BIOMASS ACCUMULATION OF 'GA BUSH' VELVETBEAN ON THE PIEDMONT AND THE COASTAL PLAIN OF GEORGIA

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ABSTRACT

Cover crops are essential tools in a sustainable crop production system that utilizes conservation-tillage or no-till practices. Cover crops can produce large amounts of biomass that improve the texture and composition of a soil, resulting in better soil fertility. Velvetbean (*Mucuna pruriens*) is a tropical legume that has been used for many years in agricultural systems world-wide. The objective of this study was to determine the best harvesting and cutting (or tilling) dates for 'GA Bush' velvetbean grown on the Piedmont and Coastal Plain in Georgia based on the amount of biomass accumulated. Four planting dates including Apr. 15, May 15, Jun. 15, and Jul. 15 and four harvesting dates including 30, 60, 90, and 120 days after planting (DAP) were tested. The most successful growing/harvesting dates were considered those that accumulated the most biomass. Although, the best results were seen when velvetbean was allowed to grow for 120 days, significant biomass was accumulated at 60 DAP for some months and at 90 DAP, as well. This data suggests velvetbean may fit well as a short-rotation fallow in a sustainable vegetable production system in the Southeast.

INTRODUCTION

For centuries people have been growing cover crops as part of an agricultural system that improves the fertility and structural composition of their soil. Today, cover crops are still grown as part of a total agricultural system that promotes sustainability. Some of the long-term benefits obtained from the use of cover crops include weed suppression through competition or allelopathy, shorter fallow periods, possible insect control through rotation, and less monetary input through the decreased use of herbicides, pesticides, and water (Jordan, 1998; Phatak et al., 2002).

Sustainable crop production is achieved through the management of soil fertility and cover crops play a key role in soil fertility through a reduction in synthetic nutrients applied, particularly nitrogen. This reduces the cost of crop production and contamination of the environment (Phatak, 1992). Commonly used as cover crops, legumes are effective in the fixation of nitrogen and can accumulate large amounts of biomass that help to increase the nutrient availability and organic matter in a soil (Phatak, 1992). Organic matter in a soil is important because it improves the composition and texture of the soil. Phatak et al. (2002) note a system that utilizes cover crops, as one part of a whole system that utilizes sustainability will become more sustainable over time (Phatak et al., 2002). Many crops have been used for cover crops, but the choice ultimately depends on climate, cropping systems practiced, and the availability of seed (Pieters, 1927). Cover crops can be incorporated into a vegetable production system, however; the question is when is the optimal time to grow certain cover crops to best fit into rotation with vegetable crops based on accumulated biomass and nutrients.

Velvetbean (*Mucuna spp.)* is a tropical legume in the Fabaceae family that has been used for many years in agriculture and may fit well in a sustainable vegetable production system in the

Southeastern Region of the U.S. Traditionally used in agricultural systems in places such as Hawaii, the Philippines, and Meso-America, velvetbean was also once used in the early 1800s in the Southeastern United States. Here it was used as a green manure in orange orchards and in rotation with cotton and corn, because it helped lower external inputs and created a more sustainable system (Buckles et al., 1998; Taylor and Kabana, 1998, 1999).

The literature shows velvetbean can contribute significant amounts of N, as well as other important nutrients, to the soil when planted as a cover crop. Buckles et al (1998) report 336 lb N acre^{-1} in Northern Honduras. In West Africa, researchers note velvetbean can contain from 168-205 lb N acre^{-1} (Steinmaier and Ngoliya, 2000). Ibewiro et al. (2000) showed that velvetbean, in *in-situ* mulch systems, released 172 lb N acre^{-1} at 28 days. Velvetbean grown in Ghana accumulated 168 lb N acre^{-1} (Osei-Bonsu et al., 1996). When grown in Tifton, GA, velvetbean accumulated as much as 472 lb N acre^{-1} when planted in May and harvested in August (Martini, 2004). In Watkinsville, Georgia, velvetbean accumulated 243 lb N acre^{-1} when planted in April and harvested in August, and 226 lb N acre^{-1} when planted in May and harvested in August.

Velvetbean is also noted to accumulate large amounts of biomass. Buckles et al. (1998) note aboveground biomass production of velvetbean ranges from 2.2 to 5.4 T of dry matter acre^{-1} and in Ghana, Osei-Bonsu et al. (1996) report up to 4 T acre^{-1}. However, in recent years little research has been done on velvetbean as a cover crop in the United States. This results in a lack of information regarding when to grow and when to harvest velvetbean for the most biomass production as part of a sustainable vegetable production system in the United States.

The objective of this study was to determine the most ideal planting and harvesting (or cutting) dates for velvetbean as a green manure/cover crop in a sustainable vegetable production system in the Southeastern United States. The study took place at two locations in Georgia, the U.S.D.A. Phil Campbell, Senior, Natural Resource Conservation Center on the Piedmont in Watkinsville, Ga., and the University of Georgia Coastal Plain Experiment Station in Tifton, Ga. The two areas represent distinct physiographic regions, both with soils low in organic matter. The Piedmont soils are severely eroded due to a long history of conventional crop production, while the Coastal Plain soils are derived from marine sand deposits and are inherently low in organic matter.

MATERIALS AND METHODS

This study took place in Watkinsville, GA at the U.S.D.A. Agricultural Research Service Station on a Cecil sandy loam (fine, kaolinitic, thermic Typic Kanhapludults) and at the Coastal Plain Experiment Station on a Tifton sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) in Tifton, Georgia. One plot of velvetbean was planted on (within two days) four different dates, including 15 Apr., 15 May, 15 Jun., and 15 Jul. in the summer of 2002. Velvetbean seed was planted at 32 pounds/acre with an in-row spacing of 1.7 seed/foot in Watkinsville and 2 seed/foot in Tifton. In Tifton a 36-inch row spacing (between rows) was used and in Watkinsville 30 inch row spacing (between rows) was used due to the difference in planters available and used at each site. The velvetbean used in this study is ‘Georgia Bush,’ a newer variety of *Mucuna pruriens* released in 1999.

All plots were irrigated approximately .50 inch shortly after planting. No more than seven days after planting, 15 pounds/acre of Ammonium nitrate were applied to each plot. During the second week of May, Round up was sprayed on the April plot of velvetbean between rows due to an abundance of grassy weeds. Dual and Prowl were also sprayed in the middle of May on the plot to be planted at a later date (June and July plots) to control weeds. Round up was again sprayed in the April plot of velvetbean in late June for weed control. Dual and Prowl were sprayed again in July plots just prior to planting. In July all plots were irrigated approximately 2 inches. All plots were irrigated approximately two inches in August, as well.

Weed control was done by hand in Watkinsville throughout the month of July with about six hours of labor (for one person). Weeds were mostly a problem on the outer edges of the plots, in between the plots and in the bare spaces resulting from harvesting. The harvest dates included 30, 60, 90, and 120 days after planting (DAP). Four replicates of each treatment were collected as defined by areas previously randomly selected and mapped accordingly (see diagrams 1 and 2). In Watkinsville, biomass samples were collected by cutting the plants at the base in 3 linear feet per row, harvesting two rows per sample so each sample contained 6 linear feet. In Tifton 6 total linear feet were harvested, as well. The fresh weight of each sample was recorded shortly after harvesting and each sample was placed in an oven at 150 degrees F for at least 72 h to dry. Dry weights were then recorded for each biomass sample.

The data were analyzed using The GLM Procedure and Duncan's Multiple Range Test with an alpha value of 0.05. The mean weight of each (16) planting/harvest date was compared among each month of planting (April-July) using 64 observations except in Watkinsville for velvetbean, which is discussed later in this paper. A comparison of each planting/harvesting date was made among and within each month. A comparison of each planting and harvesting date, for example among the mean weights for all samples that were collected 30 DAP was also analyzed for differences in significance.

For the biomass accumulation based on heat units portion of this study, heat units were determined for each day using the following formula: [(Daily maximum temperature (T) + Daily minimum T) / 2] – 61 (OMAF, 2003; Ball, 2003; Nielson, 2001). Cotton's base temperature, or the temperature at which cotton will not grow, is 61°C (Ball, 2003). For this reason, 61°C has been chosen as the base temperature for velvetbean for the purpose of this section of the study. Heat units were summed between each planting and harvest date and these values were used similar to DAP to fit regressions for biomass and N accumulation for the Tifton and Watkinsville locations. All weather related data were taken from "The Georgia Automated Environmental Monitoring Network" website (www.GeorgiaWeather.net, 2003). Regression equations were developed for each location and cover crop using the REG procedure in SAS with no intercept in the model, for example no biomass at 0 DAP. The resulting regression equations were then combined for one model per cover crop. Equations were fit using all data points, except extreme outliers; which excluded the June planting in Tifton harvested 120 DAP.

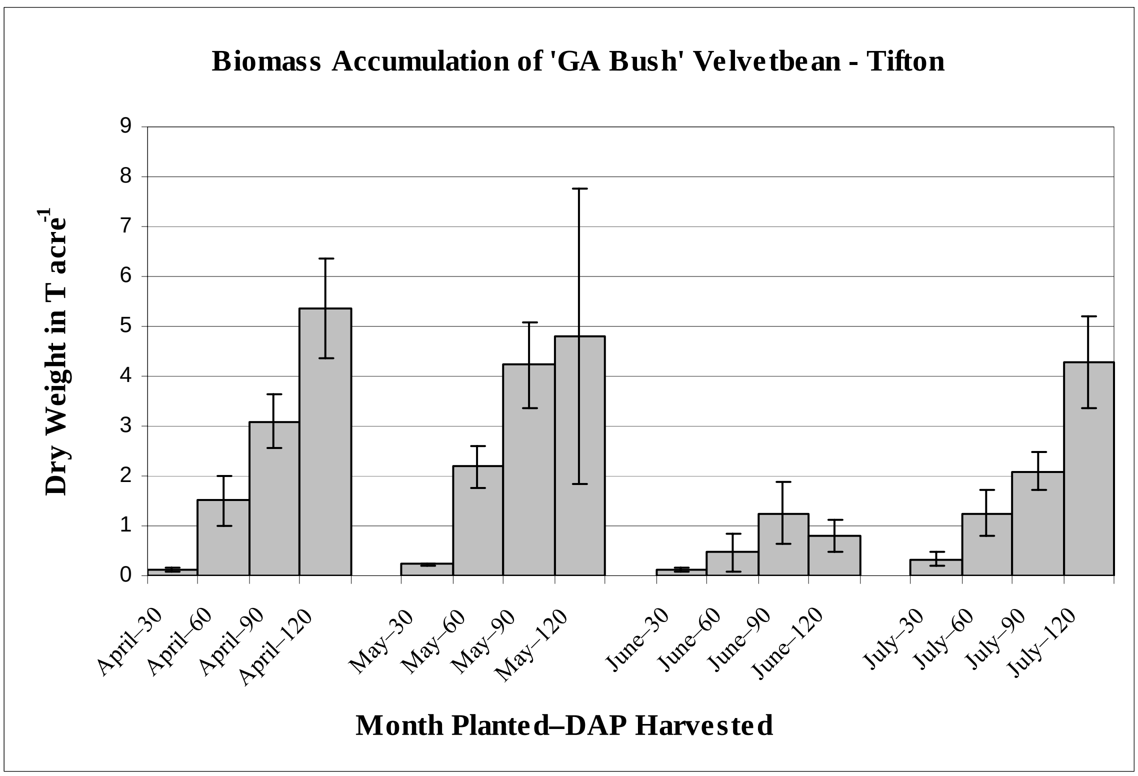
RESULTS AND DISCUSSION

In Tifton, velvetbean biomass harvested 120 DAP had the maximum mean DW of 3.8 t acre^{-1}, velvetbean harvested 90 DAP accumulated a mean DW of 2.7 t acre^{-1}, velvetbean harvested 60 DAP had a mean DW of 1.3 t acre^{-1} and velvetbean harvested 30 DAP accumulated a mean DW of 0.18 t acre^{-1}. The maximum biomass for velvetbean in Tifton was 29.2 t acre^{-1} (fresh weight) harvested 120 DAP from the May planting, however the standard error for this mean is 17.0 t acre^{-1}. The maximum DW was harvested 120 DAP from the April planting (5.4 t acre^{-1}), which was not significantly more than the May and July plantings with 4.8 t acre^{-1} and 4.3 t acre^{-1} DW accumulated respectively. The June planting harvested 120 DAP accumulated a significantly smaller amount of biomass with a DW of 0.80 t acre^{-1} probably as previously mentioned, due to a viral infection. The minimum fresh and DWs recorded for velvetbean in Tifton were 0.50 t acre^{-1} for the June and 0.1 t acre^{-1} for the April plantings, both harvested 30 DAP.

Velvetbean biomass harvested 60 DAP from each planting date accumulated from 0.4 t acre^{-1} for the June planting to 2.2 t acre^{-1} for the May planting. However, no significant difference occurred between the May planting (2.2 t acre^{-1}) and the April planting (1.5 t acre^{-1}). The biomass harvested 60 DAP from the July planting (1.2 t acre^{-1}) was not significantly less than the April planting harvested 60 DAP, which accumulated 1.5 t acre^{-1}.

Velvetbean biomass harvested 90 DAP accumulated DWs from 1.2 t acre^{-1} for the June planting to 4.2 t acre^{-1} for the May planting. At 90 DAP there was a significant difference between the April and May plantings with weights of 3.1 t acre^{-1} and 4.2 t acre^{-1} respectively. Biomass harvested 90 DAP from the July planting (2.1 t acre^{-1}) proved not to be significantly greater than the 1.2 t acre^{-1} of biomass harvested from the June planting (Figure 1).

Figure 1 DW (± SE) of 'Georgia Bush' velvetbean (*Mucuna pruriens*) planted in Tifton in April, May, June, and July, and harvested 30, 60, 90, and 120 days after planting (DAP).



In Watkinsville deer browsing was a problem for the velvetbean. For the first five months of the experiment deer were not a problem. They did go into the velvetbean plots during this time, however, they tended to only feed on the plants on the outer edge of the plots. The plot planted in July suffered slightly more damage from deer, probably because this planting had stunted growth due to a suspected virus, which kept the leaves small, tender, and more palatable to the deer. In early September, however, deer went into the velvetbean plots and completely defoliated all the plants.

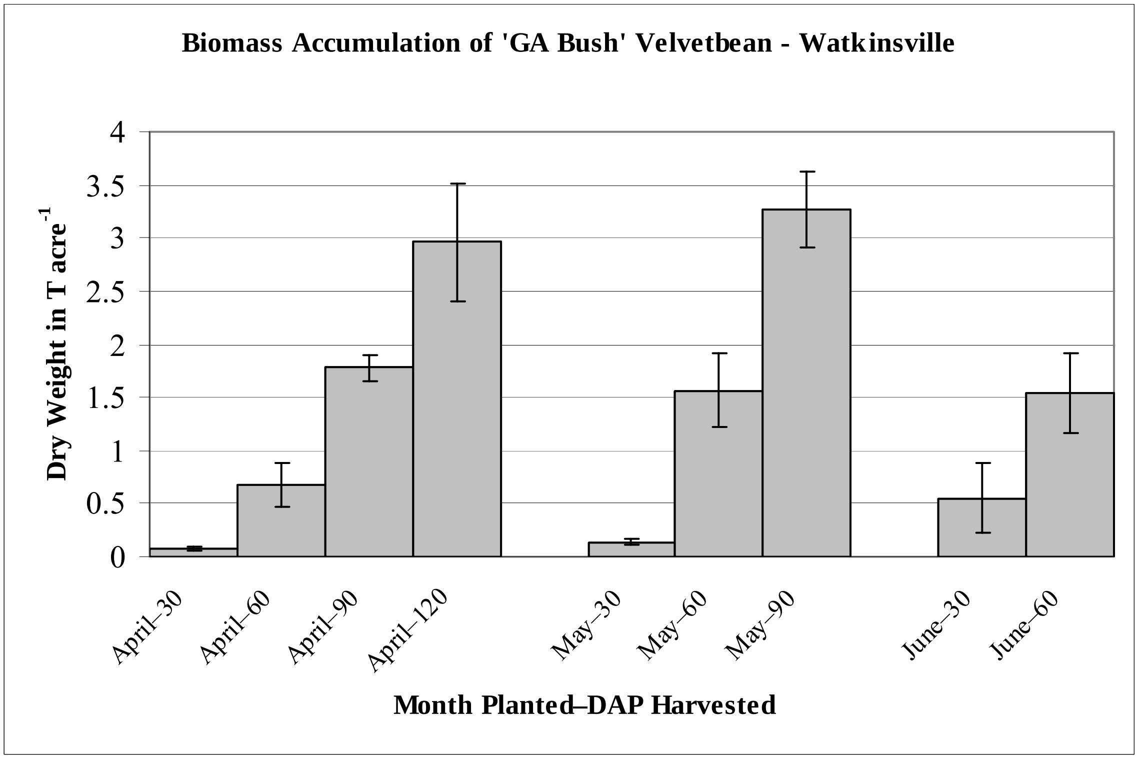
Unfortunately, due to the damage from the deer, collection of September samples of velvetbean plots was not possible. To determine the possibility of velvetbean recovering from the severe damage done by the deer, Milorganite™ nitrogen fertilizer containing human waste was put down on the perimeter of both the sunn hemp and velvetbean plots to deter the deer. The velvetbean began to put on new growth, however, in the middle of October either the fall army worm or the velvetbean caterpillar completely defoliated the foliage that remained or had grown back from the damage done by the deer.

In Watkinsville, a comparison among harvesting times (30, 60, 90, and 120 DAP) shows that velvetbean harvested 120 DAP accumulated the maximum DW of 2.9 t acre^{-1}, unfortunately only four samples were taken for this treatment of time due to damage to the velvetbean plantings as mentioned earlier. Velvetbean harvested 90 DAP accumulated a mean (of 8 samples) DW of 2.5 t acre^{-1}. The mean (of 12 samples) DW of velvetbean harvested 60 DAP accumulated 1.2 t acre^{-1} and the biomass collected 30 DAP accumulated a mean (of 12 samples) of 0.3 t acre^{-1}.

The DW of 16 samples from the April planting, 12 samples from the May planting and 8 samples from the June planting included four repetitions of each 30, 60, 90 and 120 DAP harvest time. At 30 DAP the June planting accumulated the most DW biomass with 0.5 t acre^{-1}, while the April and May plantings accumulated significantly less biomass (0.1 t acre^{-1} and 0.1 t acre^{-1} respectively) than the June planting.

Velvetbean biomass harvested 60 DAP from the May planting had the largest DW of biomass (1.6 t acre^{-1}) which is similar to the June planting (1.5 t acre^{-1}). The April planting accumulated the least amount after 60 DAP (0.7 t acre^{-1}). Biomass harvested 90 DAP was only recorded for the April and May plantings. The May planting accumulated significantly more biomass (3.2 t acre^{-1}) than the April planting (1.3 t acre^{-1}). No data were collected for the July plot (Figure 2).

Figure 2 DW (± SE) of 'Georgia Bush' velvetbean (*Mucuna pruriens*) planted in Watkinsville in April, May, June, and July, and harvested 30, 60, 90, and 120 DAP. Data are incomplete due to damage from a virus and damage from deer browsing and caterpillar feeding.



The model for velvetbean biomass accumulation versus DAP shows that as expected more biomass is accumulated the longer velvetbean is allowed to grow, however the variability increases later in time, such as at 120 DAP. The combined model for both locations is $\hat{Y}$= 0.025*DAP where $\hat{Y}$ is equal to the biomass accumulated in t acre^{-1} and r^2=0.88. The April, May, and June plantings in Tifton show a specific trend of more biomass accumulated 120 DAP. The June planting did not perform as might be expected based on the data from the other plantings, however, the suspected virus is probably the reason. Data are incomplete for velvetbean in Watkinsville due to pest damage (Figure 3).

When expressed on a cumulative heat units (CHU) basis, the combined model for velvetbean at both locations is $\hat{Y}$= 0.004*CHU where $\hat{Y}$ is equal to the biomass accumulated in t acre^{-1} and r^2=0.93. Cumulative heat units better described biomass accumulation than cumulative heat units plus cumulative rainfall. Variability among data points is small, except for the June plantings in Tifton; which are outliers due to viral damage to the planting. However, the linear pattern of the data points suggests an effective model at estimating potential biomass accumulation based on cumulative heat units (Figure 4).

Figure 3 Biomass accumulation of velvetbean in dry weight (DW) as a function of days after planting (DAP). Data points are mean of four observations. Data are incomplete for Watkinsville.

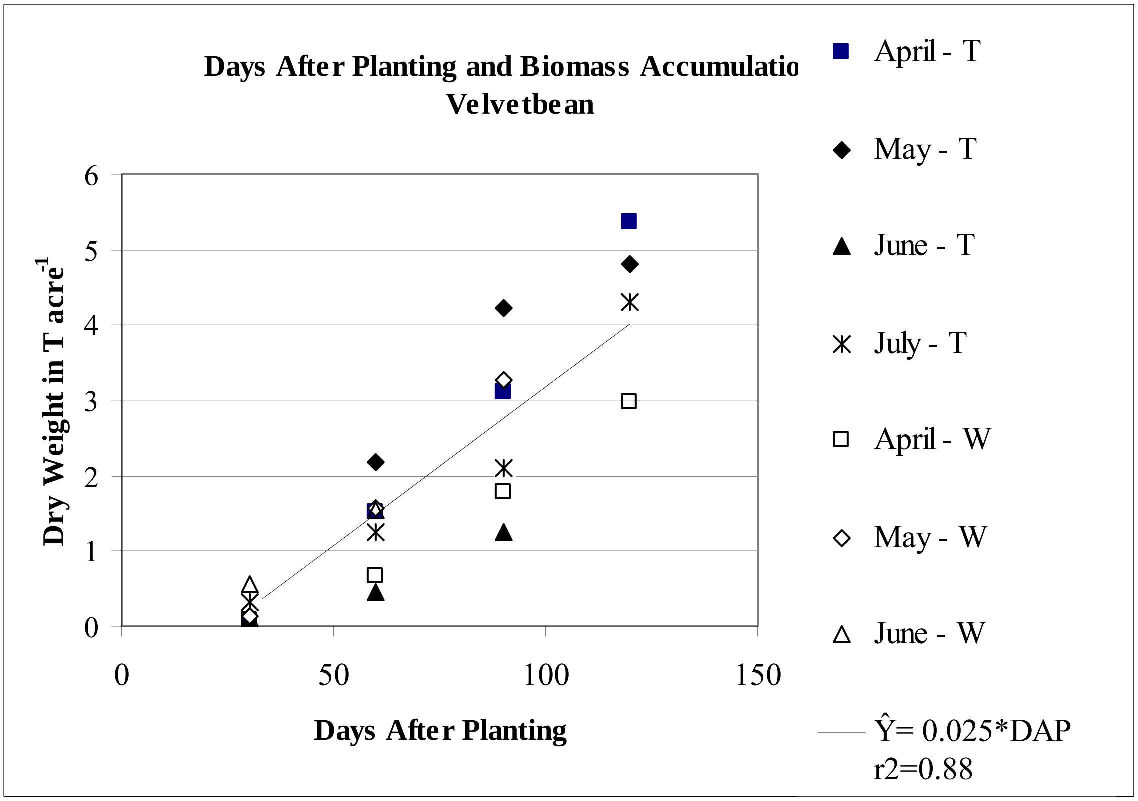
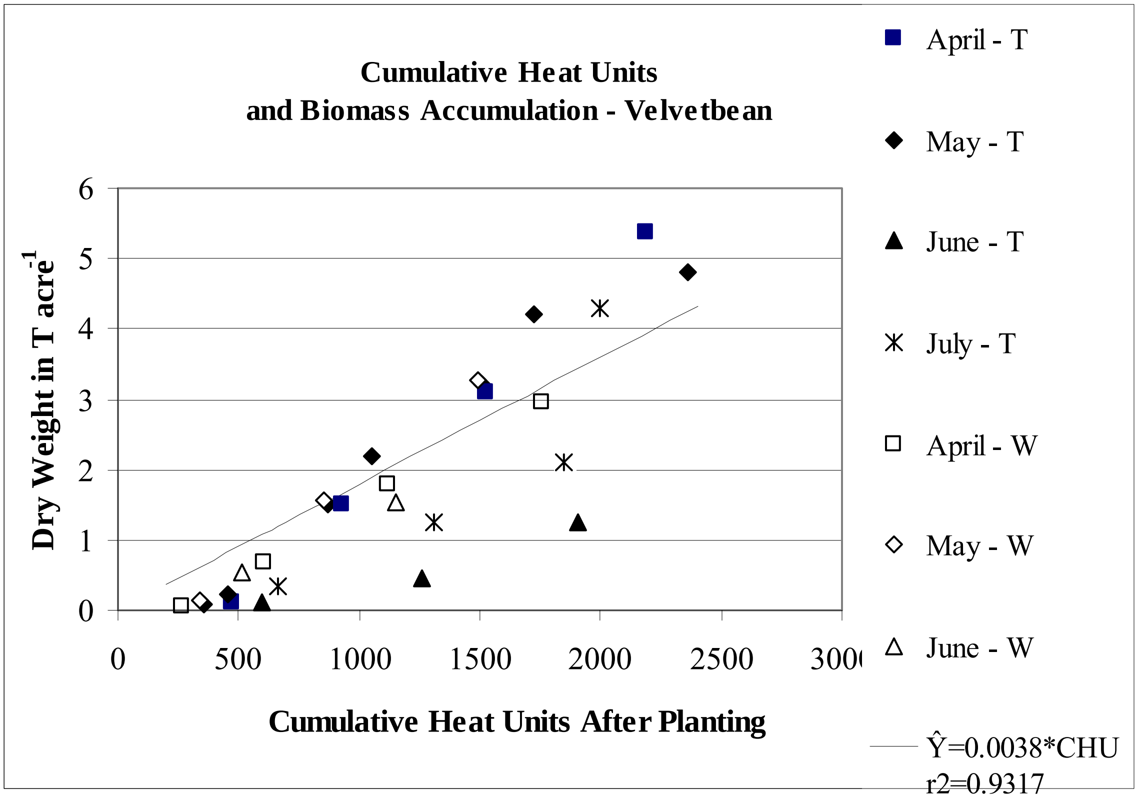


Figure 4 Biomass accumulation of velvetbean in dry weight (DW) as a function of cumulative heat units (CHU). Data points are mean of four observations. Data are incomplete for Watkinsville.



CONCLUSIONS

At 120 DAP velvetbean planted in Tifton accumulation in the April May and July plantings was similar, while the June planting accumulated significantly less DW biomass than the other plantings due to a suspected virus. The May planting harvested 90 DAP was similar to the April, May and July plantings harvested 120 DAP. It appears that to receive soil-improving benefits from velvetbean when grown in Tifton, allowing 120 days for the velvetbean to grow will provide the most benefit. If a grower needed a shorter growing period for velvetbean, planting in May and cutting 60-90 DAP or planting in July and cutting 90 DAP would also provide significant biomass. This provides two windows of opportunity for growing velvetbean in early or late summer as a short-fallow rotational crop in South Georgia.

At 90 DAP, the May planting of velvetbean grown in Watkinsville accumulated more biomass than the April planting. The April planting harvested 120 DAP accumulated less biomass than the May planting harvested 90 DAP. The data show a trend of increasing biomass accumulation with later planting dates. The May and June plantings were similar at 60 DAP, both producing average biomass. The biomass accumulated in the June planting at 30 DAP was similar to that produced in the April planting at 60 DAP. This data may suggest planting velvetbean after April is better for biomass accumulation in the Watkinsville, GA area.

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