Influence of Seed Moisture on Lima Bean Stand Establishment and Growth

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Abstract. Field studies were conducted to examine the effect of increasing the moisture content of lima bean (Phaseolus lunatus ‘Kingston 098’) seed prior to planting. Seed moisture was adjusted by combining seed, vermiculite, and varying amounts of water in plastic packets which were then sealed and incubated at 22°C for 3 days. Initial seed moisture ranged from 8% to 56%. Trials were planted at 2 locations in 1981 (Becker and Rochester, Minn.), and at 3 locations in 1982 (Becker, St. Paul and Waseca, Minn.). Seed moisture above the normal 8% to 10% range increased emergence and stand establishment at all locations. As a general trend, increased seed moisture up to about 40% improved percentage of emergence and stand establishment. Harvest data varied between locations. Results from one location in both years showed elevated seed moisture to increase pods per plant, total pod dry weight, and total plant dry weight. Results from harvest (yield) data did not show consistent increases in the variables measured.

Effects of seed hydration treatments on germination were examined in the early twentieth century by Kidd and West (9). They found that the germination rate was enhanced when seeds were soaked in water and sown in an imbibed state. Slowly drying the seeds after soaking preserved the improvement in germination, but seeds dried rapidly germinated more slowly than those unsoured. Heydecker (8) more recently considered such seed treatments, which he referred to as priming, and questioned whether a physiological advantage is provided by the slow drying of seeds after soaking or whether the drying simply allows for more convenient handling and planting.

Seeds may hydrate in 2 ways: by equilibration with atmospheric water vapor, and by imbibition of liquid water. Imbibition is the quickest method, but immersion of seeds in water has been shown to decrease total germination and/or stand establishment of Phaseolus sp. (4, 9, 11, 16), Zea mays (5), and Glycine max (7).

Hydration treatments have shown beneficial effects for species whose seeds exhibit imbibitional chilling injury at temperatures appreciably above freezing. Studies with P. lunatus (13, 14) and other warm season crops (2, 3, 11, 12, 15, 17) indicate partial or total reversibility of sensitivity to imbibitional chilling when seed moisture is increased prior to sowing. Injury seemed to result from the interaction of imbibition at chilling temperatures and low (5% to 8%) initial seed moisture. Presowing hydration treatments have affected the process of seed germination, but the mechanisms responsible for observed effects are unclear (6).

There are few reports of seed hydration effects beyond the germination and emergence stages of plant development (7, 12). One of the few field studies examining the effects of increased seed moisture at planting was conducted with grain sorghum (12). High moisture seed (11% and 14%) increased stand establishment sufficiently to increase grain yield, especially in dryland production areas. Both irrigation after seeding and elevated soil temperatures lessened the benefits of increased seed moisture.

Planting lima bean seed in cold, wet soils can result in unacceptable stand establishment, and seed hydration prior to sowing was considered as a reasonable technique for overcoming this problem. Our objectives were to determine the effect of a broad range (8% to 56%) of seed moisture on Lima bean emergence, growth and yield, and to determine if response was similar in different locations.

Materials and Methods

Field plots were established at Becker and Rochester, Minn., in 1981 and at Becker, St. Paul and Waseca in 1982. A single lot of commercial seed of Phaseolus lunatus ‘Kingston 098’ (obtained from Ben Fish & Sons, Crows Landing, CA 95313) was used throughout the study. Standard rolled towel germination tests (1) showed 95% germination. Initial seed moisture content up to 30% was measured with a Steinlite Electronic Moisture Tester (Model 400G; Fred Stein Laboratories, Inc., Atchison, KS 66002). Moisture content greater than 30% was calculated as a percentage of wet weight.

Initial seed moisture contents ranging from 8% to 56% were included in the study. Seeds were adjusted to a specific moisture content by adding 60 g vermiculite (Terra Lite vermiculite; Grace Horticultural Products, W.R. Grace and Co., Cambridge, MA 02140), 200 g composite sample of seed, and varying amounts of water (0–250 ml) to a ziplock plastic packet (1.4 liter size). The contents of the packet were mixed to allow for uniform seed-substrate contact and incubated at 22°C for 3 days. Radicle emergence was not observed in any of these treatments. Seeds were separated from the vermiculite, tested for moisture content as described above, and planted to a depth of 4 cm.

The 1981 trials were hand planted using 6 replications of 6 seed moisture levels in a randomized complete block (RCB) design. The 1982 trials were planted mechanically in a RCB design with 6 or 7 levels and 6 replications. Each plot consisted of 100 untreated seeds planted in single rows 4.6 m long and 0.76 m between rows. Alleys of 1.8 m separated the blocks, and border rows surrounded the entire planting area. Planting dates were representative of those used commercially at each location (15 May–10 June), with the exception of 1 July and 19 July, 1982, at St. Paul and Becker, respectively, to determine if late seeding had any beneficial effect. Soil temperatures at 5 cm averaged 14.6°C at planting for the earlier studies, and 22.5°C for the July plantings.

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Commercial cultural practices were used in growing the crop. Irrigation was available at all locations, except Rochester, and was used as required to maintain adequate soil moisture for plant growth.

Emergence counts were taken daily at Rochester, St. Paul, and Waseca up to 21 days after planting (DAP), and were used to construct plots of cumulative emergence. A seedling was considered emerged when the hypocotyl hook was visible above the soil surface. The following variables also were measured from 7 consecutive plants at an early pod fill stage (81-88 DAP): plant height and canopy spread, number of pods/plant, number of seeds/plant, seeds per pod; the dry weight of the plant was partitioned into pod, seed, leaf, stem, root, and total plant dry weights. Additional harvests were made at some locations when pods were more mature (102-113 DAP). Emergence data and plant growth parameters were statistically analyzed using analysis of variance and partitioning of degrees of freedom.

### Results and Discussion

Emergence rate increased and stand establishment at St. Paul and Waseca improved as seed moisture increased (Fig. 1). A 100% increase in stand establishment occurred at St. Paul for seed moisture contents above 37%. At both sites, the maximum stand for spring plantings was about 50% at high seed moisture levels (37% to 43%) and 20% to 25% at low seed moisture levels (9% to 10%). The stands 60 DAP at St. Paul were the same as those reported for 17 and 21 DAP (Fig. 1 and Table 1), suggesting that the procedures used to increase seed moisture, and the effect of temporarily increasing seed moisture to improve emergence and stand establishment do not damage or reduce seedling growth. Exposing seed to moist substrate rather than immersing during early imbibition eliminated the soaking injury reported for lima bean (16). Roos and Pollock found that submergence or soaking during early imbibition reduced subsequent growth due to imbibition of oxygen diffusion into tissue.

An effect of date of planting on seed moisture treatment also was found (Table 1). In the July 1 field planting at St. Paul, stands ranged from 69% to 80%, and stand improved (77% to 89%) for the July 19 planting at Becker. Uniformity of stand establishment also improved among replications of the late planted studies over trials planted at conventional planting dates. These improvements are likely due to the warm soil temperatures of the July plantings. At later planting dates, lima bean stand establishment was slightly decreased by some treatments, but a general trend was not evident, and the poorest stands of the later plantings were about 40% greater than the best stands of the 25 May and 1 June plantings. These data suggest that, for the best stands, growers should plant lima beans as late in the spring as possible. Nevertheless, the relatively short and unpredictable growing seasons of the Upper Midwest and the need to schedule plantings for orderly product maturity make it necessary to plant acreage early in the season. Increasing seed moisture prior to planting grain sorghum also was found to be ineffective in soils of seeds/plant, seeds per pod, average pod weight; the dry weight of the plant was partitioned into pod, seed, leaf, stem, root, and total plant dry weights. Additional harvests were made at some locations when pods were more mature (102-113 DAP). Emergence data and plant growth parameters were statistically analyzed using analysis of variance and partitioning of degrees of freedom.

### Table 1. Effect of seed moisture levels on lima bean emergence 21 days after planting.

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<sup>a</sup>Date of planting.

<sup>b</sup>Treatment effects were nonsignificant (ns) or significant at the 5% (*) or 1% (**) level.
Fig. 2. Regressions of pod yield and plant density on initial lima bean seed moisture and regression of pod yield on plant density for 4 field studies in Minnesota—1982.

Growth and yield were less affected by initial seed moisture than emergence and stand establishment. Most yield variables were not different among seed moistures, except in individual treatments with very low plant populations. Seed dry weight, number of seeds per pod, and number of seeds per plant were not affected by initial seed moisture in this study.

Regressions of pod yield and plant density on initial seed moisture, however, suggest a treatment effect beyond that of improved emergence. Linear regression analysis indicated that more than one half of the increase in pod yield can be associated with initial seed moisture for early planted studies at St. Paul and Waseca (Fig. 2). When data from these locations and the other early planted study of 1982 (Becker) were combined, the coefficient of the determination \( R^2 \) dropped to 0.40. The atypical response of one point (57% moisture), however, affected combined \( R^2 \) for this regression. The 1 July planting at St. Paul was included in Fig. 2 to illustrate the observation that initial seed moisture levels had little or no effect on late planted lima beans. In Fig. 2a–c, the St. Paul (1 July) data were not included in the combined regression calculations, since the response was clearly different for the late planting.

Results of these field studies support the practice of partial seed hydration (even to levels of 40% seed moisture) prior to planting as a method for overcoming low soil temperature injury during the germination of a warm season crop (7, 10, 12). Response was similar for all the locations studied, but planting dates and the soil temperatures experienced with early vs. late plantings, had a marked influence on the effect of initial seed moisture.

Correlation of production with carbohydrate reserves indicates that low levels of carbohydrates prevent or reduce nut yield partially to rapid dry weight accumulation (24) and to energy following year (18, 19, 25, 26). This reduction is attributed to utilization associated with kernel filling in the latter part of the growing season (18). A reduction of carbohydrate stress by defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Irregular bearing severely limits production of pecan nuts. Correlation of production with carbohydrate reserves indicates that low levels of carbohydrates prevent or reduce nut yield the following year (18, 19, 25, 26). This reduction is attributed partially to rapid dry weight accumulation (24) and to energy utilization associated with kernel filling in the latter part of the growing season (18). A reduction of carbohydrate stress by inducing early kernel development and maturation in relation to leaf abscission would likely be beneficial from both irregular bearing and marketing perspectives.

Kernel development in pecan is characterized by 2 phases. Endosperm development occurs initially, and is followed by rapid embryo development (14, 24). Embryogenesis 1st involves cell division and enlargement, then accumulation of food reserves within the cotyledons. There is evidence from other crop species that endogenous growth regulators, such as abscisic acid (ABA) (11) and gibberellin-like (GL) substances (10), are involved in these growth and development phases. Little is known of the concentration changes and the physiological role of ABA or gibberellins in developing seeds, especially pecan. This investigation reports the free and bound ABA content and estimates free GL content in relation to the growth stages of developing pecan seed at different developmental stages.

**Materials and Methods**

Pecan fruit were collected weekly from 10 'Moneymaker'