INFLUENCE OF POTASSIUM AVAILABILITY ON SOYBEAN APHID POPULATION DYNAMICS

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Introduction

The soybean aphid, *Aphis glycines* was first observed in Wisconsin during the 2000 growing season. Since its introduction many commercial soybean fields have exhibited high levels of aphid activity and yield losses have been widely reported from aphid feeding damage. Field observations of heavy soybean aphid infestations have suggested a potential link between potassium deficiency in soybeans and high aphid numbers. Areas showing symptoms consistent with potassium deficiency were also associated with high levels of soybean aphid infestation. The objective of this study was to examine the effect of potassium availability on plant selection by soybean aphids, and to quantify the resulting impact on soybean yields.

Materials and Methods

Small plot field experiments were established at the University of Wisconsin Agricultural Research Station at Arlington, WI during the 2001 and 2002 growing seasons. The soybean variety used in this experiment was Asgrow 2001 RR (glyphosate resistant). Soybeans were planted on 10 May 2001, and on 9 June 2002, in 0.76 m rows at a rate of approximately 328,700 plants per hectare in a no-till field that contained corn during the previous season. The two fields used for this experiment had been previously established by the University of Wisconsin-Madison Department of Soil Science to contain plots with 3 rates of potassium.

The experiments contained 6 treatments: three K rates (high, medium and low), were allowed to develop aphid infestations, and three K rates received insecticide applications beginning when aphids were first observed in the field, and on approximately 10 day intervals thereafter, in an attempt to keep the plots as free from aphid feeding as possible. Insecticides were applied as a foliar spray using a CO_2 powered backpack sprayer alternating applications of Warrior (?-cyhalothrin [0.030 lbs aia]) and Lorsban (chlorpyrifos [0.50 lbs aia]) to avoid any potential localized insecticide resistance problems with the aphid population. Insecticides were applied on 7/10, 7/16, 7/27, 7/31 and 8/9 in 2001; and 7/17, 7/23, 7/30, and 8/6 in 2002. Individual plots measured 3.05 m x 6.71, and treatments were arranged in a randomized complete block design with 6 replications.

Aphid populations were sampled throughout the growing season in both years. In 2001 aphid counts were taken on 3 dates: 11 July, 25 July and 1 August, and in 2002 sampling was expanded to 5 dates: 18 July, 24 July, 31 July, 7 August, and 16 August.

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The aphid sampling protocol differed between the two years of this experiment. In 2001 aphid counts were taken from 20 plants per plot on each sampling date. A rating system, based on a 1-7 scale, was used to classify the number of aphids per plant rather than count individual aphids per plant. The rating system assigned a score of 1 for plants on which no aphids were found, a score of 2 for plants with 1-10 aphids, 3 for plants with 11-25 aphids, 4 for plants with 25-50 aphids, 5 for plants with 51-100 aphids, 6 for plants with 101-200 aphids, and a score of 7 for plants with greater than 200 aphids. In 2002, actual numbers of aphids per plant were counted and the number of plants sampled per plot was reduced to 10 plants in each plot on all of the sampling dates.

Leaf tissue and soil samples were taken in on 10 July 2001 and 8 July 2002 to quantify the potassium levels in the field and accurately classify the "high, medium, and low" potassium treatment levels in individual plots. Soil samples were taken from each plot by combining 10 core samples composed of approximately 500 cm^2 of soil each and mixing them together in a large bucket. A composite sample (also approximately 500 cm^2 in size) was then taken from the soil mixture from each plot.

Leaf tissue samples were taken by removing the 4^{th} petiole and trifoliate from 20 plants in each plot. Leaf tissue and soil samples were delivered to the University of Wisconsin Soil and Plant Analysis Laboratory (Madison, WI) for nutrient analysis.

The center two rows of each plot were harvested using a two-row combine and yields were adjusted to 13% moisture. Comparisons among the six treatments were made using Fisher's least significant difference (LSD) procedure. Differences among treatment means were considered significant at the $P<0.05$ level.

Results

Significant differences in both soil available K and leaf tissue K were measured among the three K treatment levels with the exception of the high K sprayed treatment in 2001, which did not have significantly higher soil available K than either of the medium K treatments. Additionally, leaf tissue K in the sprayed high K treatment did not differ significantly from the unsprayed medium K treatment. In both years soybean plants in both medium and low K treatments were stunted and showed leaf-yellowing symptoms associated with K deficiency.

Insecticide applications made to control aphid populations during the 2001 growing season, in the high, medium and low K treatments reduced aphid numbers per plant, but did not completely eliminate aphid presence. Aphid numbers approached 50 per plant in these treatments on 25 July and 1 August, despite repeated foliar insecticide applications. No significant difference in aphid numbers were observed among the three sprayed treatments on either of the first two sampling dates, however, on 16 August, the low K treatment had significantly higher aphid numbers than the high K treatment.

In 2002, multiple foliar insecticide applications were effective in keeping the spray treatments nearly aphid free throughout the growing season, and no significant differences in aphid numbers per plant were observed among the sprayed treatments any of the sampling dates.

Of the three treatments that did not receive foliar insecticide applications (high medium and low K), in 2001, the plants in the unsprayed low K treatment exhibited aphid numbers that were significantly higher than the unsprayed high K treatment on the 11 July sampling date. Numbers of aphids per plant in the medium K treatment did not significantly differ from either the low or high K treatments.

Results of aphid sampling on 25 July and 1 August 2001 did not show any differences in the number of aphids per plant among the unsprayed high, medium and low K treatments.

In 2002, aphid numbers per plant in the unsprayed treatments were positively correlated with potassium levels with the exception of the 16 August sampling date. Significant differences in mean aphid numbers per plant were observed among the unsprayed treatments on 31 July, and 7 August. However, on the 16 August sampling date the medium K treatment exhibited the highest numbers of aphids per plant and was significantly higher than both the low and high K treatments.

Harvested grain yields were significantly reduced in both K deficient (medium and low K) and unsprayed (SBA infested) treatments over the course of this study. In 2001 both sprayed and unsprayed medium K treatments did not significantly reduce yields below their respective high K treatments (Figure 1). Both sprayed and unsprayed low K treatments, however, showed yields that were significantly less than both the high and medium K treatments indicating that yield losses due to K deficiency are more pronounced when K is extremely limited (Figure 1).

In 2002 yield differences attributable to K deficiency were significant between the high and medium K treatments, as well as between the medium and low K treatments in both sprayed and unsprayed treatments (Figure 2).

In both 2001 and 2002 the insecticide treated plots at all three K levels yielded significantly more than the corresponding unsprayed treatments (Figures 1 and 2). Statistical comparisons made between sprayed and unsprayed treatments at all three K levels indicated that the impact of SBA feeding on soybean yield was not significantly different among the three K levels in either year. This suggests that K stressed plants are not more prone to yield loss from SBA feeding. The relatively low aphid populations on the insecticide sprayed treatments (~50 aphids/plant) likely did not impact soybean yields.

Figure 1. 2001 Yields. Yields followed by the same letter do not differ Significantly at the alpha=0.05 level.

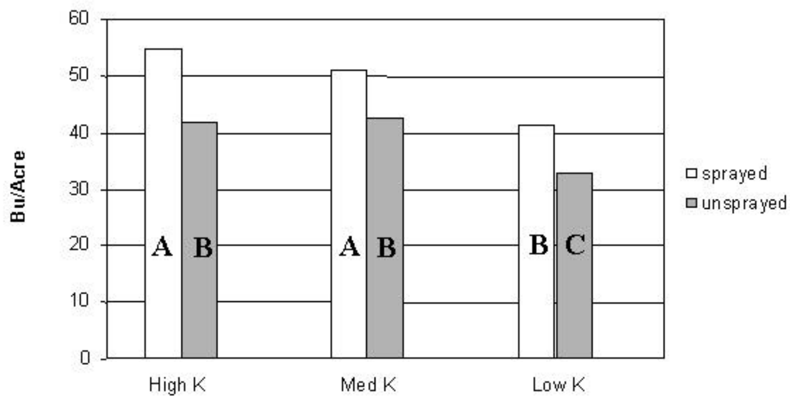
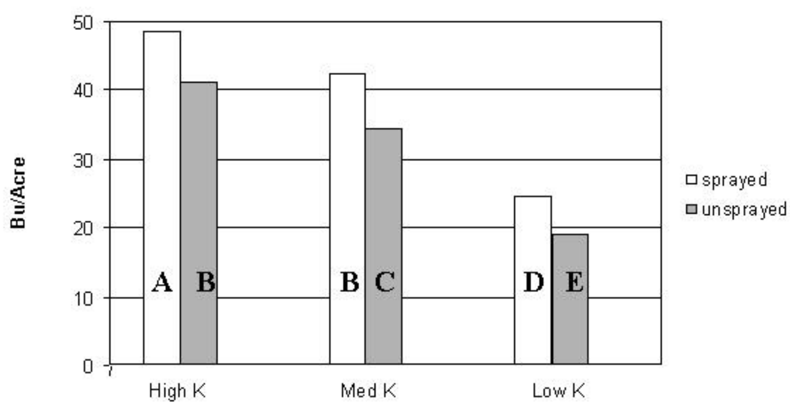


Figure 2. 2002 Yields. Yields followed by the same letter do not differ Significantly at the alpha=0.05 level.



Discussion

Results from the first sampling date in 2001 indicated that aphids first colonizing the field preferred the K deficient treatments. This may be related to the more open canopy, (soybeans were planted in 0.76m rows), or that the characteristic yellow leaves of K deficient plants served to attract early colonizing SBAs. Yellow has shown to serve as an attractant for some aphid species, and can promote aphid colonization of plants. It is also possible that SBAs benefit nutritionally from feeding on K deficient soybean plants. The lack of available K to the soybean plant may promote aphid population growth if the nutritional quality of the plant becomes more favorable to SBAs, or if the plants ability to deter SBA feeding is diminished. Increased fecundity, lifespan, and time to adulthood could all contribute to higher overall SBA numbers per plant.

Additionally, deficiencies in K may lead to increased N levels in soybean plant tissues. Elevated N levels in soybean leaves may be responsible for the high SBA populations that are often associated with K deficient soybeans. Soybean aphid sampling on subsequent dates in 2001 showed no significant differences among the three unsprayed treatments. If aphids are initially colonizing K deficient soybean plants they may then move to nearby healthy plants once populations on the K deficient plants become crowded. This may explain the results of the sampling data in 2001.

Sprayed treatments at all three K levels showed evidence of SBA population rebounds in 2001. Five insecticide applications made at 7-10 day intervals were effective in keeping aphid numbers relatively low throughout the growing season. One difference of note in the sprayed treatments in 2001 was that on the 1 August sampling date the low K treatment exhibited a significantly higher aphid number than did the high K sprayed treatment. Increased ability for aphid populations to rebound after spray applications on K deficient plants may account for the higher numbers of aphids observed on the low K sprayed treatment (compared to sprayed treatments of high and medium K).

The rating scale used in 2001 to evaluate the number of aphids per plant did not accurately reflect the total numbers of aphids per plant on the last two sampling dates as aphid populations were substantially higher than 200 per plant. The sampling program used in 2002, however, provided a more accurate assessment of the soybean aphid populations in the experiment, most notably when aphid populations reached peak numbers. Higher aphid numbers on K deficient treatments were not observed in 2002. Conversely, sampling data from 2002 indicated that SBAs preferred the high K treatment (healthy soybeans) to those deficient in K (medium and low K treatments). Aphid numbers were positively correlated with K level when SBA populations were at their peak (late July – early August).

Soybean plants in this experiment exhibited an extremely high amount of aphid feeding in both 2001 and 2002. In both years the aphid populations in this experiment were higher than separate experiments conducted at the Arlington Research Station and the Rock Co. Farm in Janesville. Most notable were the results of plant counts in 2002. While these numbers did not appear to be substantially greater than those observed during the 2001 growing season when heavy SBA infestations were commonly reported from around Wisconsin. SBA numbers found in this experiment did, however, far outnumber aphid population densities observed in other fields throughout South Central Wisconsin during the 2002 growing season suggesting that the K deficiency in this field did contribute to the high SBA populations that were observed.

So while the results of aphid population sampling in this experiment suggest that the reduced soil K levels do not result in increased SBA densities, they do not explain the presence of unusually high numbers of SBAs that were observed in this experiment over two years. There may be several possible explanations for the high numbers of aphids observed in this experiment over the two years of this study.

There was no significant difference in leaf tissue potassium between sprayed and unsprayed treatments at all three potassium treatments indicating that heavy aphid feeding pressure did not interfere with uptake of available K.

The results of harvested grain yields indicated that heavy infestations of soybean aphids are capable of causing significant yield losses. SBA infestations resulted in yield reductions in the unsprayed treatments in each of the three treatments in both 2001 and 2002.

Yield losses resulting from SBA infestations were consistent across the three K treatments indicating that K deficiency in soybean does not result in additional feeding damage from SBA, however, K deficiency in soybean fields appears to result in overall higher numbers of SBAs which could further increase yield losses in fields with low soil K.