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Yield loss to corn from feeding by the Banks grass mite and two-spotted spider mite (Acari: Tetranychidae)

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ABSTRACT

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Our research was designed to determine the effects of a mite complex consisting of the Banks grass mite (BGM), *Oligonychus pratensis* (Banks), and the two-spotted spider mites (TSM), *Tetranychus urticae* Koch, on corn yield and plant lodging. For BGM, mite days and damage rating for the whole plant and leaves in the lower third of a corn plant had the best correlation with corn yield. The best correlation with yield for TSM was plant damage ratings. The percentage loss per unit for most independent variables (mite densities, mite days, or percentage of the leaf area damaged on a plant) was very similar for BGM and TSM. Therefore, the same economic threshold can be used for either mite species. When TSM fed on corn in the dent growth stage, yield was not reduced, and their feeding did not influence corn plant lodging.

INTRODUCTION

Four species of mites have been identified in association with field corn, *Zea mays* L., in the semi-arid central region (Great Plains) of the United States (Ehler, 1973). The two most common mites on corn are the Banks grass mite (BGM), *Oligonychus pratensis* (Banks), and the two-spotted spider mite (TSM), *Tetranychus urticae* Koch. The BGM usually infests corn in May and June, but TSM is not found on corn until July or August (Logan *et al.*, 1983, Sloderbeck *et al.*, 1988). Mite control decisions are made in mid summer and either or both species may be present. The economic injury level has been determined for BGM on corn (Archer & Bynum 1990, Morrison *et al.*, 1991). Bacon *et al.* (1962) reported a 47% loss in corn yield from damage by TSM in a spray–no spray experiment, but Klostermeyer (1961) reported no loss from TSM feeding on corn. It is important to determine the potential economic loss from feeding by the TSM and determine if it is different from the loss formula already determined for BGM.

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Research was designed to determine the effects of a mite complex consisting of BGM and TSM on corn yield and plant lodging. The data were collected for each species and for the two species feeding together. Data were collected for corn in the tasseling and grain filling growth stages when corn is the best host for mites and their densities are increasing rapidly (Ehler, 1974, Feese and Wilde, 1977).

MATERIALS AND METHODS

The procedures were similar to those used by Archer and Bynum (1990) so that the data would be comparable to those collected for the BGM economic threshold on corn. The experiment was divided among three blocks which were adjacent and included (1) only BGM, (2) only TSM, and (3) a mixture of the two species. It was necessary to separate the three experiments so that we could maintain species purity in each one. Plots in each experiment were 8 m wide (8 rows) by 15 m long and were arranged in a randomized complete block design with four replications. Data were collected in two adjacent, 4-m-long sections of the two center rows per plot. The corn hybrid used was 'Pioneer 3186'. Corn was planted the third week of April each year, and agronomic practices commonly employed for producing irrigated corn were used (Petr and Bremer, 1976).

Mite damage to corn was measured in each plot from the tassel through grain-filling growth stages. Damage was the chlorotic spots that formed on leaves from mite feeding or dead leaf areas from mite feeding. Damage was measured using a 1–10 scale with 1 = 1–10% of the leaf area on a plant damaged by mite feeding to 10 = 91–100% of the leaf area damaged (Chandler *et al.*, 1979). Mites were obtained from a heavily infested commercial corn field during the first two weeks in July each year. Infested leaves were transported to the research plots and placed on experiment plants. There were five mite damage treatments based on the damage levels defined above. A predetermined number of leaves was placed on plants in each treatment based on the ultimate damage level desired, (1) 0% damage, no infested leaves placed on plants; (2) 20% damage (damage rating = 2), one infested leaf wrapped around the stalk in the lower third of the canopy on every other plant per plot; (3) 40% damage (damage rating = 4), one infested leaf per plant; (4) 60% damage (damage rating = 6), two infested leaves per plant, and (5) 80% damage (damage rating = 8), two leaves per plant (TSM only). Plants were sprayed as needed to keep the check plots mite free, or in infested treatments when mite feeding damage reached the predetermined percentage leaf area damaged. There were five treatments in the mixed species experiment; in treatment 1 plots were maintained mite free, in treatments 2 and 3 BGM was sprayed when mite damage was >20% (rating = 3) and TSM was sprayed one (treatment 2) or two (treatment 3) weeks later, and in treatments 4 and 5 BGM was sprayed when damage was >40% (rating = 5) and TSM was sprayed one (treatment 4) or two (treatment 5) weeks later. When mite damage to corn reached the predetermined level per plot, monocrotophos at 0.56 kg $(AI)^{-1}$ ha was applied in 94 L of water for

BGM control and a mixture of biphenthrin + dimethoate at 0.11 + 0.56 kg (AI)$^{-1}$ ha in 94 liters of water was applied for TSM control.

Beginning one week after infestation, the total number of female mites, predators, infested leaves, dead leaves, and total green leaves per plant were counted weekly on each of five plants per plot in the 4-m-long sample sections. Also, the average plant damage rating was determined per plot for whole plants and leaves in the upper, middle, and lower thirds of the canopy using the 1–10 rating scale. Corn growth stage was recorded each week. Yield samples consisted of collecting all ears from the plants in each of the 4-m linear sections per plot. Shelled grain was weighed, and weights were standardized for 15% moisture. Test weights were determined by measuring weight per bushel of four grain samples per plot. The number of plants lodged as a result of stalk rot was recorded when yield samples were taken.

Analysis of variance (SAS Institute, 1985) was used to determine differences in mite numbers, damage, percentage of infested leaves, grain yield, test weight, lodging, and grain moisture among the five treatments. Means were separated with the LSMEANS procedure,-least-squares estimates of marginal means (P=0.05). Linear regression analysis (SAS Institute, 1985) was used to describe the relationship of mite densities, mite days (Ruppel, 1983), damage ratings, percentage of infested leaves per plant, and combinations of these variables on yield and plant lodging. There were 6 df for BGM regression analyses and 8 df for regression analyses for TSM and the two mite species. Polynomial models did not provide a significant (P=0.05) improvement to explain variation.

RESULTS AND DISCUSSION

The year by treatment interaction was not significant ($F = 1.29$, $P = 0.31$, df = 6; $F = 1.38$, $P = 0.26$, df = 8) so all data could be combined for statistical analysis. Mite densities, mite days, damage ratings, and percentage of the plant infested by mites separated statistically among treatments for BGM and TSM (Table 1). Yield was statistically the same for all treatments in the BGM plots but separated statistically among treatments infested with TSM. Yields in treatment 4 was statistically different from the check and there was a 13% yield loss from TSM feeding compared to 47% reported by Bacon *et al.* (1962). BGM densities and damage were about a third as high as reported by Archer and Bynum (1990) which may explain the lack of statistical separation in yield among treatments. The TSM infestation was nearly twice as high as BGM and damage was a third higher so there was a statistical separation among all variables by treatment including yield. There were no significant differences in test weights among treatments for either species.

BGM densities were not well correlated with yield (Table 2), probably because of the drop in mite densities in the last treatment. Calculation of mite days overcame the effect of mite decline in the last treatment. The rationship between mite

TABLE 1

Banks grass mite and two-spotted spider mite densities and damage on corn prior to dent and yield loss from mite feeding.

Treatment no.	Damage rating/plant section[1] ± SEM: Lower one-third	Middle one-third	Upper one-third	Whole plant	$\bar{x}$No. ♀♀ mites/plant ± SEM	Mite days ± SEM	% leaves infested ± SEM	Yield kg^{-1} ha ± SEM
Banks grass mite								
1	1.0±0.0c[2]	0.5±0.2c	0.0±0.0c	1.0±0.0c	22± 7c	508± 129b	34±4c	10,859±291a
2	3.1±0.1b	1.4±0.2b	0.5±0.2b	2.1±0.1b	124±23b	2,364± 511ab	71±7b	10,692±265a
3	5.5±0.4a	2.9±0.2a	1.0±0.0a	4.0±0.3a	247±58a	4,472± 930a	96±1a	10,340±377a
4	5.9±0.8a	3.3±0.3a	1.0±0.2a	4.4±0.6a	105±13bc	4,795±1348a	94±2a	10,013±337a
Two-spotted spider mite								
1	1.0±0.0d	0.5±0.2c	0.0±0.0c	1.0±0.0c	18± 4b	275± 30c	31±2c	10,267±290a
2	2.9±0.1c	1.1±0.1c	0.3±0.2c	1.9±0.1c	107± 32b	1,388±394c	65±5b	9,824±222a
3	5.6±0.4b	2.9±0.2b	1.1±0.1b	4.1±0.4b	316± 54a	3,535±543b	92±1a	9,634±460ab
4	8.1±0.4a	5.3±0.4a	2.6±0.4a	6.5±0.3a	452± 52a	6,925±997a	95±1a	8,910±253b
5	6.5±0.9b	4.8±0.6a	2.0±0.4a	5.5±0.9a	467±134a	4,567±134b	90±2a	8,708±210b

[1] Damage rating on a 1–10 scale, when 1 = 1–10% of the leaf area damaged by mite feeding to 10 = 91–100% damage.

[2] Means followed by the same letter were not significantly different ($P = 0.05$; LSMEANS mean separation [SAS Institute, 1985].

days and yield was good, but mite days would be difficult for agricultural consultants to use because they do not make counts of mites all season as we did in this research project. Damage ratings would be easier to make and would be the most accurate decision tool. The best sampling units for damage ratings were whole plants or leaves in the bottom third of a plant. The r^2 was ≥ 0.64 for the middle and upper third of the canopy, but the standard error and mean square error values were high indicating high variation among samples. The percentage yield loss per unit for whole plant damage rating was 0.20 compared to 0.22 reported by Archer and Bynum (1990).

TSM densities plateaued at damage ratings >6 which resulted in a decline in mite days in treatment 5 and a low r^2 for the mite day-yield interaction (Tables 1, 2). Among the independent variables, damage ratings provided the best correlations with yield (Table 2). TSM tends to distribute more evenly on a plant than BGM so damage ratings for plant thirds were less accurate than for BGM particularly for the lower third. The percentage of the leaves infested with mites did not correlate

TABLE 2

Relationship between corn yield and Banks grass mite and two-spotted spider mite density, mite days, damage rating and proportion of leaves infested on corn prior to dent. Only one species of mite was on a plant.

Independent Variable	Slope	SE	Root MSE[1]	r^2	%loss/ unit
Banks grass mite					
Mite (♀♀) density	−2.70	0.90	254.8	0.57	0.028
Cumulative mite days	−0.11	0.02	180.7	0.82	0.001
Damage rating[2]					
Lower third	−137.88	28.65	179.4	0.82	0.142
Middle third	−242.32	81.66	256.1	0.64	0.252
Upper third	−724.71	210.03	231.5	0.70	0.761
Whole plant	−193.49	45.36	197.6	0.78	0.199
Percentage of leaves					
Infested	−10.09	4.15	288.08	0.54	0.102
Two-spotted spider mite					
Mite (♀♀) density	−1.90	0.69	393.9	0.52	0.021
Cumulative mite days	−0.09	0.06	484.5	0.28	0.001
Damage rating[2]					
Lower third	−140.43	46.69	375.8	0.56	0.154
Middle third	−217.67	50.18	296.3	0.73	0.240
Upper third	−370.95	103.19	337.3	0.65	0.416
Whole plant	−193.62	51.56	327.7	0.67	0.211
Percentage of leaves					
Infested	−14.43	5.23	393.66	0.52	0.151

[1] Root MSE, root mean square error.

[2] Damage rating on a 1–10 scale, when 1 = 1–10% of the leaf area damaged by mite feeding to 10 = 91–100% damage.

well with yield for either mite species. The percentage yield loss per unit for whole plant damage rating was 0.21 for TSM compared to 0.20 for BGM.

Data for plants infested with both species of mites simultaneously are shown in Table 3. Mite damage increased by ca. 30% and 40% when TSM remained on plants one and two weeks after BGM were sprayed. The standard error and mean square error for BGM were much higher in this experiment (Table 4) than for BGM alone (Table 2), probably because damage was only allowed to reach 20% and 40% before mites were sprayed. The SE and root mean square error for the TSM data in the mite mixture were only slightly higher than for TSM alone. The percentage loss per unit for cumulative mite days (both species) and for the damage rating on the whole plant or lower third (Table 4) were comparable to the values reported for either species alone (Table 2).

TABLE 4

Relationship between corn yield and Banks grass mite and two-spotted spider mite density, mite days, damage rating and proportion of leaves infested on a plant. Both species were on a plant; BGM results were calculated for densities and damage prior to spraying BGM and TSM data were calculated for densities and damage at the 2 or 4 weeks after the first spray.

Independent Variable	Slope	SE	Root MSE[1]	r^2	%loss/ unit
Banks grass mite					
Mite (♀♀) density	−2.22	1.37	579.5	0.27	0.024
Cumulative mite days	−0.21	0.10	532.5	0.39	0.0023
Damage rating[2]					
Lower third	−306.06	95.02	431.5	0.60	0.313
Middle third	−447.63	144.31	441.2	0.58	0.468
Upper third	−1028.90	396.12	485.1	0.49	1.090
Whole plant	−444.86	122.49	400.3	0.65	0.450
Percentage of leaves					
Infested	−7.60	8.20	641.6	0.11	0.082
Two-spotted spider mite					
Mite (♀♀) density	−7.56	2.57	453.8	0.55	0.079
Cumulative mite days (TSM)	−0.31	0.09	420.3	0.62	0.003
Cumulative mite days (both species)	−0.17	0.04	338.5	0.75	0.002
Damage rating[2]					
Lower third	−180.49	58.89	444.0	0.57	0.187
Middle third	−311.86	95.89	428.8	0.60	0.325
Upper third	−561.60	224.04	493.3	0.47	0.600
Whole plant	−273.91	84.70	430.3	0.60	0.280
Percentage of leaves					
Infested	−12.51	7.52	575.14	0.28	0.013

[1] Root MSE, root mean square error.

[2] Damage rating on a 1–10 scale, when 1 = 1–10% of the leaf area damaged by mite feeding to 10 = 91–100% damage.

TABLE 5

Densities, damage, and proportion of the leaves infested with two-spotted spider mite on corn in the dent or after dent growth stages and resulting yield response.

Treatment no.	Damage rating/plant section[1] ± SEM: Lower one-third	Middle one-third	Upper one-third	Whole plant	$\bar{x}$No. ♀♀ mites/plant ± SEM	Mite days ± SEM	% leaves infested ± SEM	Yield kg $^{-1}$ha ± SEM
1	1.3±0.1d[2]	0.3±0.3d	0.3±0.3c	1.0±0.0d	4± 2c	15±7c	36±6c	10,059±426a
2	3.3±0.3c	1.8±0.3c	1.0±0.0b	2.3±0.3c	73±6bc	1,003± 80c	91±2b	9,416±348a
3	5.3±0.5b	3.5±0.3b	1.0±0.0b	4.3±0.5b	182±78b	2,513± 442b	96±2ab	9,444±460a
4	6.8±0.3a	4.8±0.3a	2.0±0.4a	5.8±0.3a	385±94a	4,134±615a	99±1ab	9,610±262a
5	6.5±0.6a	5.3±0.9a	2.3±0.5a	6.0±0.7a	282±57ab	5,098±853a	100±0a	9,142±259a

[1] Damage rating on a 1–10 scale, when 1 = 1–10% of the leaf area damaged by mite feeding to 10 = 91–100% damage.

[2] Means followed by the same letter were not significantly different ($P = 0.05$; LSMEANS mean separation [SAS Institute, 1985]).

When TSM fed on corn in the dent growth stage, yield was not reduced significantly (Table 5). Mites in the first treatment were sprayed while plants were in growth stage 6, but ears were dented when mites in all other treatments were sprayed. This may explain why yield was ca. 450–900 kg/$^{-1}$ ha greater between treatment one and the other treatments. Whole plant damage ratings were comparable to those reported in Table 1, but yield did not differ among treatments.

Archer and Bynum (1990) reported that BGM did not influence corn plant lodging. The same was true for TSM in this research. In two of the three years, <1% of the plants lodged. In 1988, lodging was low to moderate (2 to 8%) but there was correlation between mite numbers and lodging ($r^2 = 0.12$ for BGM and $r^2 = 0.21$ for TSM).

The loss from feeding by the two mite species on corn was comparable and therefore, the same economic threshold can be used when either or both species infest corn. These data indicate that mites on corn can be placed into an injury guild as described by Hutchins *et al.* (1988).

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REFERENCES

Archer, T.L. and Bynum Jr. E.D. 1990. Economic injury level for the Banks grass mite (Acari: Tetranychidae) on corn. J. Econ. Entomol. 83: 1069–1073.

Bacon, O.G., Lyons, T. and Baskett, R.S. 1962. Effects of spider mite infestations on dent corn in California. 55: 823–825.

Chandler, L.D., Archer, T.L., Ward, C.R. and Lyle, W.M. 1979. Influences of irrigation practices on spider mite densities on field corn. Environ. Entomol. 8: 196–201.

Ehler, L.E. 1973. Spider mites associated with grain sorghum and corn in Texas. J. Econ. Entomol. 66: 1220.

Ehler, L.E. 1974. A review of the spider-mite problem on grain sorghum and corn in West Texas. TX Agric. Exp. Stn. Bull. 1149: 1–15.

Feese, H. and Wilde, G. 1977. Factors affecting survival and reproduction of the Banks grass mite, *Oligonychus pratensis*. Environ. Entomol. 6: 53–56.

Hutchins, S.H., Higley, L.G., and Pedigo, L.P. 1988. Injury equivalency as a basis for developing multiple-species economic injury levels. J. Econ. Entomol. 81: 1–8.

Klostermeyer, E.C. 1961. Effect of mite control on corn yield. J. Econ. Entomol. 54: 608–609.

Logan, J.A., Congdon, B.D. and Allredge, J.K. 1983. Ecology and control of spider mites on corn in northeastern Colorado. Colorado State Univ. Exp. Stn. Bull. 585S: 1–41.

Morrison, W.P., Cronholm, G.B., Parker, R.D., Stewart, J.W., Patrick, C.D., and Archer, T.L. 1991. Managing insect and mite pests of Texas Corn. TX Agric. Ext. Serv. Bull. B-1366. 14pp.

Petr, F.C. and Bremer, J.E. 1976. Keys to profitable corn production on the high plains. TX Agric. Ext. Serv. MP. 1275: 1–7.

Ruppel, R.F. 1983. Cumulative insect-days as an index of crop protection. J. Econ. Entomol 76: 375–377.

SAS Institute. 1987. SAS user's guide: statistics. SAS Institute, Cary, N.C.

Sloderbeck, P.E., Morrison, W.P., Patrick, C.D., and Buschman, L.L. 1988. Seasonal shift in species composition of spider mites on corn in the western Great Plains. South. Entomol. 13: 63–68.