Effect of sowing time on biomass production and partitioning into grain yield of pigeonpea genotypes (*Cajanus cajan* L.Millsp.)

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Abstract
The effect of sowing date on growth and partitioning of dry matter into yield of pigeonpea (*Cajanus cajan* L.Millsp) genotypes were investigated using split design. Six genotypes (Quest, UQPL941, UQPL1001, ICPL86022, CIPL86039 and ICPL14425) were sown in December 2017 and January 2018. The dry matter production and grain yield of the genotypes under different sowing conditions ranged from 12 - 17 t ha^{-1} and 3.7 – 4.6 t ha^{-1}. The highest harvest index was recorded in January. The genotypes in both sowings performed differently with respect to yield and harvest index. The results showed significant effect of sowing date on dry matter production and partitioning efficiencies of pigeonpea genotypes and an appropriate adjustment in planting time would optimize the genotype performance.

Introduction
Pigeonpea is a popular crop growth in a wide range of climatic and soil conditions in medium to low yield potential areas and plays an important role in subsistence agriculture (Joshi, et al., 2011). Its deep-rooting and drought tolerance traits make it a suitable crop in the low rainfall regions (Adjei, 2012).
The growth rate of pigeonpea is slow when compared with other legumes such as peanut and mungbean especially during early stages of growth (Wallis, et al., 1980).The successful establishment and development of seedlings depend on the rate of development of main stem leaves, timing of secondary leaf production and the ability of the seedlings to capture light (Angus, et al., 1981).
Grain growth depends on the efficiency with which dry matter is partitioned to pods (Sivakumar & Virmani, 1984). Both day length and temperature influence the partitioning of dry matter into reproductive growth and effect on sink formation and sink retention (Robertson, et al., 2001). The low initial growth rate and low harvest index of pigeonpea are major barriers when grown as a sole crop. Understanding the performance and genotype × environment (G × E) interactions on accumulation of biomass and partitioning into grain yield of new improved pigeonpea cultivars under Australian conditions is an important step in assessing its production potential.
This paper describes the results from field studies undertaken in 2017/2018 using six pigeonpea genotypes (Quest, UQPL941, UQPL1001, ICPL86022, ICPL86039 &ICPL14425) under two sowing dates (December and January) at Gatton Campus, the University of Queensland.

Materials and Methods
Experimental Details
The experimental field had grown sorghum in the previous season. The plot size was 1.2 m x 4 m with spacing between rows 0.5m and 15cm between plants within a row. Seeds were treated with fungicide “Tetramethyl Thiuram Disulphide 42 %” before seeding and plots were inoculated with *Rhizobium* (Nodule-N) at sowing. A pre-emergent herbicide (Pendimethalin 440EC) was applied within 48 hours after sowing, while mechanical weeding was conducted as and when necessary. Drip irrigation was set up using ‘T’ tapes and irrigated once a week (30ml) during December to February and irrigation frequency was reduced to fortnightly from March.
Data collection
The experiment was laid out in a split-plot design with planting dates as main plots and genotypes as sub-plots with three replicates. Genotypes were assigned to sub-plots in a randomized manner. At maturity for each sowing 0.5m^2 area was harvested to measure total dry matter (TDM) (excluding senesced leaves) and grain yield (Y). Harvest index (HI) was calculated as grain yield divided by net above ground dry matter.
Statistical analysis

All the observations recorded during the experimental period with respect to various growth and yield parameters, were subjected to statistical analysis using ‘R’. The analysis of variance (ANOVA) table was prepared and significance of treatment effects were tested with variance ratio (f-value). Appropriate standard errors and critical difference at 1% probability level to test the statistical significance of the results. The

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differences between treatment means were tested using least significant difference (LSD) where the mean values that do not share the same letter are significantly different at 95% confidence level.

Results and discussion

Plants were exposed to larger variation in temperature, solar radiation and photoperiod regimes throughout the experiment. The mean maximum temperature during experimental period ranged from 31.7ºC to 29.4ºC and mean minimum temperature from 16.9ºC to 14.8ºC. The highest rainfall of 224mm was recorded in February. The day length reduced from 14.7 hours in December to 12.2 hours in April.

The effect of sowing date and genotype × sowing date interaction were analysed using analysis of variance, sowing date as the main effect. Time of sowing had significant effect on TDM and HI leaving variability between genotypes (Table.1 & 3). The sowing dates accounted for 49% of variation in total sums of square (TSS) for TDM, whereas genotypes had highest percentage of variation in yield (35%) and HI (58%). The genotype × sowing interaction accounted for the lowest variation in TSS for TDM, yield and HI (11%, 19% and 6% respectively) (Table.1).

Table.1. Analysis of variance (ANOVA) of time of sowing and genotype interactions

Source	d.f	TDM (t ha^{-1})		Yield (t ha^{-1})		HI	
		TTSS	% SS	TSS	% SS	TSS	% SS
Time of sowing (TOS)	1	226 *	49%	100	27%	100 **	18%
Ea	2	12	3%	0.7	4%	0.7	0%
Genotype (G)	5	134 ***	29%	327 ***	35%	327 ***	58%
TOS × GTP	5	51 **	11%	31 **	19%	32 ^{NS}	6%
Eb	20	38.2	8%	91.3	14%	91	16%
Total	35						

TSS-Total Sums of Square

*Significant codes: '***' 0.001, '**' 0.01, '*' 0.05, 'NS' Non-significance*

TDM and HI varied significantly between sowing dates, a substantial reduction in TDM (5 t ha^{-1}) was observed in January (Table.2). Grain yield did not vary significantly between sowing dates, the higher mean yield was recorded (4.6 t ha^{-1}) in December however HI was higher in January (29).

Table.2. Effect of sowing date on mean TDM, Yield and HI of six pigeonpea genotypes sampled at harvesting, LSD at 95% confidence level were given in the table.

Time of Sowing	Total Dry Matter (t ha^{-1})	Grain Yield (t ha^{-1})	HI
06-Dec-17	17 a	4.6 a	26 a
09-Jan-18	12 b	3.7 a	29 b
LSD	**1.6**	**0.93**	**0.8**

The genotypic variation in the mean of all three growth and yield parameters (TDM, Yield and HI) were highly significant across sowing dates. TDM ranged from 9.5 t ha^{-1} (UQPL1001) to 13 t ha^{-1} (UQPL941). Quest, UQPL941 and ICPL14425 provided significantly higher yield (4.4 – 4.8 t ha^{-1}) than UQPL1001, ICPL86022 and ICPL86039 (3.5 – 3.7 t ha^{-1}). The ICPL14425 had highest HI (32) among all the genotypes with comparable grain yield (4.6 t ha^{-1}) (Table.3).

Table.3. Genotypic variation on mean TDM, Yield and HI of six pigeonpea genotypes sampled at harvesting, LSD at 95% confidence level were given in the table.

Genotype	Total Dry Matter ($t\ ha^{-1}$)	Grain Yield ($t\ ha^{-1}$)	HI
Quest	12 b	4.8 a	29 ab
UQPL941	13 a	4.4 a	24 d
UQPL1001	9.5 d	3.7 b	29 bc
ICPL86022	11 c	3.5 b	27 c
ICPL86039	12 b	3.8 b	24 d
ICPL14425	11 bc	4.6 a	32 a
LSD	**1.1**	**0.50**	**2.09**

Conclusion

The results of this study demonstrated that the time of sowing impacted the growth and biomass accumulation causing a significant reduction in total dry matter (5 $t\ ha^{-1}$) when time of sowing delayed by 30 days. Grain yield under both sowing conditions did not vary significantly and were comparable to those generally recorded in subtropical regions (3 – 3.8 $t\ ha^{-1}$) (Rachaputi, et al., 2018) (Akinola & Whiteman, 1974). The maximum grain yield was obtained in December (4.6 $t\ ha^{-1}$), conversely the maximum harvest index (29) value was recorded by sowing in January.

Genotypes responded differently to varying environmental conditions as indicated by different sowing dates for total dry matter, grain yield and harvest index (HI). These variations in the performance of genotypes across sowing dates were the combination of genotype × sowing time interaction. UQPL941 produced highest TDM (13 $t\ ha^{-1}$) and Quest was the high yielding genotype.

This study established a significant variation in the TDM, yield and HI for pigeonpea genotypes between two sowing dates. Further study is recommended to extending the sowing dates to represent varying environmental conditions to confirm the results of this experiment.

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