RESIDUAL PHOSPHORUS EFFECTS ON ALFALFA SEED POLLINATION AND PRODUCTION

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INTRODUCTION

Excessive vegetative growth from high plant populations, poorly thinned stands, or excessive moisture can reduce alfalfa seed yields (Abu-Shakra et al., 1968). Alfalfa seed is grown in rotation with high value crops such as onions and potatoes that are frequently fertilized with phosphorus (P) fertilizer. Soil P test values are commonly maintained at concentrations exceeding 20 ppm. Whereas soil test P values >17 ppm are not considered detrimental to other crops in the rotation, or alfalfa grown for forage, they were reported to reduce alfalfa seed yield (Pedersen et al., 1959). Why higher available P reduces alfalfa seed yield is not clear but it may be related to excessive vegetative growth that may limit pollinator effectiveness, flower survival, allocation of resources to seed, reduced harvest efficiency, or other unknown effects. Other growth characteristics that may be influenced by available P and possibly affect seed yield include bloom date and amount.

There is very little information on the P requirements or critical soil test P concentrations required for optimum alfalfa seed production in the PNW and southern Idaho in particular, or about the potential for reduced seed production from elevated soil test P. There is no information available as to the influence of plant density on the response of alfalfa seed to residual P. Residual P and plant population effects may be independent and additive, or interact to exacerbate their effect. A major obstacle in obtaining this information is finding sites where available soil P is sufficiently limiting, or the range in soil test P sufficient to establish appropriate guidelines for P fertilization.

A research trial area on the Parma Research and Extension Center received different P fertilization to establish residual Olsen soil test P concentrations ranging from approximately 5 to 15 ppm, a range for forage alfalfa that would be characterized as low to adequate. The objective of this study was to evaluate the influence of residual P on mature alfalfa biomass, date of first bloom, available bloom, seed and pod set, and seed production. A second objective was to determine stand density effects on the seed yield response to available P.

METHODS

The experimental area was seeded September 11, 2003 to alfalfa seed (Vernal) at the rate of about a lb of seed per acre in 22 inch spaced rows. The previous P treatments represent five residual P levels, three of which were duplicated and duplicate plots of the same residual P treatment (lowest and the highest) were used to evaluate two stand densities: 12" vs 24" spacing in the row in the establishment year (2004) and 24" vs 36" in the second year (2005). A low density 48" spacing in the row was also evaluated in 2005. Initial P treatments were arranged in a randomized complete block experimental design with six replications. Individual plots were 20 ft by 22 feet with 12 rows. The outside rows served as buffer rows and data was collected from 9 interior rows. The previous crop was wheat with the residue disked and roller-harrowed.

The trial was managed as much as possible as those in grower fields with the exception that hand thinning was used in the first year (April 2004) and second year (October 2004 and May 2005) in addition to mechanical thinning to establish target stand densities and control weed escapes. Labeled herbicides were applied and plots cultivated in the early spring. The 2004 crop was not set back by flailing in spring 2004 as growth in the new planting was not excessive. The 2005 crop was set back by flailing February 8 and May 23, 2005. Plots were irrigated June 11, 2004 to provide 1" of water and again on July 30 to apply 0.5" using overhead sprinklers. Due to the presence of a high water table it was not necessary to irrigate the plots in 2005. Throughout the study insects and mites were controlled using appropriate pesticides as per labled recommendations.

The number of plants with bloom in each plot were recorded after the onset of bloom on May 23, 27, and 29 in 2004 and June 21 and 23, 2005. Alfalfa leafcutting bees were released at ca. 15,000 bees per acre on June 9, 2004 and at 30,000 per acre on July 16, 2005 to provide uniform pollination. Bloom in 2004 was recorded in each plot the week of bee release and 1, 3, 5, and 7 weeks after bee release. The number of racemes per plant was recorded from three plants per plot the week of bee release and 1 week after bee release, and one plant per plot on subsequent dates. The number of pollinated (shriveled), and unpollinated open flowers were recorded from 10 racemes per plot. In 2005 flowering and pollination was documented by collecting five stems from each plot immediately prior to harvest and later counting the bracts and pods on each stem.

A chemical desiccant was applied in late August prior to harvest. Seed yield was determined using a small plot combine from 15' of 9 rows in each plot,. Field run seed was weighed, scalped over a clipper, and the seed in the light seed tray and the heavier seed weighed. Biomass of non-seed material was measured at harvest by collecting all the biomass exiting the combine and weighing. Subsamples were collected for the determination of moisture. Harvest index was calculated from the dry mass of seed and biomass. Seed weight of 200 seed was measured to provide an index of plant resource allocation to individual seed. Data was analyzed by analysis of variance and regression.

Soil samples were collected September 2004 and May 2005 from each plot to document residual soil P. Each sample was a composite of eight cores from each plot.

RESULTS AND DISCUSSION

2004 season

Alfalfa bloomed earlier in 2004 with applied P (Fig.1). There were practically twice as many plants with bloom on May 24 with added P as there was without P five days later. Plants were slower to develop under low P conditions. Harvested fresh weight in September 2004 of the non-seed biomass increased twofold with higher P (Fig. 2). However, greater vegetative growth with added P resulted in significantly lower seed yield (Fig. 2). The percentage of light seed for the 24" spacing was significantly greater in the higher (46%) than the lowest (27%) P treatments. Also, at higher P, the percentage of light seed was greater in the closer spacing.

Numbers of racemes, total open flowers, and number of pollinated open flowers increased with applied P. The proportion of open flowers pollinated decreased only slightly with applied P. It does not appear that the decline in proportion of open flowers pollinated is sufficient to explain the precipitous decline in seed yield observed with increasing P. The weight of 200 clean seeds was unaffected by treatments in 2004. The results in 2004 suggest that despite an increase in number of pollinated flowers, higher P resulted in significant blossom drop, seed abortion, reduced seed fill, or depredation.

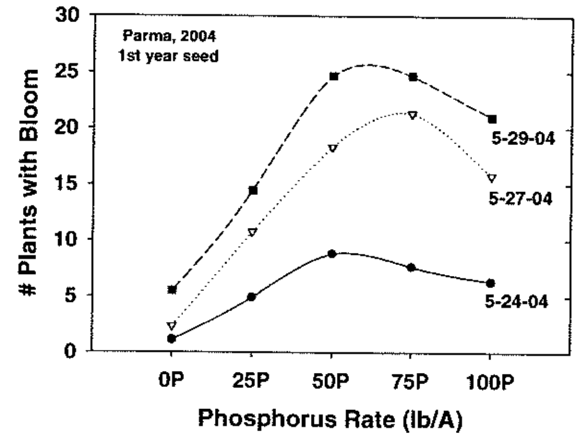

Figure 1. Number of alfalfa plants with bloom as affected by P rate on different dates in 2004.

Seed yields in 2004, even in the best treatments (low P) were poor. A sufficiently high water table at this site together with the irrigation precluded the development of moisture stress conditions late in the season, especially in the higher P treatment. Moisture stress is normally desired to avoid excessive vegetative growth. If root system development was improved with added P it may have increased access to moisture and exacerbated the situation. In addition, the dessicant used at harvest may have been unable to penetrate the excessive foliage of the higher P treatments, which was reflected in the considerably higher water content of the freshweight biomass of the higher P treatments (data not shown).

The 12" or 24" plant spacing had little effect under low P conditions on the measured parameters in 2004. In contrast, with higher P, non-seed biomass was 25 % higher, but the proportion of light seed was 42% higher, and the seed yield was 40% less with 12" spacing than with 24" spacing. However, it does not appear that either spacing in 2004 was optimal for the conditions

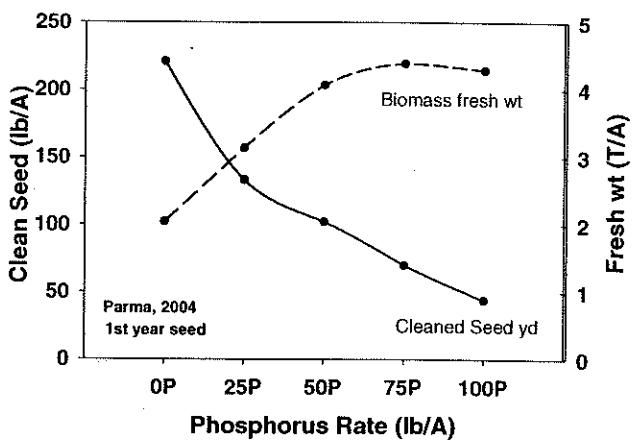

Figure 2. Clean seed yield and biomass fresh weight in 2004 as affected by previously applied P.

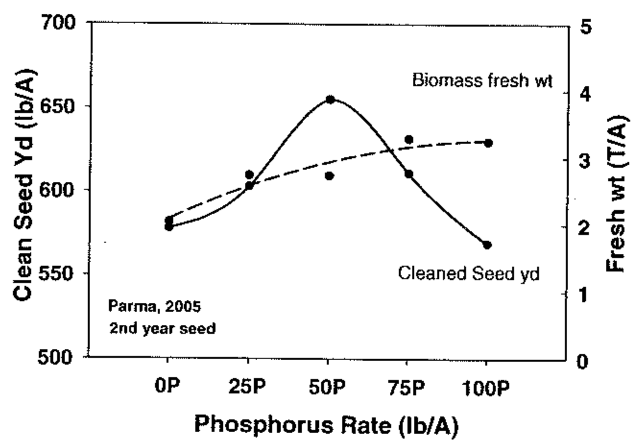

Figure 3. Clean seed yield and biomass fresh weight in 2005 as affected by previous applied P.

of this trial. Residual P after the 2004 harvest ranged from 3 to 16 ppm Olsen P.

2005 Season

Residual P in spring 2005 ranged from 2 to 13 ppm Olsen P. The number of plants with bloom in 2005 were not appreciably affected by available P as they were in the establishment year. The number of bracts per plot and pods per plot also were not significantly affected by available P. Bract and pod counts suggest that higher available P at least maintained flowering activity. Biomass increased about 38% with higher available P at the 24" spacing and 33% at the 36" spacing (Figs. 3 and 5). Total vegetative mass was clearly limited by low P but reached a maximum with the available P at the highest rate (Fig.3).

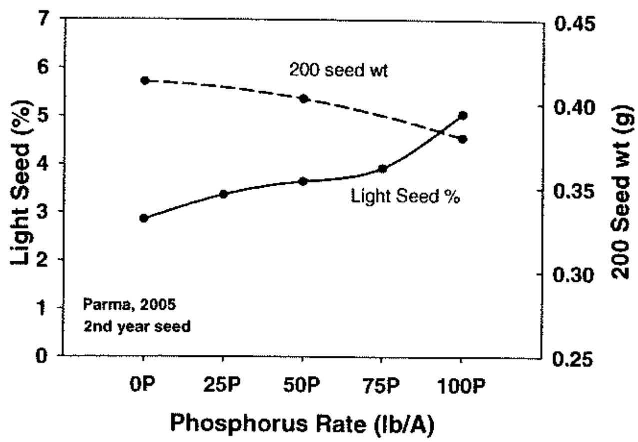

Figure 4. Percentage light seed and 200 kernel weight in 2005 as affected by previously applied P.

Seed yield increased with the first P increments but decreased at the highest available P levels with the 24" spacing (Fig. 3). Increased yield with moderate available P (peak yield) occurred primarily from increased numbers of marketable seed (data not shown). Reduced yield with the highest available P was in part due to fewer seed.

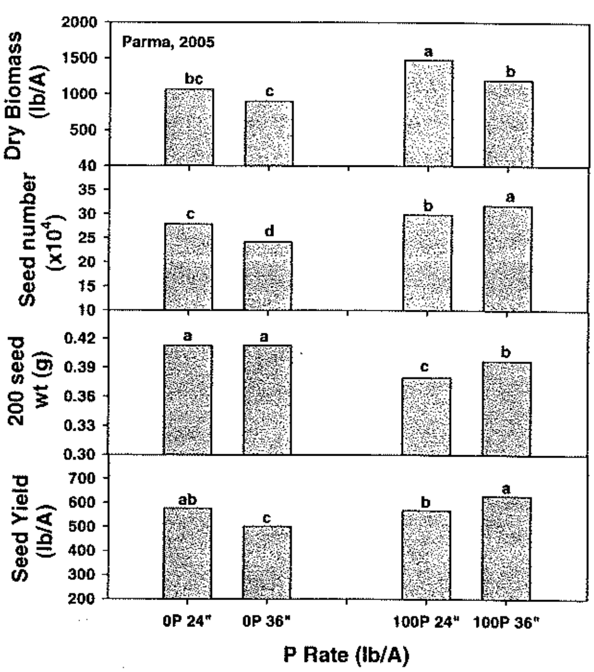

Figure 5. Non-seed biomass, seed number, 200 seed weight and seed yield in 2005 as affected by plant spacing and the lowest and highest P treatments.

Under conditions of ample P, one of the few management options for regulating canopy growth is plant spacing. Under low P conditions, wider spacing reduced non-seed biomass, seed numbers, and seed yield (Fig. 5). With the highest P rate, wider spacing reduced non-seed biomass but increased viable seed numbers, 200 seed weight, and seed yield.

As it did in 2004, the percentage of light seed increased with higher available P (Fig. 4), essentially doubling from the lowest to highest P rate, although the light seed percentage was considerably lower in 2005 than in 2004. The light seed percentage increased more with P at the closer spacing (24") than the wider spacing (36"). A higher percentage of light seed with higher available

P suggests that resources for seed filling were more limited, or perhaps that there was greater depredation of seed by lygus or chalcid at higher P rates. The percentage of light seed damaged by lygus feeding ranged from 76 to 85%. The percent lygus damaged seed was greater with closer plant spacings, especially at higher available P.

SUMMARY

We have demonstrated in both first and second year alfalfa seed significant yield reductions from higher available or residual P. The results suggest producers have little reason to apply P for alfalfa seed production at plant spacings normally used, especially when residual P is maintained at levels above those necessary for near maximum vegetative growth. Wider plant spacing can apparently compensate to some extent for excessive vegetative growth from higher available P.

Reduced yield from excessive canopy growth can not be explained by poorer pollinator visitation because the number of pollinated flowers in 2004 or proportion of bracts with pods in 2005 was not reduced with higher P. Poorer seed yield may be related to limited resource allocation from plants with increased flower numbers or greater insect depredation.

REFERENCES

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