Nitrogen, Phosphorus, and Potassium Uptake by Upland and Pima Cotton

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Abstract

Several investigations of nitrogen (N), phosphorus (P), and potassium (K) uptake by Upland cotton (Gossypium hirsutum L.) have been conduced, however no investigations of this type have included American Pima cotton (G. barbadense L.). We conducted a study to describe the total N, P, and K uptake and the partitioning of each nutrient into various plant parts for both Upland and Pima cotton. During the growing seasons of 1990, 1991, and 1992 at two south-central Arizona locations, both Upland (var. DPL 90) and Pima (var. S-6) cotton were grown. Beginning 14 to 20 d after emergence, whole cotton plants were removed and cotton plants were separated into stems, leaves (including petioles), burs (carpel walls), lint, and seeds. The bur fraction, also included squares, flowers, immature bolls, and burs from mature bolls. The appropriate analyses for total N, P, and K were determined on each fraction (except lint). Regression analyses was used to model nutrient uptake as a function of both days after planting (DAP) and heat units after planting (HUAP). Regression analyses indicated that HUAP was equally good, and in most cases superior to using DAP to model total nutrient uptake and partitioning within both Upland and Pima cotton. In every case there was close agreement between the predicted and actual total nutrient uptake. For Upland cotton the actual total N, P, and K uptake was 199, 29, and 250 kg ha^{-1} and the predicted total N, P, and K uptake was 199, 29, and 255 kg ha^{-1}, respectively. For Pima cotton the actual total N, P, and K uptake was 196, 29, and 215 kg ha^{-1} and the predicted was 210, 29, and 229 kg ha^{-1}, respectively. The pattern of nutrient partitioning in Upland cotton were similar to the findings of others and Pima showed the same general patterns of partitioning as Upland cotton. Seeds were a major sink of nutrients. Nutrient uptake in seeds resulted in decreasing uptake in leaves and stems. Presumably, due to mobilization of nutrients from those parts to the seeds during seed development. The nutrient requirements to produce 100 kg lint ha^{-1} for Upland cotton was 15, 2.2, and 19 kg ha^{-1} for N, P, and K, respectively and was 20, 3.0, and 22 kg ha^{-1}, respectively for Pima cotton.

Introduction

Several investigations of N, P, and K uptake by Upland cotton under dryland production have been conducted in the southeast (see references in Mullins and Burmester, 1990). A few of these types of studies have been conducted under irrigation in more arid environments, with Upland cotton (Bassett et al., 1970; Halevy 1976). Recently there has been expanding production of American Pima cotton in the southwestern United States. In addition, there has been a shift in production management of cotton from scheduled operations on a calendar basis to the use of heat unit (HU) accumulations to project cotton growth and development (Brown, 1989, Silvertooth et al., 1993). For these reasons, we conducted a study to describe the total nutrient (N, P, and K) uptake and the partitioning of each nutrient into various plant parts for Upland and Pima cotton. In addition, we want to determine if HU accumulations can be used to describe (model) the uptake and partitioning of nutrients over time throughout the development of the plant.

Materials and Methods

This study was conducted throughout the growing seasons of 1990, 1991, and 1992 at Marana and Maricopa Ag. Center in south-central Arizona (six site years of data). All locations received adequate moisture via furrow irrigation and N, P, and K fertility were maintained throughout, including in-season additions of N as needed (based on petiole feedback and crop monitoring). Both Upland (var. DPL 90) and Pima (var. S-6) cotton were grown each year at each location. Beginning 14 to 20 d after emergence, whole cotton plants were removed from a 1-m section of row (1-m rows) within two replications of each study. This was continued on approximately 14 d intervals until maturity. Cotton plants were then separated into stems, leaves (including petioles), and fruiting forms (mature and immature bolls). Mature bolls were separated into lint, seeds, and burs (carpel walls). The bur fraction, as denoted in the results, included squares, flowers, immature bolls, and burs from mature bolls. The dry weight of each fraction (leaf, stem, bur, seed, and lint) and the appropriate analyses for total N, P, and K were determined on each fraction (except lint). No attempt was made to account for leaves and petioles that may have shed late in the season, however all sampling was completed prior to application of any harvest aids or the final irrigation. It was thought that more error would be introduced than alleviated by trying to account for shed leaves, and that the amount of shed leaves was minimal. Cotton yields at each location were determined at maturity by mechanically picking the center four rows of each eight row plot. All plant samples were removed from the four rows which were not harvested. Basic plant measurements were made on 14 d intervals and included height-to-node ratios (HNR) and nodes above the top white bloom (NAWB, for the first or second fruiting site on mainstem fruiting branches). Heat unit accumulations after planting (HUAP, 86/55°F thresholds) were obtained from AZMET weather stations at each location (Brown, 1989). Regression analyses was used to model nutrient uptake as a function of both days after planting (DAP) and HUAP. A stepwise procedure was used that would not allow a variable to remain in the model unless it produced an F statistic significant at an α value of 0.05 or less.

Results and Discussion

Regression analyses indicated that HUAP was equally good, and in most cases superior to using DAP to model total nutrient uptake and partitioning within both Upland and Pima cotton. Figures 1 to 6 show the predicted N, P, and K uptake for Upland and Pima cotton, respectively. When you compare the pattern of nutrient partitioning into each plant part for Upland and Pima, they are very similar for a given nutrient. For N, the bur fraction in Pima takes more total N than for Upland, but still the pattern for each part is similar for the two species of cotton (Fig. 1 and 4). Also for N uptake there is an apparent redistribution of N from the leaves and stems into the reproductive plant parts, especially seeds. Notice that the decline in N in the leaves and stems begins when seed formation begins (Fig. 1 and 4). Total N uptake by Pima exceed that of Upland cotton. Total P uptake is much less in magnitude than either N or K, however the general pattern of distribution within the plant and various parts are similar as shown in Fig. 2 and 5. At maturity, seeds in Upland cotton (Fig. 2) contained about twice the amount of total P as found in the Pima (Fig. 5.), while total P uptake was very similar for the two species. Total K exceeded total N uptake for both Upland and Pima (Fig. 3 and 6). Total K in the stem fraction was also much higher when compared to N, more so for Upland than Pima. However, relative to N, seeds required less K for their maturation (Fig. 1, 3, 4, and 6).

In every case there was close agreement between the nutrient uptake predicted by regression analysis and actual total nutrient uptake. Table 1 shows the total N, P, and K uptake for Upland and Pima cotton in this experiment and compares these values to the results from the literature of Upland cotton grown in similar environments (Bassett et al., 1970; Halevy 1976). There is also good agreement between the uptake of N and P from the literature and the results of this study (Table 1). Total K uptake for both Upland and Pima in this study was greater than the total K for Upland found by Bassett et al. (1970) and Halevy (1976). It is not clear if this difference is due to luxury consumption of K by the cotton grown in this study or due to limiting K in the soils from the sited literature, or both. Halevy (1976) indicated that there may have been less K taken-up by the two varieties of Upland grown in his research than the plant may have required to alleviate leaf browning during boll development. Bassett et al. (1970) conducted his research in the San Joaquin Valley in California were numerous reports of K deficiencies have been cited (Cassman et al., 1989).

The pattern of nutrient partitioning in Upland cotton was similar to the findings of others and Pima showed the same general patterns of partitioning as Upland cotton. Seeds were a major sink of nutrients. Nutrient uptake in seeds resulted in decreasing uptake in leaves and stems, presumably due to mobilization of nutrients from those parts to the seeds during seed development. Since the lint yield of Pima is generally less than for Upland cotton and the nutrient requirements for both are about the same, the result is a greater nutrient requirement per 100 kg of lint (Table 1).

References

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Table 1. Total nutrient uptake and lint yields for irrigated Upland cotton reported by Bassett et al., (1970) and Halevy (1976) compared to predicted nutrient uptake and lint yields of Upland and Pima cotton.

Source	Variety	Nutrient N	Nutrient P	Nutrient K	Yield†
		kg ha^{-1}			
Bassett et al. (1970)	Acala 4-42	142 (10)‡	19 (1.4)	127 (9)	1403
Halevy (1976)	Acala 4-42 & 1517c	230 (14)	45 (2.6)	174 (10)	1700
Predicted§	DPL 90	199 (15)	29 (2.2)	255 (19)	
Actual¶		199 (15)	29 (2.2)	250 (19)	1328
Predicted	Pima S-6	210 (22)	29 (3.0)	229 (24)	
Actual		196 (20)	29 (3.0)	215 (22)	965

† Actual average lint yields from each study (not predicted).

‡ Values in parentheses indicate the amount of each nutrient required to produce 100 kg lint.

§ Predicted from regression models at 3611 HUAP (the average HUAP value over locations and years for the final sample dates).

¶ Actual uptake averaged over locations and years for the final sample dates.

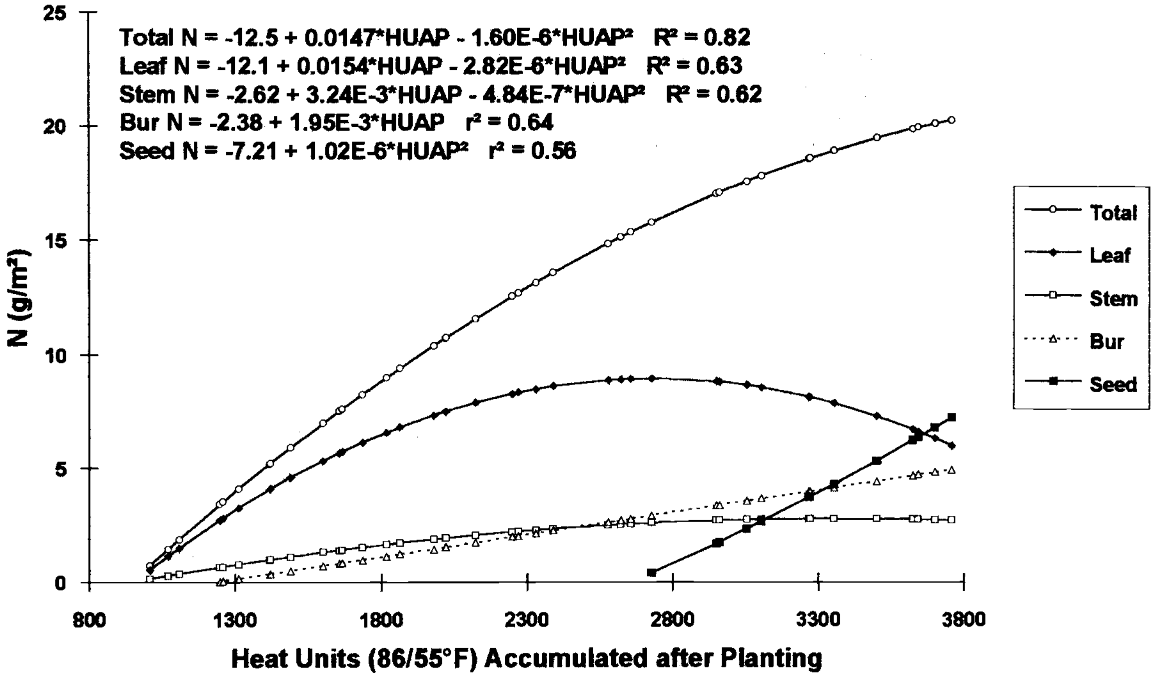

Fig. 1. Predicted N uptake by Upland cotton (var. DPL 90).

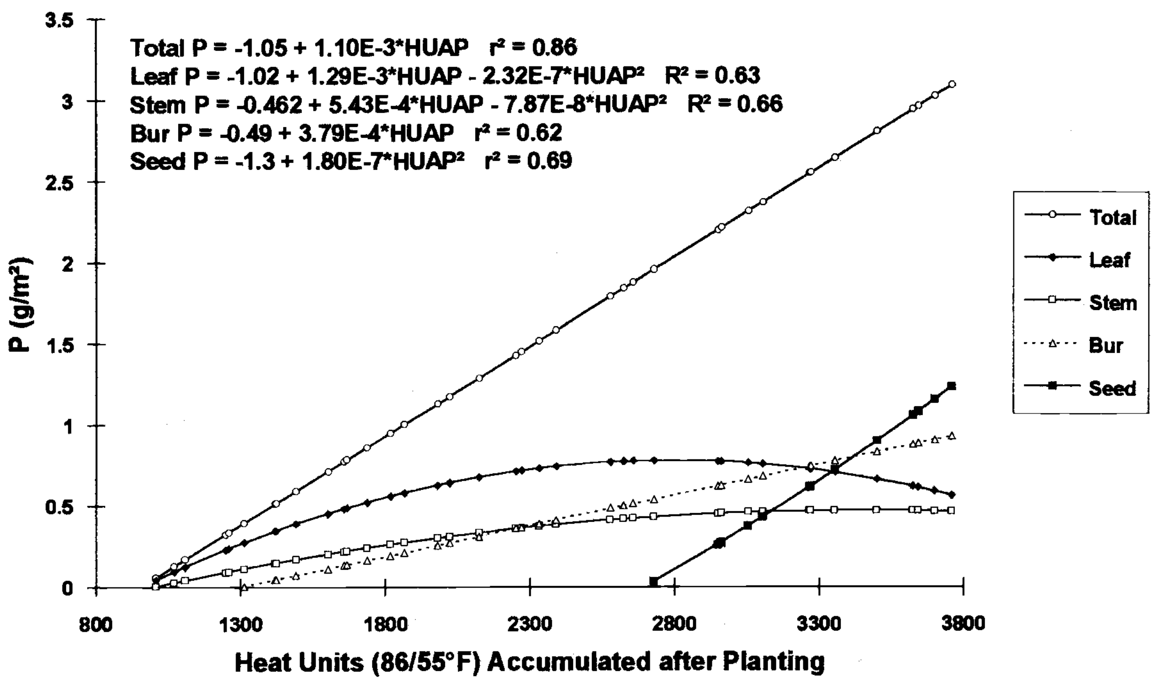

Fig. 2. Predicted P uptake by Upland cotton (var. DPL 90).

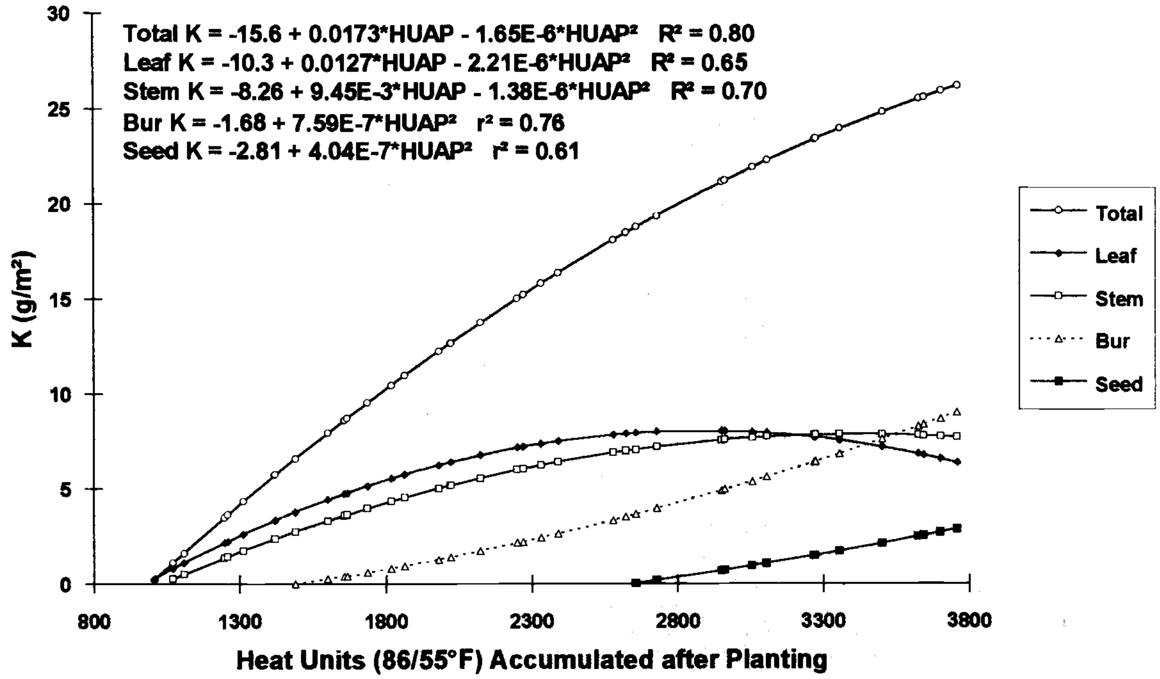

Fig. 3. Predicted K uptake by Upland cotton (var. DPL 90).

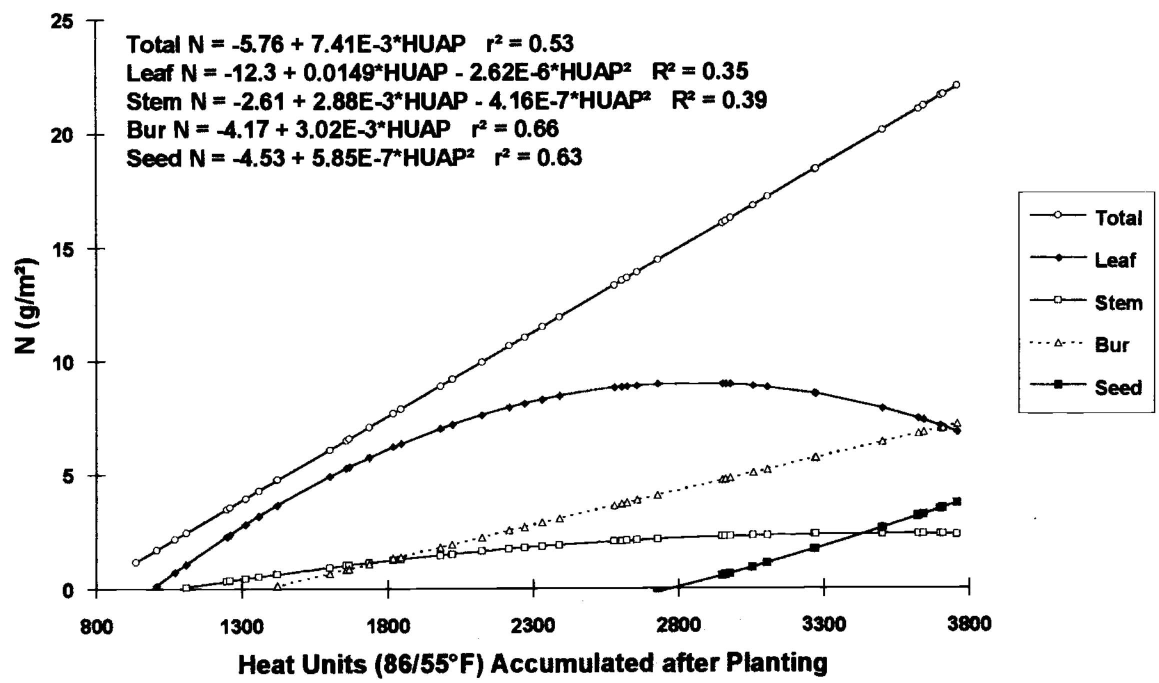

Fig. 4. Predicted N uptake by Pima cotton (var. S-7).

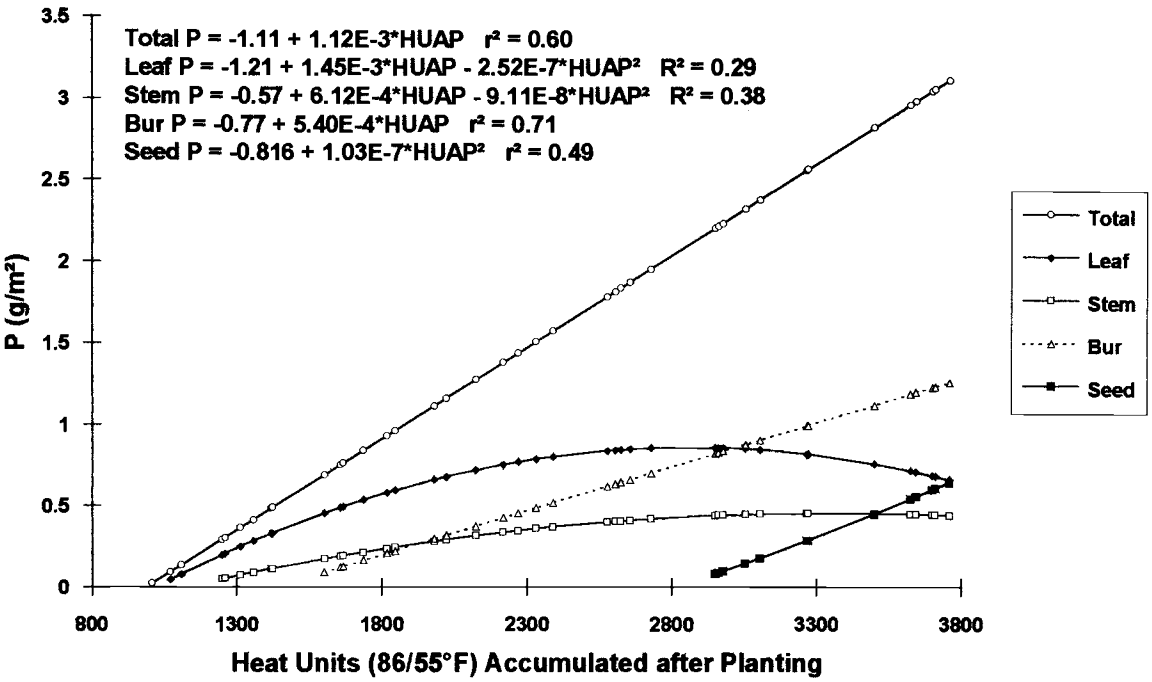

Fig. 5. Predicted P uptake by Pima cotton (var. S-7).

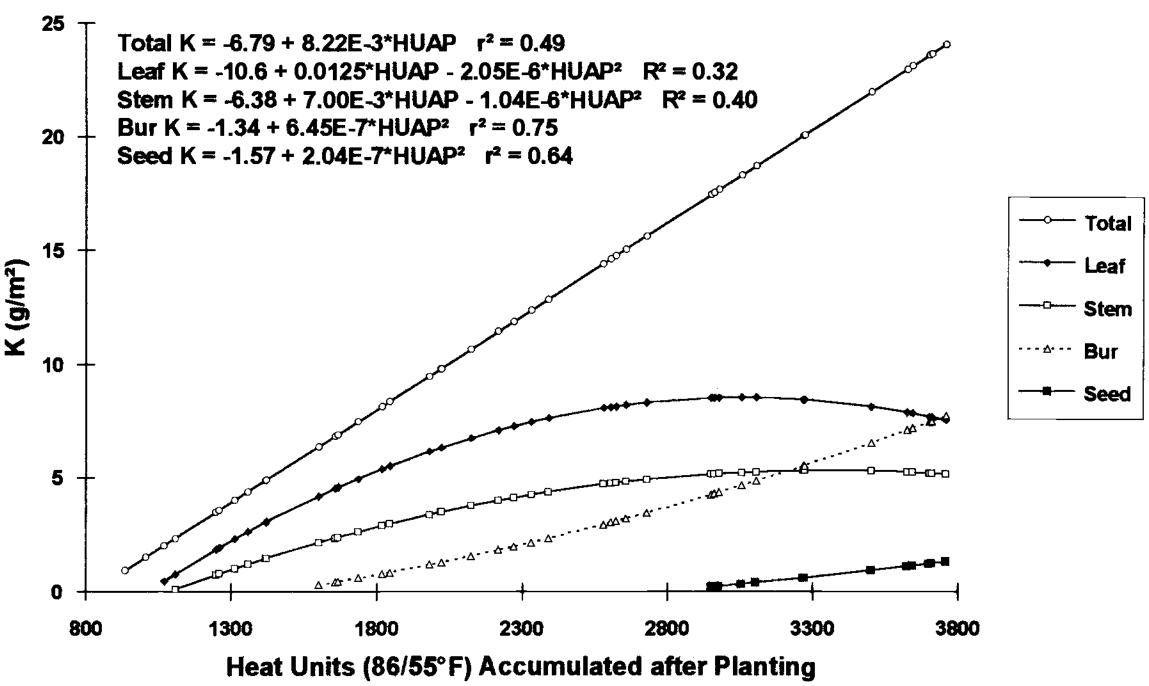

Fig. 6. Predicted K uptake by Pima cotton (var. S-7).