RESIDUAL PHOSPHORUS EFFECTS ON ALFALFA SEED POLLINATION AND PRODUCTION

Brad Brown and Jim Barbour
University of Idaho, Parma Research and Extension Center

ABSTRACT

Higher available P that increases alfalfa biomass reportedly reduces alfalfa seed yield due to poorer pollinator visitation. Available P effects were evaluated in a three year (2004-06) study with in-row plant spacing (12", 24", 36" and 48") at Parma, ID to investigate the mechanism for the yield decline. Plots differing in residual P from previously applied P were further enriched with 0, 25, 50, 75, or 100 lb P/A. Plots were split in the last year and a mix of foliar B, Zn, Mn, Cu, and Fe (5, 5, 2, 2, and 2 lb/A respectively) was applied at late bud. Higher available P increased vegetative biomass each year to a maximum but seed yield decreased each year with available P otherwise necessary for maximum growth. Yields declined with higher P primarily from fewer harvested seed but also from smaller seed in 2 of 3 years. A more dense canopy with higher P also resulted in greater seed depredation by lygus, particularly in the years of lowest production. Fewer seed due to reduced pollination was not confirmed in this study as the percentage of bracts with pods was largely unaffected by P. Wider plant spacing resulted in a higher percentage of bracts with pods but only partially compensated for greater vegetative growth with higher P. Foliar micronutrients increased yield due to increased seed numbers, presumably by reducing flower or pod abortion. Fertilizer P applied for alfalfa seed production may be counter productive in fields with soil P maintained for other crops in the rotation.

INTRODUCTION

Alfalfa seed is grown in rotation with high value crops such as onions and potatoes that are fertilized with appreciable phosphorus (P) fertilizer. Soil P test values are maintained at concentrations exceeding 20 ppm in many fields. Soil test P values of 17 ppm are not considered detrimental to other crops in the rotation, or alfalfa grown for forage, but have reduced alfalfa seed yield (Pedersen et al., 1959) reportedly from excessive vegetative growth and poorer pollinator visitation.

Excessive vegetative growth and lower seed yields can also result from high plant populations or poorly thinned stands. There is little information available on the P requirements for optimum alfalfa seed production in the PNW and no information on whether reduced plant density can ameliorate the negative response of alfalfa seed to higher residual P. This is due in part to few sites where available soil P is sufficiently limiting, or where there is a sufficient range in soil test P to establish appropriate guidelines for P fertilization.

OBJECTIVE

The objective of this research was to evaluate available P and plant spacing influence on alfalfa seed yield and factors responsible for the response in a soil known to range from extremely low to moderate soil P.

METHODS

The influence of available P on bloom, pod survival, mature alfalfa biomass, seed production and yield components was evaluated in a three year study (2004-06) conducted at the University of Idaho Parma R & E Center at Parma ID. An experimental area previously treated with a range of P rates giving soil test P ranging from approximately 6.1 to 8.2 ppm was further enriched with P fertilizer to re-establish a larger range in available P. Alfalfa (Vernal) was seeded September 11, 2003 at the rate of about a lb of seed per acre in 22 inch spaced rows. The P treatments represented 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 stand densities of 12" and 24' in the establishment year and 24", 36", or 48" in subsequent years. Main plots were split in the final year and a micronutrient foliar spray (B, Zn, Mn, Cu, and Fe) was applied June 20, 2006 at the late bud stage. Treatments were arranged in a randomized complete block experimental design with six replications. Individual main plots were 20 ft by 22 feet with 12 rows. Seed yield was measured from 10 interior rows, five rows for each subplot.

The trial was managed each year as much as possible as those in grower fields with the exception that hand thinning was used rather than mechanical thinning to maintain target stand densities and control weed escapes. Herbicides were applied and plots cultivated in the early spring. Throughout the study, appropriate pesticides as per labled recommendations were used to control insects and mites. The field was irrigated with 1.5" water in 2004 but was not irrigated in subsequent years due to the presence of a high water table. Above normal spring rainfall occurred in 2006.

The established crop was set back by flailing February 8 and May 23 for the 2005 season and November 11, 2005 and April 21, 2006 for the final season. Soil samples were collected in the spring from each plot to document residual soil P (a composite of eight cores from each plot). Alfalfa leafcutting bees were released at 1.5 gal/A in 2004 and 3.0 gal per acre on July 16 in subsequent years to provide uniform pollination.

A chemical desiccant was applied in September prior to harvest. Three to five stems were collected from each plot immediately prior to harvest, stored, and bracts and pods counted later to determine the extent of flowering and pollination. Biomass at harvest of non-seed material was measured by collecting and weighing all the biomass exiting the combine. Subsamples were collected for the determination of moisture content.

Seed yield was determined using a small plot combine. Field run seed was weighed, scalped once over a clipper, and the light seed and remaining seed weighed. 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.

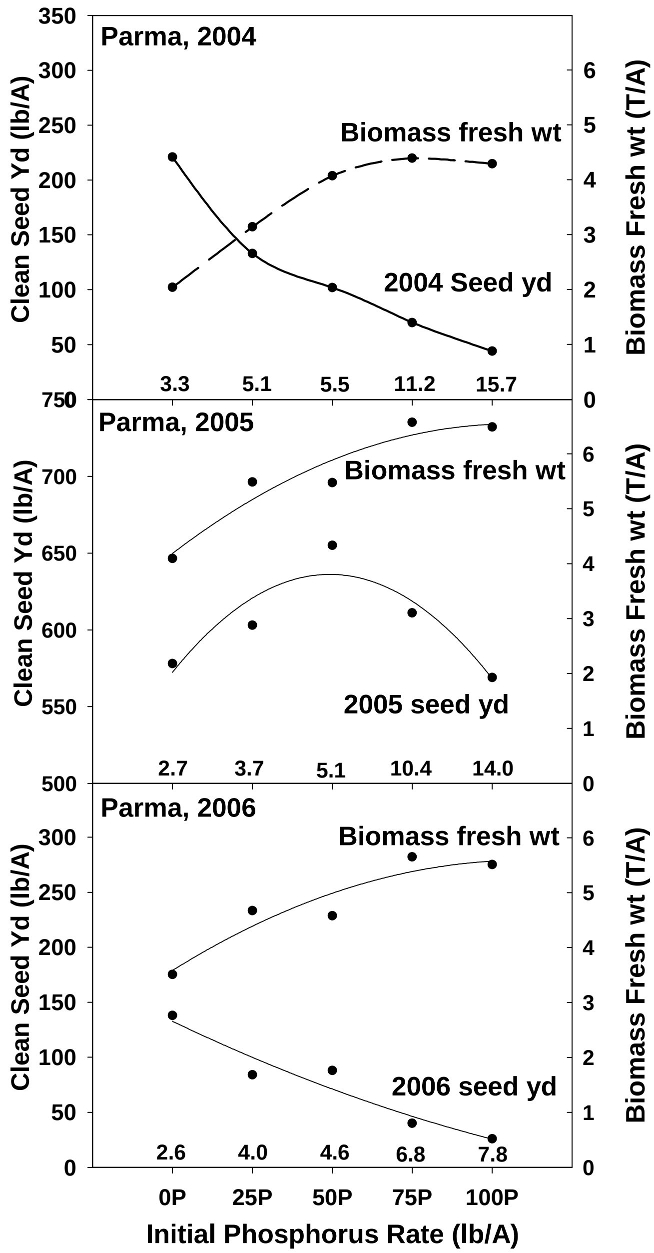
RESULTS AND DISCUSSION

Biomass during the study increased from 58% to110% with higher available P at the 24" spacing and 47% to 79% at the 36" spacing. Total vegetative fresh weight was clearly limited by low P, but it reached a maximum with the available P at the highest rate in all years (Fig.1). Greater vegetative growth resulted in a more dense canopy that lodged by the season end. Seed yield was highest in 2005, the driest year. Seed yield declined each year with higher P that was otherwise necessary for maximum vegetative biomass. Seed yield increased with P only in 2005 when the optimum P treatment was the 50 lb rate, but even in that year, higher P resulted in lower seed yield. Lower seed yields with higher P and more dense canopies were due primarily to fewer harvested seeds (Fig. 2). Fewer seed did not appear to be related to poorer pollination and seed set. Flowering during the first season and the percent of bracts with pods at the end of the season in subsequent years were not appreciably affected by P treatments (data not shown).

The percentage of light seed was greatest in 2004, and lowest in 2005, the most productive year. The light seed percentage increased in each year, essentially doubling with higher P (Fig. 2) and reaching as much as 24% with higher P of all seed harvested in 2004. Over 85% of the light seed was damaged by lygus feeding. Seed Chalcid damage was also found but was minor. Uniform pesticide applications for lygus control were apparently less effective in the more dense canopies. Smaller seed also resulted from higher P in some years (Fig. 2).

Wider plant spacing (24” vs 12” or 24” vs 36”) resulted in higher seed yield than the closer spacing (24") at the lowest and highest available P level in two out of three years (Fig. 3). Higher yields with wider spacing were due to greater harvested seed numbers which resulted from less seed depredation and a greater percentage of bracts with pods (better seed set and survival).

Foliar micronutrients increased yield in the more productive treatments (low P, wider spacings) primarily by increasing the percentage of bracts with pods and the number of harvested seed.



alfalfa fresh weight (right Y axis) as affected each year by available P at Parma with 24” plant spacing. Spring residual P is shown above the initial P rate in each year.

In this study, seed numbers, for reasons that are unclear, were limited by residual P that would otherwise be necessary for maximizing vegetative growth. Neither flowering, the number of pollinated flowers, or the percentage of bracts with pods was limited by higher soil P. Poorer pollination with higher available P in a more dense and lodged canopy does not explain the results. Though greater seed depredation may account for some of the viable seed number decline, others factors such as limited allocation of plant resources to developing seed and lower seed survival may also be responsible. Providing additional micronutrient resources just prior to flowering apparently increased seed set and/or survival.

Lower seed yield with higher P appears then to be due to a number of factors related to greater vegetative biomass, some of which may be unrelated to pollinator visitation.

We have demonstrated for a three year alfalfa seed crop that seed yield each year was reduced with available soil P that would otherwise be necessary for vegetative growth. Wider plant spacing can compensate to some extent, but not fully, for the effects of excessive vegetative growth due to P. The results suggest producers have little reason to apply P for alfalfa seed production at plant spacings normally used and soil test P normally found in seed fields.

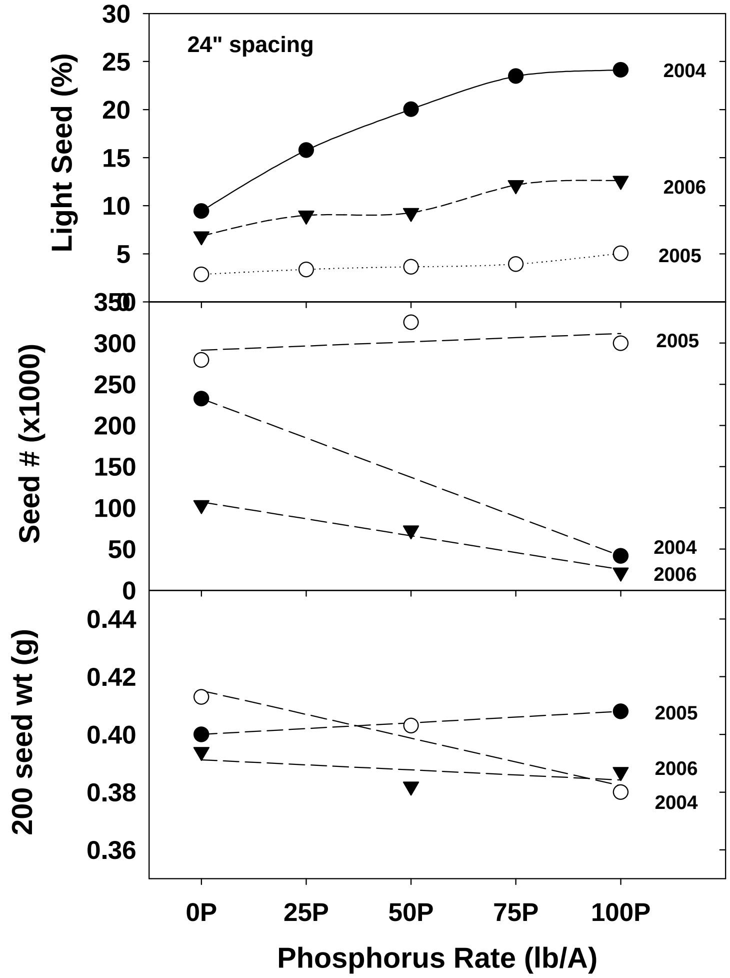


Fig. 2. Percentage light seed, harvested seed number, and 200 seed weight of 24" spaced alfalfa seed as affected by available P in each year.

REFERENCES

Pedersen, M.W., G.E. Bohart, M.D. Levin, W.P. Nye, S.A. Taylor, and J.L. Haddock. 1959. Cultural practices for alfalfa seed production. Utah Sate University Agri. Exp. Sta. Bull. 408.

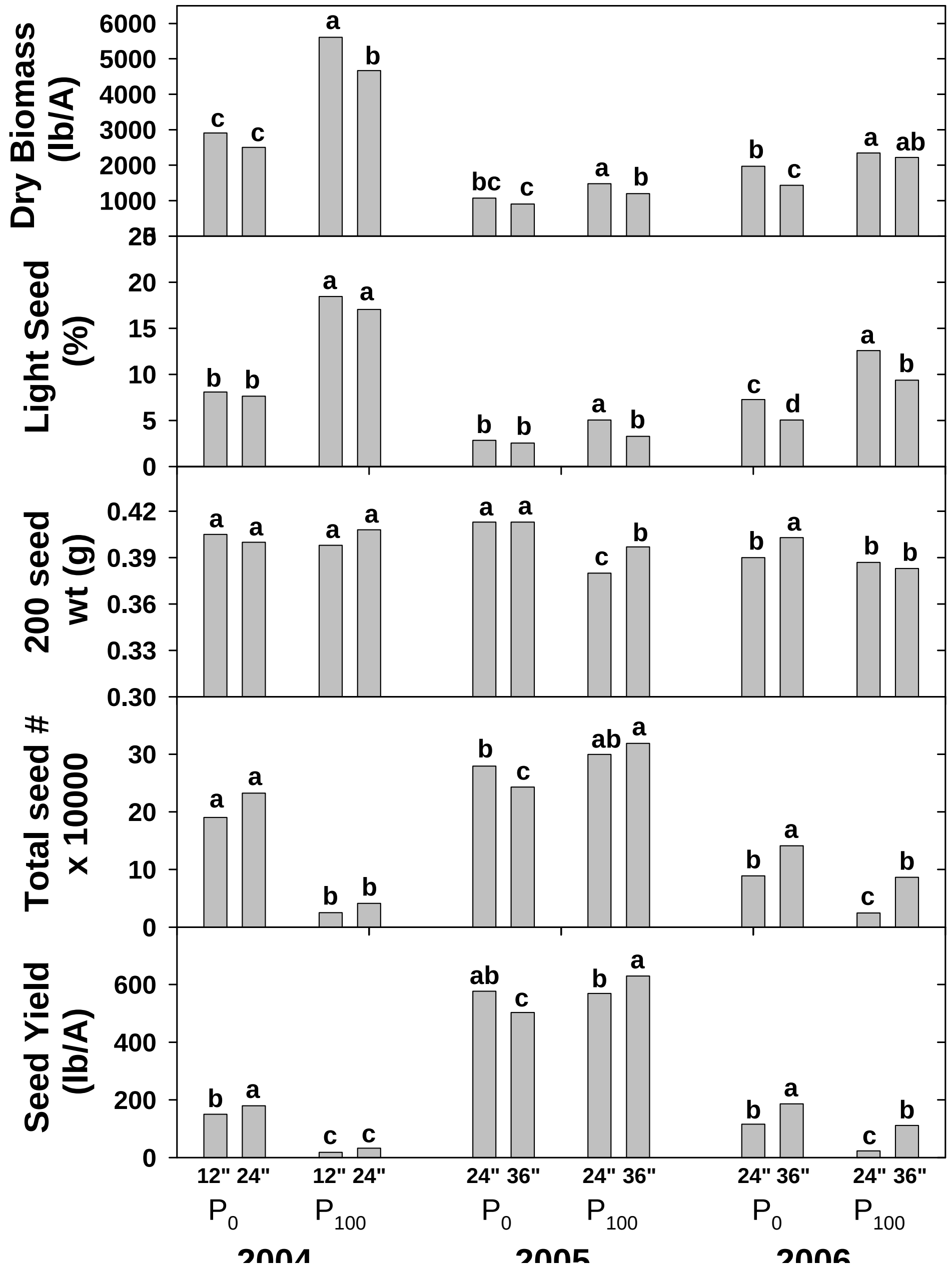


Figure 3. Dry biomass, percentage light seed, harvested seed number, 200 seed weight, and cleaned viable seed yield as affected by year, available P and spacing.

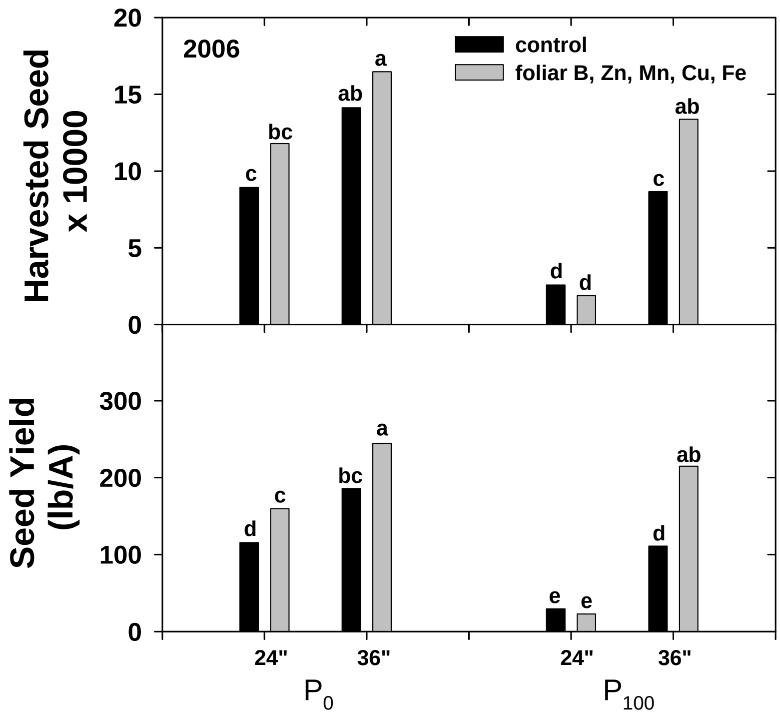


Figure 4. Harvested clean seed and seed yield as affected by foliar micronutrients at late bud in 2006.

PROCEEDINGS
OF THE
WESTERN NUTRIENT
MANAGEMENT CONFERENCE

Volume 7

MARCH 8-9, 2007
SALT LAKE CITY, UTAH

Program Chair:
John Hart
Oregon State University
Corvallis, OR
(541) 737-5714
john.hart@oregonstate.edu

Publicity Chair:
Richard Koenig
Washington State University
Pullman, WA
(509) 335-2726
richk@wsu.edu

Coordinator:
Phyllis Pates
International Plant Nutrition Institute
Brookings, SD
(605) 692-6280
ppates@ipni.net