YIELD LOSSES IN WHEAT DUE TO WEED COMMUNITIES DOMINATED BY GREEN FOXTAIL [*Setaria viridis* (L.) BEAUV.]: A MULTISPECIES APPROACH

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A model was developed to predict wheat (*Triticum aestivum* L.) loss due to interference by multi-species weed communities dominated by green foxtail [*Setaria viridis* (L.) Beauv.], 3–4 wk after seeding. Results indicated that green foxtail-dominated weed communities averaging 427 plants m^{-2} over 4 yr reduced yield by about 7.8%. When plots were kept free of green foxtail, different species became important components of a second model developed to predict the yield loss. The combined effect of precipitation and growing degree days was an important component of both models. It is postulated that these environmental variables reflected the relative time of emergence of the weeds and the crop. Advantages of models based upon multispecies tests over those determined from one-weed one-crop tests are discussed as they relate to crop loss in multispecies situations.

Key words: *Setaria viridis*, green foxtail, crop loss, multispecies competition, weed communities, modeling

[Pertes de rendement du blé attribuables à des communautés de mauvaises herbes dominées par la sétaire verte [*Setaria viridis* (L.) Beauv.]: une méthode multispécifique.]
Titre abrégé: Pertes de rendement du blé attribuables à des communautés de sétaire verte.
On a mise au point un modèle pour prédire les pertes de rendement du blé (*Triticum aestivum* L.) attribuables à la concurrence exercée par des communautés de plusieurs espèces du mauvaises herbes dominées par la sétaire verte [*Setaria viridis* (L.) Beauv.], 3 à 4 semaines après le semis. Les résultats révèlent que les communautés de mauvaises herbes dominées par la sétaire verte atteignant en moyenne 427 plants m^{-2} pendant 4 ans réduisent les rendements du blé d'environ 7,8%. Lorsque les parcelles sont maintenues exemptes de sétaire verte, diverses espèces deviennent d'importantes composantes d'un second modèle mis au point pour prédire les pertes de rendement. L'effet conjugué de la précipitation et du nombre de degrés-jours de croissance constitue une composante importante des deux modèles. L'auteur pose comme hypothèse que ces variables environnementales rendent compte du temps relatif de levée des mauvaises herbes et de la culture. L'auteur discute des avantages de modèles fondés sur des essais de plusieurs espèces de mauvaises herbes par rapport à ceux fondés sur des essais d'une espèce de mauvaise herbe et d'une culture relativement à la perte de récolte en situations multispécifiques.

Mots clés: *Setaria viridis*, sétaire verte, perte de récolte, concurrence multispécifique, communautés de mauvaises herbes, modélisation

Most published weed-crop competition studies have examined the influence of one weed on a crop (Zimdahl 1980). Such studies have been used to construct generalized models of crop losses caused by weeds (Cousens 1985) and crop loss models specific to many crops including wheat (Dew 1972; Carlson and Hill 1985), barley (Dew 1972; Rauber 1977;

Table 1. Density of weed species in nonweeded subquadrats determined 3–4 d prior to the normal time of application of post-emergent herbicides

Species common name	Binomial	Species density – Field 1981	1982	1983	1986	Average
		(plants m^{-2} ± SE)				
American dragonhead	(*Dracocephalum parviflorum* Nutt.)	0.4 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.06 ± 0.04
Bluebur	(*Lappula echinata* Gilib.)	11.3 ± 1.8	24.6 ± 3.8	0.4 ± 0.2	0.0 ± 0.0	8.1 ± 1.8
Cowcockle	(*Vaccaria pyramidata* Medik.)	0.3 ± 0.2	0.6 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Dock	(*Rumex* sp.)	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.02 ± 0.02
Flixweed	(*Descurainia sophia* (L.) Webb.)	0.4 ± 0.2	0.1 ± 0.1	0.4 ± 0.1	0.0 ± 0.0	0.2 ± 0.1
Green foxtail	(*Setaria viridis* (L.) Beauv.)	349.0 ± 51.8	692.2 ± 47.2	151.8 ± 24.9	160.4 ± 18.0	337.1 ± 37.3
Lamb's quarters	(*Chenopodium album* L.)	5.3 ± 0.9	15.6 ± 3.4	13.2 ± 1.4	2.4 ± 0.6	9.6 ± 1.3
Perennial sowthistle	(*Sonchus arvensis* L.)	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.02 ± 0.02
Prostrate knotweed	(*Polygonum aviculare* L.)	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 0.2	0.0 ± 0.0	0.1 ± 0.1
Pigweed sp.	(*Amaranthus blitoides* S. Wats. and *Amaranthus retroflexus* L.)	14.2 ± 3.3	0.3 ± 0.2	1.4 ± 0.5	9.1 ± 2.9	5.3 ± 1.2
Russian thistle	(*Salsola iberica* Sennen & Pau)	0.0 ± 0.0	0.5 ± 0.1	1.1 ± 0.3	3.7 ± 0.8	1.5 ± 0.3
Scentless chamomile	(*Matricaria perforata* Merat.)	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.04 ± 0.03
Shepherd's purse	(*Capsella bursa-pastoris* (L.) Medic.)	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.2	0.0 ± 0.0	0.1 ± 0.1
Thyme-leaved spurge	(*Euphorbia serpyllifolia* Pers.)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Stinkweed	(*Thlaspi arvense* L.)	45.6 ± 11.6	45.9 ± 7.8	111.3 ± 15.8	0.6 ± 0.2	51.5 ± 7.9
Wild buckwheat	(*Polygonum convolvulus* L.)	12.0 ± 2.1	30.6 ± 2.9	1.1 ± 0.3	1.4 ± 0.3	11.2 ± 2.0
Wild mustard	(*Sinapis arvensis* L.)	1.8 ± 0.7	1.4 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	0.7 ± 0.2
Wild oats	(*Avena fatua* L.)	2.3 ± 1.1	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.0	0.4 ± 0.2
Totals		442.6 ± 42.6	812.4 ± 53.8	281.6 ± 27.8	177.7 ± 18.8	426.9 ± 40.8

O'Sullivan et al. 1982), flax (Dew 1972), rapeseed (O'Sullivan et al. 1985), and soybean (McWhorter and Anderson 1979; Marra and Carlson 1983). In actual cropping situations, however, the weed community normally comprises a number of species including one or two dominants, several other abundant species, and a number of less-abundant or rare species. Weed species interfere with each other interspecifically as well as with crop plants. The degree to which interference among weed species influences the competitive interactions among the weed species and the crop remains to be determined.

The majority of studies involving multi-species weed systems have dealt with the relationship between crop yield and total weed density or biomass (Nelson and Thoreson 1981; Lawson 1982; Ervio 1983; Ayeni et al. 1984). Austin et al. (1985) had some success predicting species dominance of six thistle species grown in mixtures. The plants were grown in monocultures over a nutrient gradient in pots of sand. Alex (1970) showed that in three-species mixtures in field situations, cow cockle (*Vaccaria pyramidata* Medik.) was suppressed by wild mustard (*Sinapis arvensis* L.), and the combined competitive effects of both species on wheat were not additive, one species tending to obscure the effects of the other. Kroh and Stephenson (1980) studied four weed species grown together in competition. These were redroot pigweed (*Amaranthus retroflexus* L.), lamb's quarters (*Chenopodium album* L.), witch grass (*Panicum capillare* L.), and green foxtail. It was determined that two-species experiments cannot be used to predict species performance in multispecies systems. Based upon these studies, a multispecies competition approach was considered necessary to enhance the predictive accuracy of weed-crop competition models.

The objective of this study was to utilize a multispecies approach in the development of a model predicting yield loss in wheat caused by interference from the weed community. The model could be used to predict potential yield losses prior to the application of post-emergent herbicides. Such a model would enable farmers to determine the economic usefulness of applying a post-emergent herbicide in any given year. The weed community examined was one dominated by green foxtail since this species is a major weed in the Regina area (Thomas 1979).

MATERIALS AND METHODS

Field Operations

Four wheat fields were selected for study, one in 1981, 1982, 1983 and 1986. The fields were within 60 km of Regina, Saskatchewan, the soil being medium-textured loam on undifferentiated glacial till deposits. Each field was sown with hard red spring wheat, was fallow the previous year, and had heavy weed infestations dominated by green foxtail. Within the fields, an area 35 m by 35 m was staked within 7 d of crop emergence. Within this staked area, a 5-m border was left. Sampling was done using eight randomly placed triplet quadrats in the field in 1981, and 14 in 1982, 1983 and 1986. The triplet quadrat sampling unit consisted of three subquadrats of 1 m^2 area (75 by 133 cm) laid end to end in the same orientation as the wheat rows so that the same wheat rows were contained in each subquadrat of the triplet. One subquadrat of a triplet was hand-weeded, the second was nonweeded, and in the third only green foxtail was removed by hand. Weeds overhanging weeded subquadrats were also removed from around weeded areas to limit border effects to places where the subquadrats of each triplet came into contact. The relative position of each subquadrat within a triplet was randomized. The number of crop plants in each subquadrat was determined when tillering started, about 3–4 wk after seeding. The number of seedlings of each weed species was determined about 4 wk after seeding, at the 4- to 5-leaf stage of the wheat. The plot areas were not treated with herbicides. The crop was harvested by hand and yield determined for each subquadrat.

Wheat was seeded in mid- to late May, and harvested in late August to early September. Participation and growing degree data (base 5°C) were obtained from the Agriculture Canada Research Station in Regina.

Data analysis

Data from all fields and all years were pooled and two separate multiple regression analyses were performed. In the first analysis, apparent wheat loss (weed-free minus weedy subquadrat yield) was related to independent variables including weed density for each species, crop density, relative crop density (weed-free minus weedy subquadrat crop density), precipitation, growing degree days, and precipitation × growing degree days. Precipitation periods were examined 1, 2, 3, 6, 8, and 12 mo prior to the month in which weed counts were made. In the second analysis, the wheat loss occurring when green foxtail had been removed (weed-free minus part-weeded subquadrat yield) was related to these same independent variables.

The most efficient equations to represent the data were selected using SAS, Proc RSQUARE (Statistical Analysis System Institute, Inc. 1985), which computes all possible regression equations. Selection of the best equation was a two-step process. First, the most efficient number of variables to use in the model was determined using Mallows Cp (Mallows 1973; Freund and Minton 1979). Second, the best equation with this number of variables was determined using those providing the largest r^2 (the smallest Cp). All minor species (averaging <1 plant m^{-2}) in each quadrat were grouped and considered a single variable.

In addition, attempts were made to fit the data to sigmoidal and hyperbolic distributions.

RESULTS AND DISCUSSION

Total weed densities in the weedy subquadrats ranged from 178 in 1986 to 812 plants m^{-2} in 1982 (Table 1). In each field, green foxtail was the dominant weed species representing, on average, 79% of the community. Six other major weed species (>1 plant m^{-2}) made up an additional 20%, including stinkweed, wild buckwheat, lamb's quarters, redroot pigweed, bluebur, and wild oats. The remaining 1% of the weed community consisted of 12 minor species (<1 plant m^{-2}). In the part-weeded subquadrats, the average density among the fields was 91 plants m^{-2}, ranging from 18 in 1986 to 146 in 1983 (Table 2). The dominant weed species in these plots was stinkweed, comprising an average of 59% of the total number. Other major weeds, including lamb's quarters, wild buckwheat, bluebur, redroot pigweed, wild oats, and wild mustard made up an additional 39%. Nine minor species formed the remaining 2% of the weed community.

The weed-free wheat yield was 249 g m^{-2} from an average density of 198 crop plants m^{-2} (Table 3). The relative wheat densities averaged -4 and -2 plants m^{-2} respectively, where relative wheat density was the weed-free minus the weedy or part-weeded subquadrat density (Table 3). On a field-by-field basis, differences in wheat density

Table 2. Density of weed species in part-weeded subquadrats determined 3–4 d prior to the normal time of application of postemergent herbicides

Species	Species density				
	Field				
	1981	1982	1983	1986	Average
	(plants m^{-2} ± SE)				
American dragonhead	1.0 ± 0.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Bluebur	10.3 ± 2.2	27.4 ± 3.5	0.1 ± 0.1	0.0 ± 0.0	9.1 ± 1.9
Cowcockle	1.0 ± 0.6	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.1
Flixweed	0.1 ± 0.1	0.2 ± 0.1	0.6 ± 0.3	0.0 ± 0.0	0.2 ± 0.1
Lamb's quarters	6.3 ± 0.5	15.6 ± 3.1	13.2 ± 1.8	2.6 ± 0.4	9.7 ± 1.2
Prostrate knotweed	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.04 ± 0.03
Pigweeds	7.1 ± 3.0	0.2 ± 0.1	0.8 ± 0.2	8.6 ± 1.7	3.9 ± 0.9
Rose	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.02 ± 0.02
Russian thistle	0.0 ± 0.0	1.1 ± 0.3	1.2 ± 0.3	3.8 ± 0.6	1.8 ± 0.3
Scentless chamomile	0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.02 ± 0.02
Stinkweed	44.8 ± 10.2	40.1 ± 6.2	128.9 ± 15.6	1.7 ± 0.5	53.9 ± 8.4
Thyme-leaved spurge	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.02 ± 0.02
Wild buckwheat	14.0 ± 2.5	26.4 ± 1.6	1.3 ± 0.3	1.3 ± 0.3	10.2 ± 1.7
Wild mustard	1.4 ± 0.5	2.1 ± 0.6	0.1 ± 0.1	0.0 ± 0.0	0.8 ± 0.2
Wild oats	3.0 ± 1.9	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.0	0.5 ± 0.3
Totals	89.1 ± 10.3	113.4 ± 12.3	146.4 ± 16.2	18.1 ± 1.9	90.6 ± 9.1

Table 3. Summary of wheat data used for crop loss model including measures of wheat density and yield (±SE)

Parameter measured (units m^{-2})	Field 1981	1982	1983	1986	Average
Sample number	8	14	14	14	13
Weed-free wheat density	231 ± 8	190 ± 4	188 ± 6	223 ± 10	198 ± 4
W-Relative wheat density (Weed-free minus nonweeded quadrats)	−30 ± 10	−5 ± 7	4 ± 7	13 ± 10	−4 ± 4
PW-Relative wheat density (Weed-free minus part-weeded quadrats)	−5 ± 10	−1 ± 6	−8 ± 7	4 ± 9	−2 ± 4
Weed-free yield (g)	221 ± 7	216 ± 10	268 ± 5	279 ± 6	249 ± 5
Potential yield minus weedy yield (g)	−21 ± 9	39 ± 9	3 ± 5	35 ± 6	18 ± 5
Potential yield minus part-weeded yield (g)	−19 ± 9	28 ± 7	1 ± 8	4 ± 8	6 ± 4

between weed-free or partly weeded subquadrats and weedy subquadrats were not statistically significant, except for the weed-free : weedy comparison in 1981 (matched pair *t*-test, $P=0.05$). The difference in yield between the weed-free and weedy subquadrats averaged 18 and 6 g m^{-2} for the weedy and part-weeded subquadrats, respectively.

Using Mallows Cp, the best number of variables to use was five, with the best Cp=4.78 at that subset size. The second best Cp was 7.22, or 1.51 times greater. The period from 1 Mar. through 31 May proved to be the most efficient for use in the equation with respect to precipitation × growing degree days (Table 4). The multiple regression equation relating apparent wheat loss to independent variables for the weedy subquadrats is:

$$y=0.39\ X_1+1.35\ X_2-2.18\ X_3+4.13\ X_4+0.0206\ X_5-82.18 \quad (1)$$

where:

y = apparent yield loss (kg ha^{-1}),
X_1 = green foxtail plants (m^{-2}),
X_2 = stinkweed plants (m^{-2}),
X_3 = wheat density (m^{-2}) in weed-free quadrats,
X_4 = relative wheat density (m^{-2}) which is the difference in wheat density between weed-free and weedy subquadrats, and
X_5 = cumulative growing degree days (base 5°C) × total precipitation for the period 1 Mar. through 31 May.

Substituting the means of the field data for each independent variable, the average apparent crop loss for these fields over the 4-yr period was 179±33 kg ha^{-1} (±SE) or 7.2% of the potential yield. Note that the apparent crop loss was the difference between yields of weed-free and weedy subquadrats. The real crop loss was determined by correcting for the relative wheat density between adjacent subquadrats, giving a value of 194 kg ha^{-1} (7.8%) yield loss. The regression r^2 was 0.59, and the equation was significant to $P < 0.0001$. Standard errors of the partial regression coefficients are shown in Table 5. Square root transformations of species counts were not used since they did not improve the

Table 4. Cumulative precipitation and growing degree days (base 5°C) 1981–1983, and 1986, for the period 1 Mar. through 31 May

	1981	1982	1983	1986
1. Precipitation (mm)	41.9	129.0	73.1	151.0
2. Growing degree days (°C)	279.4	221.3	188.5	235.3
3. '1' × '2'	11832.6	28541.3	14344.9	38097.3

Table 5. Partial regression coefficients (±SE) for all variables used in Eqs. 1 and 2

Equation	Variable	Partial regression coefficient	SE
1	X_1 (green foxtail plants m^{-2})	0.39	0.13
	X_2 (stinkweed plants m^{-2})	1.35	0.80
	X_3 (wheat density m^{-2})	−2.18	1.49
	X_4 (relative wheat density m^{-2})	4.13	1.42
	X_5 (growing degree days × precipitations)	0.0206	0.0041
2	X_1 (wild buckwheat plants m^{-2})	8.15	3.68
	X_2 (stinkweed plants m^{-2})	1.79	0.97
	X_3 (minor species plants m^{-2})	17.02	13.88
	X_4 (growing degree days × precipitation)	0.0158	0.0058

model, but marginally reduced the r^2 values (by about 0.05). Hyperbolic and sigmoidal functions did not fit the data as well as the multiple regression equations. The best attempt to fit such functions resulted in $r^2 = 0.48$.

Wheat density was a useful variable in Eq. 1 describing the relationship between the green foxtail dominated community and wheat. This supports results from other recent studies. Rauber (1977) has shown that wild oats competition in barley is significantly influenced by variation in barley density. In a study by Carlson and Hill (1985), yield loss caused by wild oats in wheat was also shown to be influenced by crop density. Hume (1985) demonstrated the importance of considering crop density as a variable in weed-wheat competition studies.

The variable growing degree days × precipitation was also important in the equation. In southern Saskatchewan, both soil moisture and temperature are important variables that can influence germination. For green foxtail, it has been shown that the germination rate is reduced when either moisture level or temperature is too low. The combined effect of both has a significant effect on weed seedling emergence (Weaver et al. 1988). In addition, crop plants are bred for very low degrees of dormancy, and as a consequence, tend to germinate more readily than weeds under cool or dry conditions (Blackshaw et al. 1981a). It has also been demonstrated that the time of emergence of the crop and weeds has a major affect upon their relative competitive abilities, in that late-emerging weeds cause less crop loss than those that emerge early (O'Donovan et al. 1985). Soil moisture and temperature are directly related to growing degree days and precipitation. It is possible, therefore, that the reason the combined effect of these environmental variables was so important was due to their influence upon the relative time of emergence of wheat and weeds. In the current investigation, the largest yield reductions occurred in 1982 and 1986 when both growing degree days and precipitation were high (Tables 3 and 4).

Some weed species present in the wheat field were not represented in either Eq. 1 or 2 of the model. For some minor species, sample sizes were too small to enable conclusions to be drawn regarding their competitive effects. Lumping all such minor species together increased sample size for the minor species variable, but this variable did not contribute to the efficiency of the regression equation.

For other more abundant species not included in the model, their effects may have been correlated either positively or negatively to the other important weed species that were included. An example is lamb's quarters. When this species was included in the model, it was negatively correlated to crop loss, with a partial regression coefficient of -6.55 ± 5.31 (SE). Although lamb's quarters may not be a strong competitor (LaPointe et al. 1984; Roush and Radosevich 1985), it can cause significant yield losses in wheat (LaPointe et al. 1984) and rapeseed (*Brassica napus* L.) (Blackshaw et al. 1987). Kroh and Stephenson (1980) have indicated that lamb's quarters is more competitive than green foxtail. However, in their experiment, all weed species started out with the same number of plants, and total plant density was 51 m^{-2}. In the current study, green foxtail densities were far greater (337 plants m^{-2} vs. 10 lamb's quarters plants m^{-2}) and overall plant density ranged from 400 to about 1000 plants m^{-2}, including the wheat crop. It seems illogical that one could increase crop yield by increasing the number of lamb's quarters plants. More likely the lamb's quarters plants were suppressed by the more abundant weed species, green foxtail and stinkweed. This is a similar finding to that of Alex (1970) where wild mustard suppressed cow cockle in a three-species mixture with wheat. This point highlights one major benefit of models based upon multispecies tests over those developed from one-weed one-crop studies. The effect on crop loss caused by lamb's quarters, green foxtail, and stinkweed, had they been determined by one-weed one-crop tests, could not be summed to enable prediction of crop loss which would be caused by all three species growing together with the crop. Their effects are not additive in this manner.

The model indicates that there were significant wheat losses in these fields, averaging 194 kg ha^{-1}, or 7.8% of wheat yield over the 4-yr period. This yield loss was small, but not unusual in this relatively dry area in the Canadian prairies. There is considerable variation in the literature concerning the magnitude of the effect that green foxtail has on wheat in this region. Losses in wheat have been reported to be as low as 0 for densities of 932–1600 plants m^{-2} and as high as 44% for densities of 100 plants m^{-2} (Dew 1975; Blackshaw et al. 1981b; O'Donovan 1984). Such variation may reflect differences in relative dates of weed and crop emergence as demonstrated in this paper and by Blackshaw et al. (1981a) and O'Donovan et al. (1985) or differences in wheat variety and climate.

It was determined for the equation representing the part-weeded subquadrats, that the most useful number of variables was four. The best Cp = 1.54, with the second best Cp at this subset size of 2.66, or 1.73 times greater. The equation representing loss caused by the part-weeded subquadrats is:

$$y = 8.15\ X_1 + 1.79\ X_2 + 17.02\ X_3 + 0.0158\ X_4 - 542.245 \qquad (2)$$

where:

y = wheat loss (kg ha^{-1}),
X_1 = wild buckwheat plants (m^{-2}),
X_2 = stinkweed plants (m^{-2}),
X_3 = minor species plants (m^{-2}), and
X_4 = cumulative growing degree days (base 5°C) × total precipitation for the period 1 Mar. through 31 May.

The relationship between wheat loss and the independent variables in Eq. 2 was significant (P=0.02). The average yield loss occurring in the absence of green foxtail was quite low, only 64±40 kg ha^{-1} (±SE), or 2.6%. As a result, the proportion of variation accounted for by the model was low, with an r^2=0.23. Standard errors of the partial regression coefficients, are shown in Table 5.

The substitution of either crop density, relative crop density, or pigweeds in place of minor species in Eq. 2 would result in only a slight (2%) reduction in r^2. Relative crop density was not as important as it was in Eq. 1. This is likely because the difference in wheat density between the weed-free and part-weeded subquadrats used to determine Eq. 2 was only one half that for Eq. 1.

On the removal of green foxtail, wild buckwheat and minor species took on increased importance in describing the relationship with crop loss. One possible implication is that when the dominant species is removed, the effect is to change the nature of the weed community, resulting in different species becoming important in causing yield loss.

A multispecies approach is most appropriate for development of predictive models of crop losses from weeds in many instances, since the traditional one-weed one-crop studies often do not reflect the norm in actual farm situations. For clarification, it is worth noting that a multispecies approach may not always result in the development of a multispecies equation. It is quite possible that one species is so dominant that it alone in a model would be adequate for predictive purposes. For the green foxtail model, it was necessary to include only two weed species.

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