ONION RESPONSE TO FUMIGATION AND P PLACEMENT

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ABSTRACT

Fall fumigation and loss of beneficial mycorrhizal associations in soil planted to onions the following spring can result in stunted onions due in part to reduced P availability, especially in high lime soils. Fall P placement (broadcast or banded below and between double onion rows planted 4 inches apart the following spring,) in fall prepared beds was evaluated at the rate of 0 or 58 lb P_2O_5 A^{-1} in fumigated (Metam Sodium® at 112 lb ai A^{-1}) and non-fumigated Nyssaton silt loam with over 10% calcium carbonate equivalent. Fumigation reduced onion whole plant dry matter production and bulb diameter at early bulbing and maturity in all years. Plant P content was markedly reduced at early bulbing with fumigation but recovered somewhat by maturity. Adding P, regardless of placement, compensated for the fumigation effects in at least one year but failed to restore growth and P uptake in all years. Subsurface banding P into fumigated fall beds did not always prove as effective as broadcast P incorporated during the fall bedding operation. In contrast, subsurface banding P into non-fumigated soil was consistently as effective as broadcast P.

INTRODUCTION

Unrestricted early season growth is essential for maximizing onion yields and financial returns. Fumigation can reduce P available to mycorrhizal dependent crops (1). Early season onion stunting occurs in highly calcareous soils that are moderately low in phosphorus (P) and especially when fall fumigated (Vapam®). The stunting is commonly attributed to loss of beneficial mycorrhizal associations because onions are known to have limited root systems and to be more mycorrhizal dependent than most crops (2).

Though significant fumigation effects on mycorrhizal associations weren't measured in previous local research trials, broadcast applied P (80 - 160 lb P_2O_5/A) prior to fall bedding prevented onion stunting in soils fall fumigated with Vapam® (3,4). Broadcasted P fertilizers followed by fall bedding is a common practice for this production area.

Surface distributed P from broadcast applications would seem to be less favorably positioned than P banded below and to the side of the onion seed. While broadcast and banded P have been compared for many crops including onions (5), broadcast vs banded P have not been compared in the irrigated production of western Idaho onions.

Furthermore, fumigation may be useful as a research tool for lowering available P to onions in order to facilitate a comparison of P application methods. The objective of this study was to further evaluate the stunting effects of the commonly used fumigant Vapam®, the extent to which P could ameliorate the effect, and to facilitate a P broadcast vs banded comparison for the area's production system.

METHODS

The study was conducted for three years at the Parma Research and Extension Center on a Nyssaton silt loam (coarse-silty, mixed, superactive, mesic, Xeric Haplocalcids) with low to moderate soil test P (6.8-8.2 ppm Olsen P) and appreciable lime (11-12%). P rates (0 or 58 lb P_20_5 A^{-1}) as treble super phosphate were either broadcast prior to bedding or banded into 22 inch

bed centers after bedding in the fall and the beds reformed. Banded P was placed such that the band was located between the onion double rows spaced 4 inches apart. This would provide, with perfect placement and subsequent planting operations, P placement 2 inches to the side and 2 to 3 inches below the planted seed. All P treatments were evaluated with and without Vapam® (33%ai) applied at 35 gal A^{-1} after beds were formed in the fall. The added P treatments (broadcast vs banding) were nested within Vapam® treated and non-treated main plots in a randomized incomplete block design with six replications. Onions followed a previous wheat crop.

Planted double rows of onions (4 inches apart) were centered on the original 22 inch beds after the tops of the beds were removed by tillage to the inter-row area. This configuration left onion double rows on the shoulder of larger slightly raised 44 inch beds, a standard configuration for the production area. Nitrogen was sidedressed as urea prior to bulbing according to UI fertilizer guide recommendations (6). The onions were furrow irrigated as needed. Weed control and thrips were controlled with labeled pesticides.

Onion tops were collected from at least 2 feet of one double row in June and near the end of bulbing in August or early September and their P contents determined. Onion roots from ten plants of non-fumigated and fumigated soils were collected at bulb initiation for measurement of mycorrhizal infection. The percentage of onion tops fallen over was visually estimated periodically when bulbing was completed. Onion yield and grade were measured from a minimum of four 44 inch beds for a distance of 40 ft. Onions were graded into <2in, 2-3in, 3-4in, and >4in sizes. Marketable onions were considered all grades >3in and colossals were taken as those >4in.

Data were analyzed using GLM procedures in SAS. Vapam® and P added effects were analyzed as a 2x2 factorial. P method and Vapam® were evaluated as a 2x2 factorial subset of the data.

RESULTS AND DISCUSSION

Fall fumigation consistently reduced onion dry matter in June of each year (Fig. 1, top) and June P uptake in two of three years (Fig. 1, bottom), but dry matter and P uptake were not significantly affected at maturity. Tissue P concentrations were not significantly affected by Vapam®. Mycorrhizal root infection was reduced by Vapam® in 1998 (15.9 vs 2.9 vesicles per plant) but infection levels were low in subsequent years and Vapam® effects in those years were not significant. Despite consistently reducing pink root infection in August, Vapam® consistently delayed maturity (Fig. 2) and reduced bulb size at harvest, resulting in fewer marketable onions, especially colossals (Fig. 3).

Adding P in the fall increased June dry weight and P uptake significantly in only one of three years (1998) although trends were consistent each year. Tissue P concentrations in June were higher with P in two of three years. In 1998 added P did not affect total dry matter at maturity, but P uptake at maturity was increased with added P. In other years P uptake at maturity was not significantly affected by added P, though the trend for higher P uptake was consistent in each year. Added P consistently hastened maturity but yield of jumbo (3-4in) and colossal onions (>4in) increased significantly with P only in 1998. Onions showed a surprising ability to access P in this high lime soil, despite moderately low soil test P values, and particularly if not fumigated.

Reduced P availability does not explain the response to Vapam® in all years. Other than 1998, the detrimental effects of Vapam® could not be totally compensated for with added P. The

lack of effective mycorrhizal infection possibly reduced the availability of other nutrients, but the uptake of K, Ca, Mg, and S were unaffected by Vapam® in this study in any year. Nitrogen was side-dressed and should not have been limiting.

The micronutrients Mo, Zn, Mn, Cu, and Fe in plants were measured in June and both Mn (30.1 vs 26.9 ppm) and Fe (462 vs 192 ppm) concentrations were significantly reduced by Vapam® in 1999 despite DTPA extractable soil test values (4.0 ppm Mn and 6.8 ppm Fe) above published critical levels. Uptake of Zn, Mn, Fe, and Cu were all reduced with Vapam® in 1999. The June Mo, Zn, Mn, Cu, and Fe concentrations and uptake in 2000 averaged lower with Vapam®, but concentrations and uptake were not significantly different at the 10 % probability level due to the variability associated with small samples. All Zn, Mn, Fe, and Cu concentrations in 2000 tended to be lower than in 1999, especially Mn (28.5 vs 10.5 ppm). Micronutrient shortages due to Vapam® are quite possible although the trials were not designed to evaluate these nutrients per se.

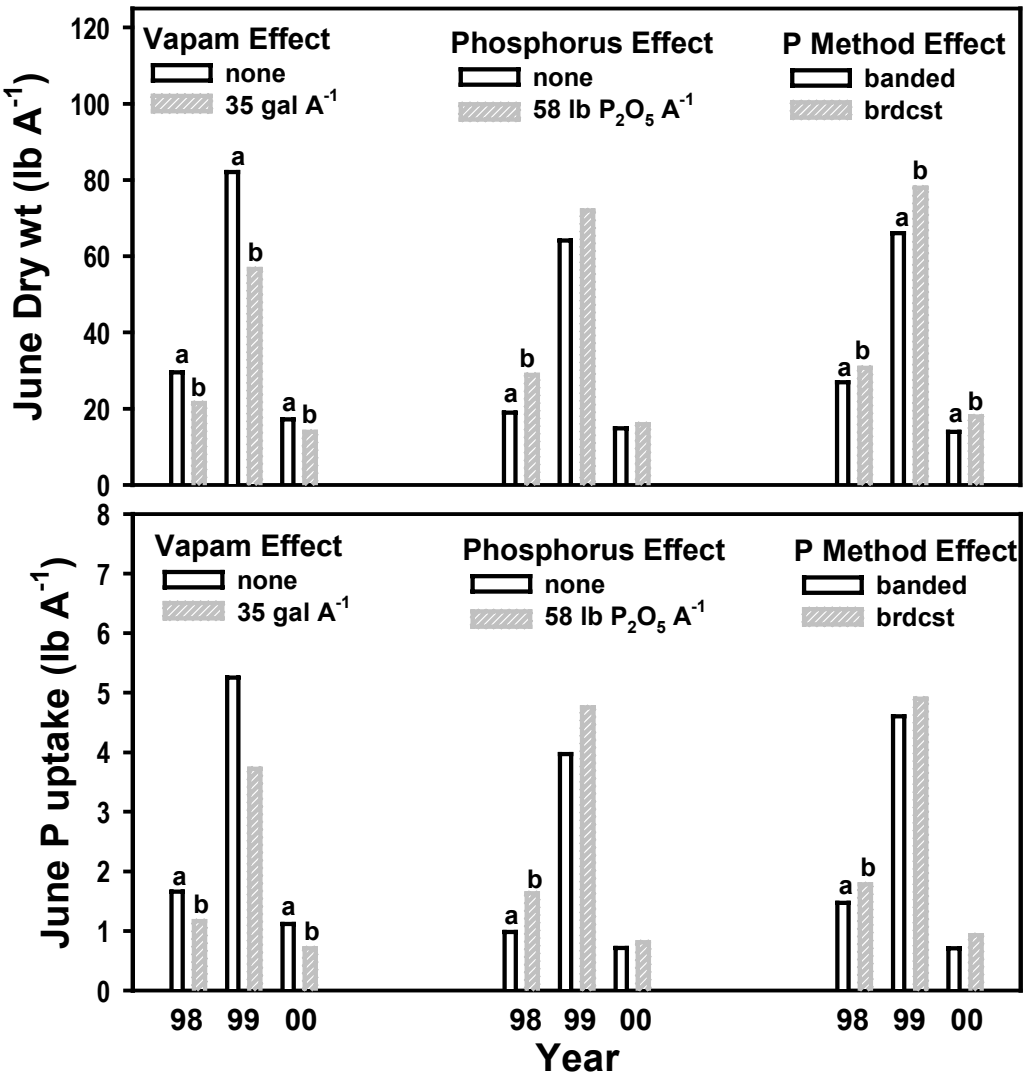

Figure 1. June dry weight (top figure) and P uptake (bottom figure) as affected by Vapam®, P rate, and P application method main effects at Parma in each year. Bars within years that differed at the 10% probability level are topped with different letters.

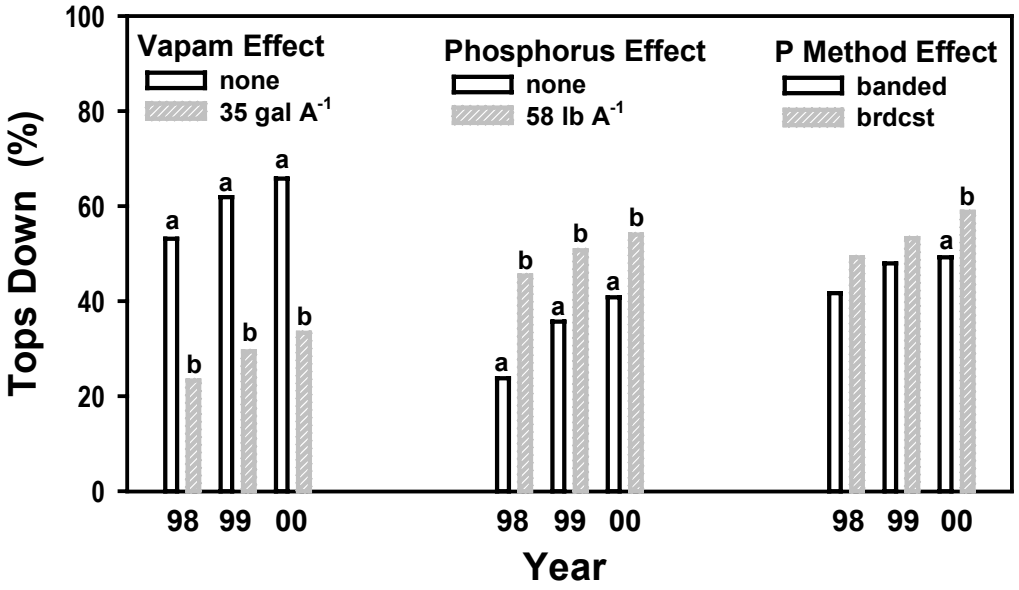

Figure 2. Onion maturity, indicated by the percentage of tops down, as affected by the Vapam®, P added, and P method effects. Parma, 1998-2000.

Significant Vapam® X P interactions occurred with P uptake at maturity and the grade or size fractions of onions at harvest. Added P fully compensated for Vapam® effects in 1998 but this compensation did not occur to the same extent in the 1999 or 2000 seasons. Vapam® fumigation facilitated the evaluation of P treatments in 1998. That is, with Vapam® use, added P increased yield and the proportion of the total yield that graded as colossals, but P had no effect with no fall fumigation.

Banding P in fall beds provided no advantage over broadcast P. In fact onion dry weights were consistently greater in June with broadcast P than banded P and maturity was consistently delayed with banded P. Tissue P concentrations and P uptake in June were higher with broadcast P in 1998 but did not differ significantly in other years. Broadcast P resulted in greater yield of colossals in 2000 and fewer small onions but did not differ in other years. Banded P appeared to be much less effective for early season onion growth in all years, but onions apparently recovered more in years other than 2000.

Band placement in this study was not ideal. The band was both below and to the side of the planted seed. Placement below the seed was more effective than lateral placement in a Texas study (5). We did not have equipment for banding P directly underneath both double rows on each side of the bed. It is unlikely that the P rate was excessive, given that the salt index of treble super phosphate is not as great as other fertilizer salts and the fertilizer was not placed with the seed.

In summary, Vapam® stunting of onions prior to bulbing was striking and consistent each year in this high lime soil, but fall applied P could fully compensate for the Vapam® effect in only one of three years. Other factors appear to be involved which this study was not designed to evaluate. These factors need to be determined if Vapam® is to be considered as a research tool for reducing available P and facilitating P fertilization practices. Banded P under the conditions of this study was surprisingly less effective than broadcast P in supporting early season onion growth, in contrast to other reports of banding being more effective.

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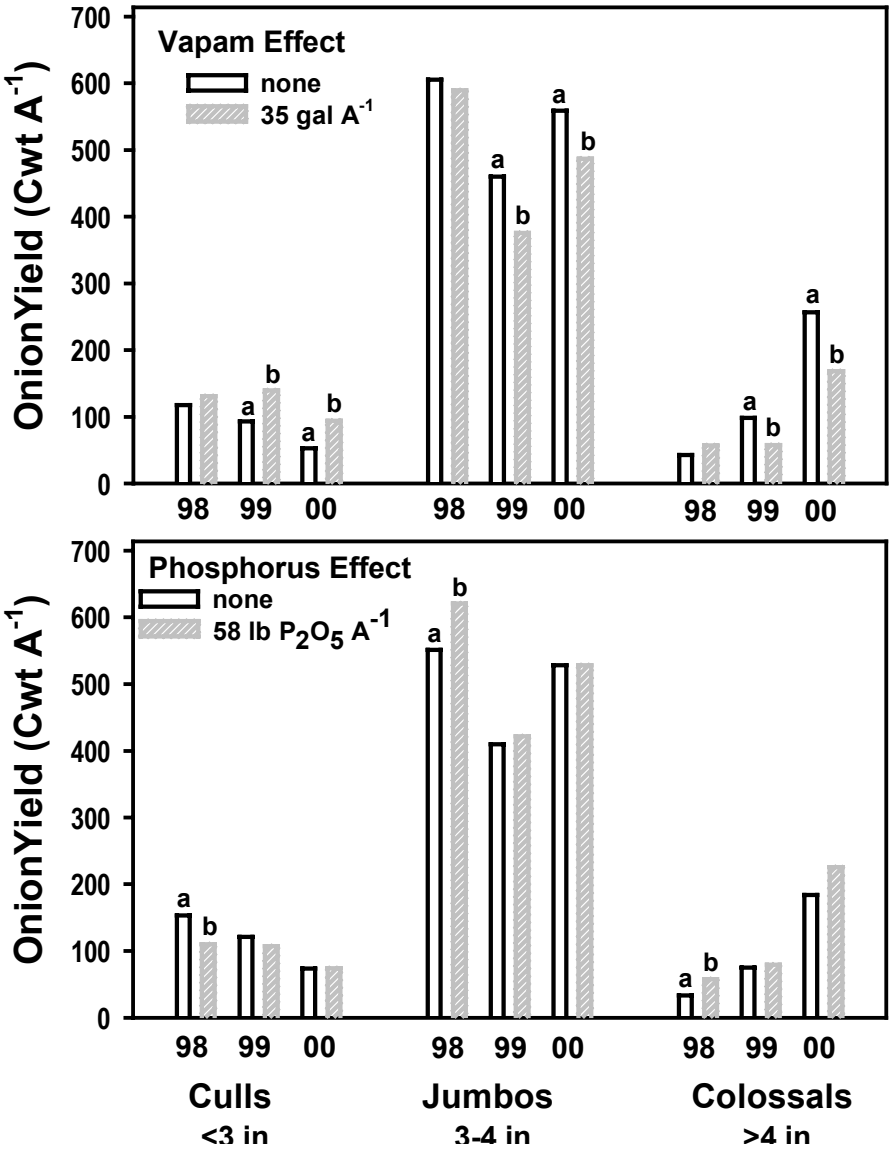

Figure 3. Onion yield and grade as affected by Vapam® (Top figure) and P added (bottom figure) effects in each year. Parma. 1998-2000.