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# Dual-Purpose Peanuts: A potential high-value legume crop to address the feed demand of the beef Industry in northern Australia

Nawaz Shah[1], **Drew Portman[2]**, Edward Mwando[1], Staci Stanley[1], Nick Hartley[1], Peter Shotton[1]

[1]Plant Industries Group, Department of Industry, Tourism and Trade; Northern Territory Government, NT 0828, Australia
[2]Institute of Future Farming Systems, Central Queensland University, CQIRP, 630 Ibis Avenue, Kawana, QLD 4701, Australia

## Abstract
Peanuts (*Arachis hypogaea L.)* sown in northern Australia have the potential to provide quality feed and a high value cash crop. This research investigates the potential of four newly developed peanut varieties (Taabinga, Alloway, Holt and Kairi) within tropical farming systems for in-season biomass cutting and the trade-offs with kernel yield. Field trials were conducted at Katherine Research Station, Northern Territory for 2 years (2022 and 2023 seasons) to evaluate genotype and in-season biomass removal on yield of hay and kernels. The results indicated that harvesting inseason peanut biomass at 70 % canopy cover could significantly improve the quantity of biomass and its nutritional value as a feed source for livestock. Peanut crop can produce as high as 1.5 - 2.5 t $ha^{-1}$ of in-season dry matter. It was shown that any penalty that in-season biomass harvest has on kernel yield (t $ha^{-1}$) is likely to be associated with moisture and temperature stress preceding harvest. This research shows the potential of peanuts as a dual-purpose crop; and the limitations that can inhibit the development of dual-purpose peanut production in Northern Australia.

## Keywords
Northern Territory, Tropical farming system, in-season biomass, nutritional value, dry matter, kernel yield.

## Introduction
The beef industry in northern Australia incorporates Queensland, Northern Territory, and north of Western Australia, representing 64 % of Australia's national beef herd (ABARES 2019). Cattle in the northern Australia is mainly forage for feed on native perennial grasses (Bortolussi et al. 2005). The grasses have low crude protein and low digestibility, mostly limited in quantity as well (Costa et al. 2012). However, legumes such as dual-purpose peanuts have greater crude protein and digestibility than grasses (Waghorn et al. 1989; Wilson, 1994).

Peanuts (*Arachis hypogaea* L.) is an important food crop, with over 33 million tonnes of worldwide annual production (FAO STAT, 2022), and also enhance soil fertility through its ability to fix nitrogen (Agegnehu et al. 2015). The peanut production in Australia was predominantly under dryland conditions but due to climate change, the industry has shifted to irrigated production regions of Queensland and the Northern Territory (NT) (Chauhan et al. 2010). Kernels are used as a food source for human however; the above ground foliage is incorporated into the soil and can greatly increase organic matter content of the soil (Balkcom et al. 2004). However, peanut foliage contains high crude protein, desirable fibre content and high digestibility (Longhini et al. 2020), and when cut in-season as a forage, grazed, or baled as hay could provide an additional high quality feed source for livestock whilst creating additional revenue for growers at harvest (Sorensen, Nuti, & Butts, 2009).

The objective of this study was to assess new peanut varieties as dual-purpose crops for kernel yield in combination with different fodder production options, for growing conditions of Katherine region, NT.

## Methods
*Experimental site*
A field experiment was carried out at Katherine Research Station (KRS) NT during the 2022 and 2023 growing seasons. The trial site has clay loam red Kandosol soil type and the tropical climate, with hot and humid wet season (November to April) and cooler dry season (May to October).

*Experimental design and treatments*

The experimental design was a randomised complete block design under split plot arrangements (Fisher 1935 and Box et al. 2005), containing six replications. Peanut genotypes were assigned as main-plot and in-season fodder removal (cut/un-cut) were assigned as split-plot treatment. The plot size was 40 m long and 3.6 m wide, with seeds sown in four rows spaced 90 cm apart at a rate of 180,000 seeds $ha^{-1}$. The early maturing runner type varieties Alloway, Kairi and Holt were planted in May 2022, while Alloway, Kairi and Taabinga were planted in March 2023 growing season. Before sowing, the selected site was disk ploughed and harrowed, and cotton sustain applied at a rate of 330 kg $ha^{-1}$, 1.3 t $ha^{-1}$ gypsum and foliar application of micronutrients (zinc, boron, iron, manganese and molybdenum). During each of the two seasons, irrigation (600-700 mm over the season) was supplied as required and the crop was managed for grass and broadleaf weeds, pests and diseases using the recommended control methods. The crop was sprayed fortnightly with fungicides as preventive measure to control fungal diseases.

*Data collection*

In the first year of the trial, the peanut crop was sampled for biomass production at 50% flowering, however, in year two in-season biomass sampling was conducted when the overall canopy cover reached 70%. A 1 metre section of biomass was cut at 5 cm above ground level from each treatment plot. The biomass simulating hay harvest or cattle grazing was dried down and use to calculate the tonne per hectare of potential dry biomass (hay) production in-season. For each season when the peanut crop reached maturity, pre-harvest biomass samples cuts at 5 cm above ground level was obtained from all plots to establish the peanut plant's ability to recover. After digging and harvesting peanuts the stubble from behind the thresher was also collected, dried down and used to calculate t $ha^{-1}$ for end of season biomass (also available for hay). Eight-metre sections of harvested peanuts were then taken from each plot to calculate t $ha^{-1}$ of peanut (nut and shell) assessing the differences between cut and uncut treatment.

*Data Analysis*

All data was subjected to analysis of variance (ANOVA) and Fisher's protected with GenStat (17th edition) statistical software (Payne 2009). Means were analysed for the least significant difference at a probability level of $p < 0.05$**. Results are expressed as a mean value ± SD. There were six replicates.

## Results and Discussion

There was no significant differences between varieties for in-season hay production at $p < 0.05$ ($p = 0.941$) (Figure 1) in 2022 as all varieties produced 2.5 t $ha^{-1}$. In 2023, there was a significant difference at $p < 0.05$ in in-season hay production between varieties ($p < 0.001$). A recent variety, Taabinga, produced the highest amount of hay in 2023 at 2.3 t $ha^{-1}$ followed by Kairi 1.5 t $ha^{-1}$ and lastly Alloway 1.3 t $ha^{-1}$. The difference for in-season dry biomass production may be explained by the different sowing dates, the 2022 trial was sown in May (temperatures were low) and the preceding 2023 trial was sown in March (high temperatures). Peanuts are particularly susceptible to extreme soil temperatures and the recovery of plants after in-season harvest may be delayed during the June-August period where the temperatures in Katherine range between 3-20°C. Research completed by (Sorensen et al. 2009), suggested that minimal midyear forage harvest of irrigated peanut would have to be around 1.2 t $ha^{-1}$ to be profitable, it can be seen that over two years in this trial we have achieved above this recommended base line for in- season hay harvest.

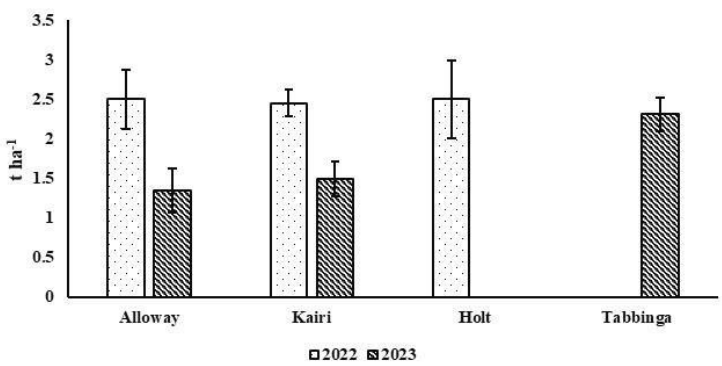



**Figure 1. Production of hay (t $ha^{-1}$) harvested in-season at 50 % flowering in 2022 and at 70 % canopy cover in 2023. Error bars show standard error (SE) across 6 replicates.**

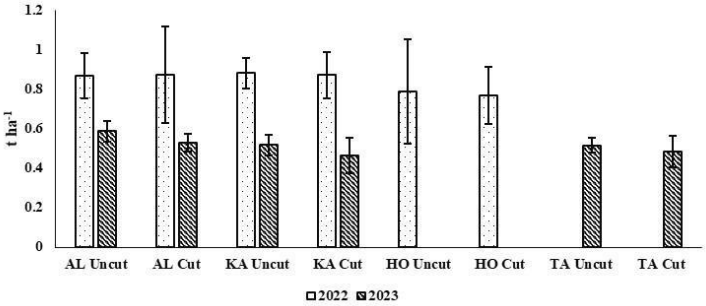



**Figure 2. End season dry biomass (t ha$^{-1}$) after harvest for Alloway (AL), Kairi (KA), Holt (HO) and Taabinga (TA). Error bars show standard error (SE) across 6 replicates.**

The final dry biomass harvest of stubble in 2022 was not significantly different between variety ($p = 0.801$), and there was no significant difference for variety to treatment interaction ($p = 0.695$), and no significant effect on final biomass produced between cut and uncut peanuts ($p = 0.441$), (Figure 2). The end of season dry biomass for Alloway in 2022 was 0.88 t ha$^{-1}$, followed by Kairi 0.87 t ha$^{-1}$ and Holt 0.83 t ha$^{-1}$. In 2023, the results showed a similar pattern with no significant difference between varieties for final biomass yield ($p = 0.063$), and no significant for variety to treatment interaction ($p = 0.830$). In 2023 there was again no significant effect on final biomass production between uncut and cut treatments ($p = 0.830$). In 2023, the end of season dry biomass for Alloway was 0.56 t ha$^{-1}$, followed by Kairi and Taabinga, which both produced 0.50 t ha$^{-1}$. More extensive research and detailed analysis on the quality of in-season and end season peanut hay are strongly recommended.

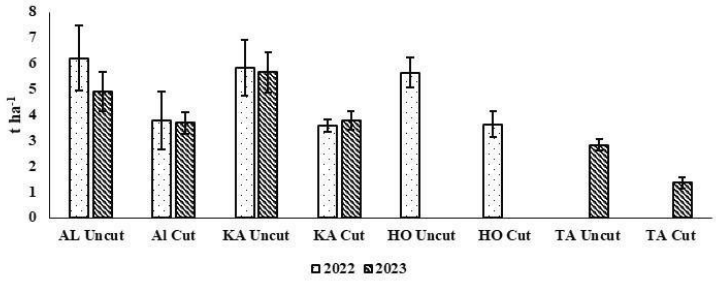



**Figure 3. Processed nut and shell (t ha$^{-1}$) for uncut and cut treatments for Alloway (AL), Kairi (KA), Holt (HO), and Taabinga (TA). Error bars show standard error (SE) across 6 replicates.**

Figure 3 shows the results for nut and shell yield for 2022 and 2023. In 2022 there was no significant difference in nut and shell yield between variety ($p = 0.468$), and non-significant for variety to treatment interaction ($p = 0.803$). On the other hand, cutting of biomass in-season in 2022 significantly affected nut and shell yield ($p \leq 0.001$). The average yield for uncut treatments was 5.89 t ha$^{-1}$ and cut treatments 3.63 t ha$^{-1}$. Nut and shell yield in 2023 did show a significant difference between varieties ($p < 0.001$), however, there was no significant difference for a variety and treatment interaction ($p = 0.117$). Like the 2022 trial, cutting of biomass in-season significantly affected nut and shell yield ($p < 0.001$). The average yield for uncut peanuts was 4.3 t ha$^{-1}$ and cut peanuts 3.05 t ha$^{-1}$. Interestingly Kairi produced the greatest quantity of nut and shell in the uncut treatments in 2023 at 5.4 t ha$^{-1}$, but within the cut treatment, plots did not recover well and yielded 3.5 t ha$^{-1}$. A similar pattern was also observed in Taabinga where the uncut plots nut in shell yield was 2.7 t ha$^{-1}$ and cut treatments was 1.5 t ha$^{-1}$. Alloway was the most capable variety of peanut for retaining yield at harvest, for example in 2022, uncut Alloway yielded 4.7 t ha$^{-1}$ and cut Alloway yielded 4.2 t ha$^{-1}$. This may suggest that harvesting biomass in-season at 70% canopy cover instead of 50% flowering results in a more mature stage of growth, allowing for pegging to be complete and thus the effect of in-season biomass harvest on nut and shell yield is not as severe as demonstrated in 2022 in the cultivar Alloway.

## Conclusion

The results for the peanut crop at Katherine Research Station in 2022 - 2023, shows the potential role dual-purpose peanuts could provide in mixed farming practices. In a well-managed crop, there is a potential to produce up to 2.5 t ha$^{-1}$ of high-quality hay for cattle. Peanut hay is high in protein and fibre (Gorbet et al.

1994). The in-season harvest of peanut biomass does reduce the harvested processed kernel yield, the context of this reduction is important. There needs to be a differentiation between standard commercial peanut crops compared to a dual-purpose peanut crop. For instance, whilst the reduction in nut and shell is significant for a commercial peanut grower, for a mixed farm that has livestock, producing 1.5 t $ha^{-1}$ of peanuts at harvest time still represents a significant additional source of income that a grower would not have if they were to grow alfalfa or barley for hay. Furthermore, dual-purpose peanuts could be grown as a failsafe protection crop in a mixed farming system. For example, when animal feedstock is in good supply and the season is favourable, sowing peanuts instead of alfalfa or barley and not cutting for hay or grazing gives an opportunity to harvest a high value legume crop potentially yielding 3.5 - 5 t $ha^{-1}$. However, if within the season, pressure on feed resources for livestock become an issue, there is an option to harvest the peanut crop biomass for hay or graze as an additional feed source for livestock and still be able to harvest around 1.5 t $ha^{-1}$ of kernels at the end of the growing season. Further research on economic feasibility is highly recommended.

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