrobenzene
Terrazole		5-ethoxy-3-trichloromethyl-1,2,4 thiodiazole
Herbicides:		
*Avadex	diallate	S-(2-3-dichloroallyl) diisopropylthiocarbamate
*Betanal	phenmedipham	methyl m-hydroxycarbanilate m-methyl-carbanilate
*Betanex	desmedipham	ethyl m-hydroxycarbanilate carbanilate (ester)
Carbyne	barban	4-chloro-2-butynyl m-chlorocarbanilate
*Dalapon	dalapon	2,2-dichloropropionic acid
*Eptam	EPTC	S-ethyl dipropylthiocarbamate
*Herbicide 273	endothall (K salt)	7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid
IPC	propham	isopropyl carbanilate
*Nortron	ethofumesate	2, ethyoxy-2,3-dihydro-3,3-dimethyl 5 benzo-furanyl methanesulphonate
Paraquat	paraquat	1,1'-dimethyl-4-4'-. bipyridinium ion
Pyramin	pyrazon	5-amino-4-chloro-2-phenyl-3-(2H)-pyridazinone
*Ro-Neet	cycloate	S-ethylcyclohexylethylthio carbamate
TCA	TCA	trichloroacetic acid
Tillam	pebulate	S-propyl butylethylthiocarbamate
Tolban	profluralin	N-(cyclopropylmethyl-trifluoro-2,6,dinitro-N-propyl-p-toluidine

Table 3, cont. Sugarbeet crop protection chemicals.

Classification	Common Name	Chemical Name
Herbicides:		
Treflan	trifluralin	*a,a,a,-trifluoro-,2,6, dinitro-N,N- dipropyl-p-toluidine*
*Betanal + Betanex		
Betanal + Betanex + Herbicide 273		
Dalapon + Betanal		
Dalapon + Herbicide 273		
*Eptam + Treflan		
Nortron + Ro-Neet		
Pyramin + Betanal		
Pyramin + Dalapon		
Pyramin + Herbicide 273		
Pyramin + Nortron		
Pyramin + Ro-Neet		
Pyramin + TCA		
*Ro-Neet + Avadex		
Ro-Neet + Herbicide 273		
Insecticides:		
Counter	terbufos	*S-[[(1,1-dimethylethyl)thio] methyl]O,O-diethyl phosphorodithioate*
Dasanit	fensulfothion	*O,O-diethyl O- 4-(methylsulfinyl) phenyl phosphorothioate*
Diazinon	diazinon	*O, O-diethyl O-(2 isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate*
Dibrom	naled	*1,2-dibromo-2,2-dichloroethyl dimethylphosphate.*
Di-Syston	disulfoton	*O, O-diethyl S-[2-(ethylthio) ethyl] phosphorodithioate*
Dyfonate	fonofos	*O-ethyl S-phenylethylphosphonodithioate*
*Dylox	trichlorfon	*dimethyl (2,2,2,-trichloro-1-hydroxyethyl) phosphonate*
*Furadan	carbofuran	*2,3-dihydro-2,2-dimethyl-7-benzofuranyl methycarbamate*
Lannate	methomyl	*S-methyl-N-[(methylcarbamoyl) oxy] thioacetimidate*

Table 3, cont. Sugarbeet crop protection chemicals.

Classification	Common Name	Chemical Name
Insecticides:		
Lorsban	chlorpyrifos	*0, 0-diethyl 0-(3,5,6-trichloro-2-pyridyl) phosphorothioate*
Malathion	malathion	*0,0-dimethyl S-1,2-dicarbethoxyethyl) phosphorodithioate*
Metasystox-R	oxydemeton-methyl	*S-[2-(ethylsulfinyl)ethyl] 0,0-dimethyl phosphorothioate*
Parathion	parathion	*0, 0-diethyl 0-p-nitrophenyl phosphorothioate*
*Sevin	carbaryl	*1,naphthyl methylcarbamate*
Systox	demeton	Mixture of *0,0-diethyl 0-[2-(ethylthio)ethyl] phosphorothioate* & *0,0-diethyl S-[2-(ethylthio)ethyl] phosphorothioate*
*Temik	aldicarb	*2,methyl-2(methylthio) propionaldehyde 0-(methylcarbamoyl) oxime*
Thimet	phorate	*0.-diethyl S-(ethylthio methyl) phosphorodithioate*
Thiodan	endosulfan	*6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodiaxathiepin-3-oxide*
Nematicides:		
D - D		*1,3-dichloropropene* & *1,2-dichloropropane* mixture
*Telone II		*1,3-dichloropropene*
*Temik	aldicarb	*2,methyl-2(methylthio) propionaldehyde 0-(methylcarbamoyl) oxime*

*Most frequently used.

DEVELOPMENTS IN PEST MANAGEMENT

Pest management systems in sugarbeets involve integrated utilization of all available control tactics to maintain the major pest species at sub-economic levels. Although chemical control of various pests, with exception of herbicides, has been somewhat deemphasized in recent years, pesticides still play a major role in total pest

management programs (Table 4).

Table 4. Typical weed control scheme, 1979.

Pest	Timing	Application	Herbicide
Weeds (Major) Barnyardgrass Black Nightshade Common Lambsquarters Green Foxtail Kochia Redroot Pigweed Russian Thistle	Early April	Preplant	cycloate or ethofumesate
Weed Escapes Common Lambsquarters Kochia Redroot Pigweed	Mid-May	Before crop thinning postemergence	phenmedipham + desmedipham
Late Weeds Redroot Pigweed Barnyardgrass	Mid-June	Row closure, soil-applied	EPTC or EPTC + trifluralin

New pesticides and candidates are constantly synthesized, evaluated and registered for control of various sugarbeet pests (Table 5). RP-26019, an experimental fungicide manufactured by Rhone-Poulenc, is highly effective on seed-borne *P. betae* and *R. solani*. A new improved seed treatment involves a combination treatment of fenaminosulf/RP-26019; fenaminosulf to control *Pythium* and *Aphanomyces* spp., and RP-26019 to control *P. betae* and *R. solani*. (Tables 3 and 5).

Table 5. Sugarbeet crop protection candidates.

Trade Name	Common Name	Chemical Name or Manufacturer
Fungicides:		
	RP-26019	Rhone-Poulenc
Bayleton	triadimefon	*1-(4-chlorophenoxy)-3,3-dimethyl-1-(1H-1,2,4-triazol-1-yl)-2-butanene*
	CGA-64251	CIBA-Geigy
Herbicides:		
Antor	diethatyl-ethyl	*N-chloroacetyl-N-(2,6-diethylphenyl) glycine ethyl ester*
	BAS-9052	BASF Wyandotte

Table 5, cont. Sugarbeet crop protection candidates.

Trade Name	Common Name	Chemical Name or Manufacturer
Herbicides:		
Hoelon	diclofop-methyl	2-[4-(2,4-dichlorophenoxy)phenoxy] propanoate
Roundup	glyphosate	N-(phosphonomethyl)glycine
Antor + Nortron	See Table 2	See Table 2 for chemical names
Nortron + Betanal		
Nortron + Betanal + Betanex		
Nortron + Hoelon		
Insecticides:		
Ambush or Pounce	permethrin	(3-phenoxyphenyl)methyl(±)-cis,trans-3-(2,2-dichloroethenyl)-2,2-dimethyl-cyclopropanecarbexylate

Research on the development of sugarbeet cultivars resistant to nematode attack is continuing. When a resistant cultivar is developed, it will revolutionize conventional sugarbeet production and pest management systems. No new progress has been made on chemical control of sugarbeet nematodes.

Synthetic pyrethroids, Ambush and Pounce (Table 5), applied at low rates, are highly effective on the variegated cutworm (*Peridroma saucia*) and some other lepidopterous insects. These pyrethroid compounds are ecologically more compatible than many conventional insecticides currently being used.

For control of mid-season rhizoctonia crown rot, triadimefon and RP-26019 have shown highly promising results. Moreover, University of Nebraska researchers are investigating biological control of *R. solani* using certain antagonistic fungi. No conclusive data have been obtained, but the Nebraska approach is new and noteworthy. Research on the development of rhizoctonia-resistant cultivars is

making slow but steady progress (11, 13).

Recent experiments show that triadimefon and CGA-64251 are effective on sugarbeet powdery mildew. These compounds, particularly triadimefon, have a longer residual control than that obtained with sulfur compounds. Research on erysiphe-resistant cultivars has just begun; preliminary data indicate considerable genetic variability among different sugarbeet lines for susceptibility, and this is encouraging.

Experimental herbicide results and projections indicate that the most promising scheme to control annual weeds in sugarbeet fields is ethofumesate + diclofop-methyl/ phenmedipham + desmedipham (or diclofop-methyl/endothall) applied preplant and postemergence, respectively, with a directed glyphosate application on weed escapes protruding above the canopy, if needed (25, 30 and Table 6). Evidence indicates further that diclofop-methyl, when applied in tank-mix with ethofumesate, enhances chemical weeding, especially grassy weeds, while promoting crop safety and production (concept of dual synergism) (28, 29).

Table 6. Experimental weed control scheme.

Pest	Timing	Application	Pesticide
Weeds (Major) Barnyardgrass Black Nightshade Common Lambsquarters Green Foxtail Kochia Redroot Pigweed Russian Thistle	Early April	Preplant	ethofumesate or ethofumesate + diclofop-methyl
Weed Escapes Kochia Common Lambsquarters Redroot Pigweed	Mid-May	At crop thinning, postemergence	phenmedipham + desmedipham (+ Herbicide 273)/ diclofop-methyl
Late Weeds Kochia Redroot Pigweed	Mid-July	Above canopy, directed foliar	glyphosate

DISCUSSION

Sugarbeets require a long growing season, and in the Central Great Plains Region it is the first row crop to be planted and the last crop harvested. Consequently, sugarbeets harbor many seasonal pests, making pest management more difficult than other crops.

Seed-borne *Phoma* has become an increasing problem in recent years. The fungicide candidate, RP-26019, particularly effective on *P. betae*, must be included in future seed treatment programs.

Sugarbeet nematodes have been the major pest problems since sugarbeets were introduced into this country. The main problem involved in nematode control is the high price of soil fumigants and aldicarb, which cost growers about $170 per hectare. Growers rely mainly on crop rotation and nematicides, but it is quite discouraging to growers when they realize that they have to use a nematicide after a long rotation period. New and less expensive nematicides are urgently needed to reduce production costs.

Rhizoctonia crown rot is another major factor limiting sugarbeet production in the region. At the present time, growers rely entirely on cultural means to reduce field rhizoctonia populations. Additional direct control tactics must be discovered to provide growers with more reliable tools to combat rhizoctonia.

Because of the long growing season required for sugarbeets, weed control is more complex and difficult than that for corn and beans. The general tendency has been to use more herbicides, thus, hand labor has been significantly reduced during the past decade. Complete spring mechanization of the crop depends on more effective weed control coupled with planting to stand.

Geneticists and plant breeders must develop not only pest

resistant cultivars, but also pesticide tolerant cultivars, particularly those more resistant to residual herbicides. Phytotoxicity delays timely management practices, especially when associated with cultivars displaying delayed emergence and early growth characteristics. Improved crop emergence and early growth undoubtedly will make the current pest control systems more manageable.

Finally, an important feature in sugarbeet or any other crop pest management is the training of growers and technical personnel. Success or failure in pest management remains in the hands of managers and technologists - individuals or growers who manage farms. Growers should always be well informed on all major pest problems and control practices. Through regular inspection of fields and crops, and properly selected control measures, successful pest management can be accomplished more consistently.

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