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The Effect of Harvesting Age on Dry Matter Yield and Crude Protein Content of Pigeon Pea (*Cajanus cajan* (L.) Huth) Grown as a Forage in the Savannah Zone Of Northern Ghana

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ABSTRACT
Effect of different harvesting dates on dry matter yield and crude protein content of pigeon pea (Cajanus cajan (L.) Huth) was assessed in the Savannah agroecological zone in northern Ghana. The pigeon pea seeds were sourced at Tamale market as a land-race variety. Good quality seeds were carefully selected and planted in the pasture field of CSIR – Animal Research Institute, Nyankpala Station. The spacing was 40 cm within rows and 60 cm between rows on four separate plots (8m x 15m) each was demarcated with 3m inter-plot spacing to separate the plots. The forage was harvested at 3 different ages and data collected on plant population/ha, dry matter yield and crude protein content determined for two planting seasons in 2021 and 2022. The plant height at harvest did not show a statistical difference (P>0.05). Significant differences (P<0.001) were, however, observed in biomass yield among the harvesting ages. The dry matter yields obtained at different harvesting ages were 8.09, 5.95 and 3.59 tonnes DM/ha for 100, 120 and 140 days of plants age at harvest, respectively. Each mean value was significantly higher (P<0.05) than the other from 100 days to 140 days harvest. The crude protein content of the biomass harvested at 140 days of plant age was significantly lower (P=0.001) than the mean protein content of the 100 and120 days harvest. The results showed that at 100 to 120 days of plant age, the quality of the forage was not affected except for a slight reduction in dry matter yield. The best age for harvesting the forage was found to be between 100 to 120 days in order to obtain maximum forage dry matter yield and good crude protein content.

Keywords: *Crude protein, Dry matter yield, Forage, Pigeon pea, Ruminant animals*

INTRODUCTION
Feed resource such as natural pasture, crop residues and agro-industrial by-products are the major inputs needed to achieve sustainable animal productivity (Shah et al., 2025). Inadequate feed resources for ruminant animals in terms of quality and availability in the natural pasture is one of the serious limiting factors in ruminant production (Amole, 2016) especially during the long dry season in the Savannah ecological zone that records acute feed shortages annually (Amole, 2016: Shah et al., 2025). Pasture development and improvement is therefore one of the major activities that need to be done to provide high-quality feed in addition to the poor natural pasture and crop residues available, especially during the dry season within the Savannah agro-ecological zone (Ibrahim and Usman, 2021). Cultivation of pigeon pea as a forage crop could provide feed, especially as a protein source fodder for animals to fill in the feed shortage gap in the dry season (Buthelezi *et al.,* 2022; Shah et al., 2025).

Pigeon pea (*Cajanus cajan (L.) Huth)*) plant is a

well-known crop that delivers food and feed proteins for both human and animals in rain-fed agriculture, and is typically farmed on poor soils with minimal to zero use of fertilizer in most less developed nations (Cheva-Isarakul,1992; FAO, 2008) and it considerably improves food and feed security in Africa and Asia (Martınez-Villaluengaa et al., 2010). The pigeon pea plant provides high quality green protein forage for ruminant animals feeding when other forages have dried up during the dry season in Savannah ecological zone in the West Africa Sub-region (Sloan et al., 2009; Buthelezi et al., 2022). Pigeon pea is a tropical perennial pulse crop that accumulates good amount of carbohydrates, proteins, vitamins, minerals, and vital amino acids both in leaves and in fruits (Rabia and Ying, 2018). The fodder of pigeon pea is highly digestible and supply high quality protein to ruminant animals (Corriher et al., 2007). Small ruminant in Ghana, have been found to have high pigeon pea preference to other legumes (Karbo et al., 1998). When the crop is matured at field, the pods are harvested and threshed to separate the grain and the husk. Farmers combined the husk with dry leaves and twigs of pigeon pea and offer it to ruminants as feed in the dry season (Agyare et al., 2002).

Botanically, pigeon pea belongs to the Fabaceae family and is one of the promising forage plants that can serve as a good source of forage for feeding ruminants. It thrives widely in the tropics and sub-tropics even under poor soil conditions (Speranza et al., 2007). Pigeon pea is a glandular -pubescent shrub that grows and have a lifespan of 1–5 years (Crop Trust, 2014). In the Savannah ecological zone of northern Ghana, the plant is usually grown as an annual plant (Karbo et al., 1998; Agyare et al., 2002; Tenekwa et al., 2022) and its height range between 0.5 – 4 m with roots being 15 – 20 cm deep and 15 cm stem diameter at maturity (Speranza *et al.,* 2007). It is commonly used for feeding ruminant animals either fresh or dried (Agyare et al., 2002; Tenekwa et al., 2022). As a multipurpose crop, it provides grain, fodder, and fuelwood for household use and also fixes nitrogen to improve soil fertility. The seeds of pigeon pea can be consumed as food for humans or as an ingredient for formulation of concentrate feed. The leaves and twigs (young stems) are very good source of fodder, highly nutritive and contain a range (21 – 30%) crude protein (CP) levels (Amaefule and Onwudike, 2000).

In most forage crops, the interval between planting and harvest of the crop significantly affect the concentration of carbohydrate reserves in leaves and other part of the plant as measured in dry matter yield of the forage biomass (Tenakwa et al. 2022). Determining the forage dry matter yield of pigeon pea as a forage at different ages of harvest will provide scientific information on the crop performance in terms of dry matter yield and crude protein content. Pigeon pea is propagated by seeds which is sown with other crops in a mixed cropping system or in pure stands (Karbo et al., 1998; Tenakwa et al. 2022). A planting distance of 40 x 60 cm within and between rows respectively, has been reported to produced high forage yield of 8.96 tonnes DM/ha (Omotoso *et al.,* 2018). There is inadequate information on the effect of different ages of harvesting pigeon pea planted as a forage on dry matter yield and its nutritive quality in in the Savannah ecological zone of northern Ghana.

The objective of this work was therefore to assess the effect of different harvesting ages of pigeon pea on dry matter yield and crude protein content of the harvested forage. This will elucidate the potential of pigeon pea as a good source of supplementary protein feed for the production of ruminant animals.

MATERIALS AND METHODS

Experimental location

The experiment was conducted in the pasture development experimental field of Council for Scientific and Industrial Research - Animal Research Institute (CSIR – ARI) Nyankpala Station. The area is located on longitude 0° 58'46" W and latitude 9° 23'46" N and at an altitude of 168 m above sea level (SARI, 2015). The Nyankpala area experiences one rainy season in a year which begins in April and ends in October annually with average rainfall of 1200 mm per annum (SARI, 2015). Cold harmattan winds also occur in the area from November to February every year. The annual temperature range between 19°C to 42°C with an average of 28.5°C (SARI, 2015).

Planting materials, land preparation and planting

Physically good-looking landrace variety of pigeon pea seeds were acquired from Tamale market. The smooth and good quality seeds were carefully selected and used for planting after a germination test was conducted on the seeds. The experimental field was within CSIR-ARI pasture field in which four separate (approximately one-acre) plots (8m x 15m) each was demarcated with 3m inter-plot spacing to separate the plots and to allow vehicle movement between the plots for collection of harvested forage for feeding animals. To clear off pre-existing weeds from the field, it was sprayed with non-selective post-emergence herbicides (glyphosate) with the trade name Sunphosate 360 SL (Zhejiang Xinan chemical Industrial group Co. LTD, China) at a rate of 200 mls into 600 L of water per hectare (1 ml: 3 L of water) one week before ploughing was done. The plots were then harrowed to get smooth surfaces for the planting. The plant spacing was 40 cm within rows and 60 cm between rows (Omotoso et al., 2018). The data on the pigeon pea was collected in two cropping seasons; it was harvested and the field cleared and replanted in the second year. Seeds were planted on each plot same day on 28th June, 2021 for the first year and plants harvested completely as fodder for animals and cleared after sampling in 2021 cropping season. The field was re-prepared following the same procedure as in year one and the pigeon pea seeds planted on 30th June, 2022 for the second-year data collection. The field was sprayed with pre-emergence herbicides (Atrazine powder, Agrocrown company limited, Shanghai-China) immediately after the planting was done in each year as a way of controlling early weed emergence in the field.

Data Collection and Analysis

The pigeon pea forage yield data was collected at different harvesting ages after planting for both first and second year (2021/2022). These harvesting periods were 100, 120 and 140 days after planting. At each collection period, four samples were collected in each plot. The parameters considered were; plant height at harvest, plant population per square metre (to see the plant establishment in each plot), fresh biomass yield, dry matter yield and crude protein content determined in the laboratory. At each harvesting age, four random square meters were harvested in each plot. Plant height was measured from the base to the tip of the plant with a measuring tape and recorded in meters whereas the plant population within a meter square was counted and used to extrapolate the plant population per hectare by multiplying the plant population per meter square by 10,000 to obtain plant establishment in each plot. To determine fresh and dry matter yields, the forage was cut at 5 cm above ground level within one metre square area randomly in each plot to estimate the forage yield. The fresh biomass harvested was weighed with an electronic scale to estimate fresh biomass yield after which sub-samples were taken to laboratory for dry matter and crude protein determination. The fibre fractions (Neutral detergent fibre, Acid detergent fibre and hemicellulose) were not determined due to resource constraints but literature values of previous similar work have been provided (Table 4) to improve reader understanding of the subject matter studied.

All the four fresh sub-samples from each plot were pooled into one sample per plot in each harvest and oven-dried at a temperature of 60^{o}C for 48h to determine the dry matter weight of the forage samples in the nutrition laboratory of CSIR-SARI (CSIR - Savannah Agricultural Research Institute) in Nyankpala. The temperature of 60^{o}C for 48h was chosen to prevent the escape of some component of protein that may lead to under estimation of the crude protein level of the forage samples (Hove et al., 2003). The crude protein content of the forage samples was determined by using micro-Kjeldahl method, where total nitrogen content was predetermined and the crude protein content obtained by multiplying the percentage of total nitrogen by 6.25 as done in all plant material crude protein determination (AOAC, 2005).

The data collected was analyzed in ANOVA using GenStat 12th edition (VSN International Ltd, 2009). The two planting seasons and three harvesting ages served as fixed factors and the other parameters such as plant population, plant height at harvest, forage fresh and dry matter yield and crude protein content of forages as variable factors. Differences of means were determined using Fisher's protected least significant difference test at $P<0.05$ levels.

RESULTS AND DISCUSSION

Monthly rainfall amount and distribution recorded for the 2021 and 2022 rainy seasons at CSIR-SARI's weather station, which is about one km distance from the experimental fields is presented in figure 1a and 1b. In 2021 rainy season, there was wide distribution of the rainfall starting from March and ended in November than in 2022, where the rainfall ended in October (Figure 1a). The amount of monthly rainfall was however, higher in 2022 compared to the values recorded in 2021. The higher monthly rainfalls led to higher annual percentage of rainfall in 2022 than 2021 as illustrated in Figure 1b.

The agronomic parameters measured and other data taken on pigeon pea are presented in Tables and Figures for easy comprehension of readers. The germination and establishment of the pigeon pea was statistical uniform in all the experimental plots with no differences ($P>0.05$) in plants population per hectare (ha) during the three harvesting ages (Table 1). The plant height at harvest did not show statistical difference ($P>0.05$) too. However, significant differences ($P<0.001$) were observed in biomass yield among the harvesting ages. The dry matter yields obtained at different harvesting ages were 8.09, 5.95 and 3.59 tonnes DM ha^{-1} for 100, 120 and 140 days of plants age at harvest respectively (Table 1), with each mean value significantly higher than the other from 100 days to 140 days harvest. The results obtained on dry matter yield in this study showed a decreasing trend as the days after planting increased from 100 to 140 days. This is contrary to an increasing biomass yield trend of 3.175 tonnes DM/ha and 6.515 tonnes DM/ha reported at pigeon pea harvesting age of 84 and 140 days after planting respectively (Tenekwa et al., 2022). The differences in trend seen here is attributable to the early harvesting age of 84 days after planting when the plant would have been actively growing, but at 100 days the pigeon pea would have gotten to or close to its maximum vegetative growth stage and will start to flower after which it begins to lose leaves.

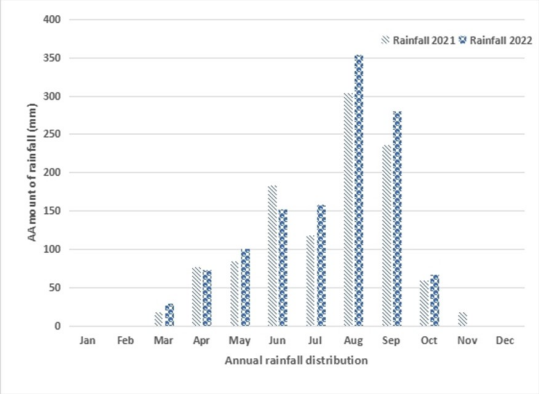


Figure 1a: Monthly amount and distribution of rainfall in 2021 and 2022 rainy seasons

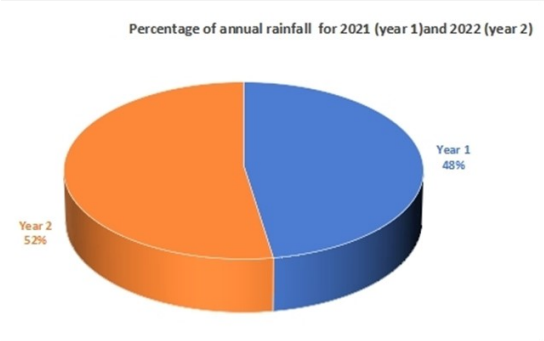


Figure 1b: Two years percentage annual rainfall recorded in 2021 and 2022 rainy seasons

The dry matter yield values obtained in this study at 100 days harvest is comparable to the 8.96 tonnes DM/ha reported by Omotoso *et al*. (2018) but 120-days and 140-days harvest are lower than their value obtained in similar pigeon pea forage dry matter yield experiment in Nigeria. Differences observed could be due to better soil health and agronomic practices followed (Karbo et al., 1998; Agyare et al., 2002). The dry matter yield showed a decreasing trend as the plant advanced in age from 100 days to 140 days of harvest. The crude protein content of the biomass harvested at 140 days of plant age was significantly lower ($P=0.001$) than the mean protein content of the 100 and 120-days harvest of the *Cajanus caja*n forage. This suggested that at 100 up to 120 days of plant age, the quality of the forage as feed is not affected except slight decrease in dry matter yield associated with loss of plant leaves. These trend of values in dry matter yield and crude protein content indicates that the

period from first to second harvesting ages of 100 to 120 days is good phase for harvesting pigeon pea as forage in order to obtained maximum forage yield in terms of dry matter and good crude protein content as observed in this study. Similar observation was reported by Tenekwa et al., 2022 that showed an increased in neutral detergent fibre (NDF) value from 478 g/kgDM at first cutting age of 12 week after planting to 485 g/kg DM at second cutting age of 16 weeks after planting and then declined to 434 g/kg DM at third cutting age of 20 weeks after planting (Table 4) which is the same as the 140 days of harvesting in this study. The acid detergent fibre (ADF) composition in the stem of pigeon pea that influences forage digestibility did not change from first to second cutting signifying that the quality of the forage was same between first and second harvest (Table 4) but increased significantly at the third cutting age at 20 weeks after planting. The increased in fibre content of the forage has the potential of reducing the forage digestibility (Chand et al., 2022) and therefore lowering the forage quality when harvested late.

The crude protein content values of 39% and 34% for 100, 120 days of the pigeon pea forage harvest respectively, obtained here are higher than the range of 21 – 30% crude protein content reported in pigeon pea forage by Amaefule and Onwudike (2000), but 28% value for 140 days harvest fell within their reported range. They further emphasized the importance of pigeon pea forage as a source of high protein feed for ruminant animals, which agrees with the assertion of Corriher et al., 2007 that pigeon pea supply high quality protein to ruminant animals.

On comparative performance of the forage between the two years, most of the *Cajanus cajan* agronomic and biomass yield parameters did not vary from year one (2021) to year two (2022) growth in the same field (Table 2). The plant establishment as in plant population/ha (164,167 plant/ha) in year one was however, significantly higher ($P<0.05$) than the value of 122,500 plant/ha in year two. Also, crude protein content of the dry matter harvested was 37.14 % in year one and higher ($P<0.05$) than 30.61 % obtained in year two (Table 2). The higher plant establishment in year one more than that of year two was associated with wide distribution of the rainfall in year one compared to year two as shown in figure 1a. It has been asserted by other researchers that plants establishment during the rainy season is a function of the amount and distribution of the rainfall in that season (Negi et al., 2024; Griffin et al., 2021).

There was significant ($P=0.009$) two-way interaction effect between year and age of plant at harvest on plant population/ha (Table 3). Significant ($P=0.05$) interaction was also, observed between year and plant harvesting age on dry matter yield of the forage. The interaction effect on these two parameters observed in this study came as a result of variations in rainfall amount, distribution and duration in the two planting seasons. It has been reported that, insufficient rainfall in the first two months of planting *Cajanus cajan* can affect its establishment and growth, and consequently affect forage yield negatively (Valenzuela, 2011). An irrigation measure may be required to avert the negative performance (Valenzuela, 2011).

Tenakwa *et al.* (2022) reported a comparatively higher dry matter yield (6.52 tonnes DM /h) of same *Cajanus cajan* plant harvested at 140-days (20 weeks) after planting than 3.59 tonnes DM ha^{-1} in this study and also the lowest (4.12 tonnes DM ha^{-1}) dry matter yield for plants harvested at 12 weeks (84-days) far less than 8.09 tonnes DM ha^{-1} obtained here, and further stated that the 84-days period was immature date for harvesting. The results of this study did not follow a similar pattern as the 100-days harvest gave higher forage yield than the 120 and 140-days' harvest. The differences may be associated with wider harvesting dates of 84-days when plants were not at its maximum vegetative growth stage and 140 days when plants could have been fully matured with decreased accumulation of dry matter in plant biomass (Hidosa et al., 2020) due to loss of leaves. The values obtained in this study fell within the reported range of 20 – 40 tonnes DM /h (FAO, 2016). It has been reported that dry matter yield of forage is greatly affected by climatic conditions (Gezahagn et al., 2016), which might have resulted in the lower dry matter yield in this study as it did not get to upper limit of 40 tonnes DM / ha reported by FAO (2016). Hidosa *et al*. (2020)

Table 1: Growth performance, forage yield and crude protein content of *Cajanus cajan* at different ages of harvest

Parameter	100 days	120 days	140 days	SEM	PV
Fresh yield (tonnes /h)	23.75[c]	17.25[b]	13.25[a]	1.691	<.001
Dry matter yield (tonnes /h)	8.09[c]	5.95[b]	3.59[a]	0.304	<.001
Plant height at harvest (m)	1.911	1.994	2.407	0.2047	0.057
Plants population /h	150,000	116, 200	163,800	2.425	0.16
Ash %	4.83	5.7	5.36	0.518	0.273
Crude Protein %	39.18[b]	34.33[b]	28.11[a]	2.259	0.001

Mean with different superscripts in the same row are significantly different at P<0.05, SEM= Standard error of mean, P V = Probability value

Table 2: Growth performance, forage yield and crude protein content of *Cajanus cajan* in year two

Parameter	year 1	year 2	SEM	PV
Fresh yield (tonnes/h)	18.67	17.5	1.381	0.409
Dry matter yield (tonnes/h)	5.68	6.08	0.248	0.123
Plant height at harvest (m)	2.058	2.15	0.1672	0.59
Plants population /ha	164,167	122,500	19,802.3	**0.05**
Ash %	5.36	5.23	0.423	0.772
Crude Protein %	37.14	30.61	1.845	**0.004**

SEM= *Standard error of mean, P V = Probability value*

Table 3*:* An interaction effect of year and harvesting age on agronomic parameters, biomass yield and crude protein content of *Cajanus cajan* as a forage

		Parameters					
Years	**Harvest age (days)**	**FBY Tonnes/ DM/ha**	**DMY Tonnes/ DM/ha**	**Plant height at harvest (m)**	**Plants pop. /h**	**Ash %**	**CP %**
Year I	100	24.25	8.18[d]	1.747	220,000	5.44	41.81
	120	19.5	5.93[c]	1.987	107,500	5.51	37.86
	140	12.25	2.92[a]	2.44	165,000	5.12	31.76
Year II	100	23.25	8.01[d]	2.075	80,000	4.21	36.55
	120	15	5.98[c]	2	125,000	5.89	30.8
	140	14.25	4.25[b]	2.375	162,500	5.59	24.47
SEM		2.392	0.431	0.2895	34,299	0.732	3.195
P V	harvest	<.001	<.001	0.057	0.16	0.273	0.001
	Year	0.123	0.409	0.59	0.05	0.772	0.004
	H x Year	0.186	0.05	0.606	0.009	0.222	0.887

Mean with different superscripts in the same column are significantly different at P<0.05,
SEM= Standard error of mean, P V = Probability value, CP= Crude protein, H= Harvest, pop. = population

Table 4: Fibre composition of *Cajanus cajan* at different cutting regimes on dry matter basis (g/kgDM)*

Cutting regime	Botanical fraction	NDF	ASH	ADF	HEM
C12 (184 days)	Leaf	478	70[a]	298[d]	172.8
	Stem	599.8	45[d]	466.6[b]	133.2
C 16 (112 days)	Leaf	485.3	55[c]	330.1[c]	155.2
	Stem	622.6	60[b]	462.3[b]	160.4
C 20 (140 days)	Leaf	434	60[b]	292.5[d]	141.5
	Stem	631	45[d]	495.1[a]	135.9
Sed		13.23	0.05	6.57	16.1
P values	cutting regime	0.019	<.001	0.023	0.25
	fraction	<.001	<.001	<.001	0.21
	cutting x fraction	0.351	<.001	0.02	0.26

*Means in the same column with different superscript are significantly different at P <0.05, NDF = Neutral Detergent Fibre, ADF = Acid Detergent Fibre, HEM = Hemicellulose, C= cutting age after planting in weeks, * Tenkwa et al., 2022*

asserted that lower dry matter yield of forages could be attributed to the variety of pigeon pea planted. They further argued that, if forage variety has been screened and bred for many years for increase dry matter yield and other forage quality the yield will normally be higher than the land-races. In this study the pigeon pea variety planted was not a variety developed for forage yield but just a collection of the local germplasm from farmers. The collection of these land-races for planting may be the reason for the low dry matter yield values obtained. If these land-races are screened for few years purposely for forage production, the dry matter yield could be increased higher than this current results.

CONCLUSION AND RECOMMENDATIONS

Harvesting of *Cajanus cajan* at the various harvesting ages yielded good quality forage, however, harvesting at 100 days after planting recorded higher forage dry matter yield and crude protein content compared to the other days in the Savannah ecological climatic conditions. The best period to harvest the pigeon pea forage is between 100 to 120 days after planting to obtained maximum forage yield in terms of dry matter and high-quality crude protein content. More work needs to be done on the establishment of other *Cajanus cajan* varieties in order to obtain the best performing varieties for fodder production in the Savannah zone for ruminant production. If land-races are screened for some few years purposely for forage production, in terms of dry matter yield and protein content it could increase feed availability.

REFERENCES

Ahamefule, F.O., Ibeawuchi, J.A. and Ibe, S.N. (2006). Nutrient intake and utilization of pigeon pea-cassava peel-based diets by WAD bucks. Pakistan Journal of Nutrition 5, 419-424

Amaefule, K.U. and Onwudike, O.C. (2000). Comparative evaluation of the processing methods of pigeon pea. Journal of Sustainable Agricultural Environment, 1, 134-136.

Amole, T. A. (2016). Improving livestock productivity: Assessment of feed resources and livestock management practices in Sudan-Savanna zones of West Africa. *African journal of agricultural research*.

AOAC. (2005). Determination of Moisture, Ash, Protein and Fat (AOAC (ed.); 18th ed.). Official Method of Analysis of the Association of Analytical Chemists. https://www.scirp.org/(S(lz5mqp453edsnp55 rrgjct55.))/reference/referencespapers.aspx?referenceid=1788579

Buthelezi, L., Mupangwa, J., & Washaya, S. (2022). Fodder production and chemical composition of pigeon pea [*Cajanus cajan* (*L.*) millspaugh] varieties grown in the Subtropical Region of South Africa. *Tropical and Subtropical Agroecosystems*, *25*(2).

Chand, S., Indu, Singhal, R. K., & Govindasamy, P. (2022). Agronomical and breeding approaches to improve the nutritional status of forage crops for better livestock productivity. *Grass and Forage Science*, *77*(1), 11-32.

Cheva-Isarakul, B. (1992). Pigeon pea as a ruminant feed, Asian Australasian Journal of Animal Sciences, vol. 5, no. 3, pp. 549–558,

FAO, 2016. Grassland Index. A searchable catalogue of grass and forage legumes. FAO, Rome, Italy.

FAO, FAO Statistical Databases (FAOSTAT), FAO, Rome, Italy, 2008.

Griffin-Nolan, R. J., Slette, I. J., & Knapp, A. K. (2021). Deconstructing precipitation variability: Rainfall event size and timing uniquely alter ecosystem dynamics. Journal of Ecology, 109(9), 3356-3369.

Hidosa, D., Kibret, S., & Belachew, B. (2020). Evaluation of Pigeon pea (Cajanus cajan) for dry matter yield, and chemical composition on station of Jinka Agricultural Research Center, South Omo, South-Western Ethionpia. "*American Eurasian Journal of Agriculture and Environment*, 20, 129-136.

Hove, L., Ndlovu, L. R., & Sibanda, S. (2003). The effects of drying temperature on chemical composition and nutritive value of some tropical fodder shrubs. *Agroforestry Systems*, *59*(3), 231-241.

Ibrahim, K. H., & Usman, L. A. (2021). Management practices of pasture, range and grazing reserves for livestock production in the tropics: A Review. *Am. Entomol*, *5*(2), 18.

Mart´ınez-Villaluengaa, C., Torresb, A., Friasa, J. and VidalValverde, C. (2010). Semolina supplementation with processed lupin and pigeon pea flours improves protein quality of pasta volume, LWT–Food Science and Technology, vol. 43, no. 4, pp. 617–622,

Omotoso, O. B., Fajemisin, A. N. and Ogunshola, O. J. (2018). Effects of spacing, cutting height and cutting interval on fodder yield and nutritional value of cajanus cajan. *International Journal of Environment, Agriculture and Biotechnology (IJEAB)* 3: 3. http://dx.doi.org/10.22161/ijeab/3.3.14

Rabia S., and Ying, W. (2018). "A review article on health benefits of Pigeon pea (Cajanus cajan (L.) Millsp)," International Journal of Food and Nutrition Research, vol. 2, p. 15.

Shah, A. M., Zhang, H., Shahid, M., Ghazal, H., Shah, A. R., Niaz, M., ... & Zhao, H. (2025). The vital roles of agricultural crop residues and agro-industrial by-products to support sustainable livestock productivity in subtropical regions. *Animals*, *15*(8), 1184.

Sloan, J., Heiholt, J. and Iyer, H. (2009). Pigeon Pea: A Multipurpose, Drought Resistant Forage, Grain and Vegetable Crop for Sustainable Southern Farms, SARE Research and Education Project, Annual Report, Feedipedia-Animal Feed Resources Information System, Lubbock, TX, USA, 2009.

Speranza, C. I., Kiteme, B. and Wiesmann, U. (2007): Droughts and famines: The underlying factors and the causal links among agro-pastoral households in semiarid Makueni district, Kenya. *Global Environmental Change*. *DOI: 101016/j.gloenvcha. 2007. 05.001*

Tenakwa, E. A., Imoro, A. Z., Ansah, T., & Kizito, F. (2022). Pigeon pea (Cajanus cajan) fodder cutting management in the Guinea Savanna Agro-Ecological Zone of Ghana. *Agroforestry Systems*, *96*(1), 1-10.

Valenzuela, H. (2011). Pigeon pea: A multipurpose crop for Hawaii. The food Provider, March-April-May edition, 1(8).