

Evaluation of *Cajanus cajan* (Pigeon Pea) Genotypes for Agronomic Parameters, Yield and Nutritional Composition at Lowland Areas of Eastern Hararghe Zone, Ethiopia

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Abstract

The study was conducted at lowland of Fedis district during 2018 and 2019 growing season to evaluate the performance of eleven improved pigeon pea genotypes for agronomic yield and nutritional composition. The study revealed that there were no significant differences among pigeon pea genotypes in terms of days to flowering and maturity. However, significantly higher dry biomass and grain yields were obtained. Grain yield ranged from 1,200 kg ha⁻¹ to 3,030 kg ha⁻¹ with 16524 having the highest and 11575 had the lowest grain yield. Herbage dry matter yield ranged from 2 to 4.4 t/ha. Genotype 16524 had the highest herbage dry matter yield (4.4 t/ha). Leaf to stem ratio of local check was ($p < 0.05$) lower than 11563 genotype but similar to the remaining tested genotypes and seed yield of 16528 genotype was lower than 16524 genotype but similar to the remaining tested genotypes. The crude protein (CP %), ASH%, neutral detergent fiber (NDF %), acid detergent fiber (ADF %) and Acid detergent lignin (ADL %) were significantly ($p < 0.05$) different among genotypes. However, dry matter (DM %) was not different ($p > 0.05$) among genotypes. It was concluded that genotype 16524 had performed best most agronomic parameters, biomass yield, seed yield and LSR as compared to the other tested genotypes and adapted check. Thus, it was found promising to be promoted or demonstrated in Eastern Oromia under climatic conditions similar to Fedis.

Keywords: Pigeon pea, Genotypes, Dry matter, nutritional composition

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1. Introduction

The productivity and sustainability of the livestock industry is influenced by technical and socioeconomic factors. One of the major constraints to increasing livestock productivity in this region is the feed supply, followed by animal health and management practices. Poor animal nutrition and productivity arising from inadequate supply and low quality feed are among the major constraints facing livestock production in developing countries (Fekede *et al.*, 2015b). Similarly, feed shortage in terms of both quantity and quality is the leading problem affecting the livestock productivity in Ethiopia (Fekede *et al.*, 2015a). Nutritional factors are the binding constraint to sustaining livestock production in Ethiopia. According to the Country Feed Balance (FAO, 2018) “The difference between availability of feed resources as dry matter (DM), ME and CP and the requirements of all animal species (i.e. feed balance) showed that feed deficiency in Ethiopia is 9 per cent as DM, while ME and CP deficiencies are 45 per cent and 42 per cent deficient respectively”. These numbers clearly show the lack of quality feed. Thus integration of livestock and cropping systems is essential for sustainable natural resource management and improved livestock productivity (Alemayehu *et al.*, 2017). The production of adequate quantities of good quality forages, better nutrition, genetics, and the combination of these strategies, are the only way to economically overcome the feed shortage and improve milk/meat production in Ethiopia (Mayberry *et al.*, 2017).

The increased utilization of leguminous and other tree and shrub species, fed as a high quality supplement to the low quality natural pastures and crop residues, has been recognized as one of the means of improving the forage supplies to ruminants in pastoral and crop-livestock systems. Pigeon pea (*Cajanus cajan* L.) is an important grain legume in Eastern and Southern Africa, Asia and Central America. In Africa it is mostly grown by subsistence farmers in the semi-arid areas due to its drought tolerance (Khaki, 2014). In Ethiopia, pigeon peas (*Cajanus cajan*) is known as lowland pulse crop which grows in areas where there is high temperature, erratic rainfall, and short growing season (Amsalu *et al.*, 2016). Pigeon pea is hardy, warm-season, drought tolerant, widely adaptable and tolerant to temperatures as high as 35°C (Vittal *et al.*, 2004). An average annual rainfall of between 600 and 1000 mm is most suitable for pigeon pea production (Green Harvest, 2013). The crop can be grown in a wide range of soil textures, from sandy soils to heavy clays; and is well suited for soil with pH range of between 4.5 and 8.4 (Singh and Oswalt, 1992).

The crop is a multi-purpose leguminous crop that plays important role in food security, maintenance of soil fertility through litter fall and nitrogen fixation, provision of fodder for livestock, source of protein, cash income and fuel for small-scale farmers in subsistence-agriculture (Wilson *et al.*, 2012). It is an important grain

legume, particularly in rain-fed agricultural regions in the semi-arid tropics, as well as an excellent, high-protein cover/forage for livestock (Pal *et al.*, 2011) which can be intercropped or grown in mixed cropping systems with cereals or other short duration annuals (Joshi *et al.*, 2001). The main products of pigeon pea are dry grain, green pods and fodder (Mergeai *et al.*, 2001). The leaves and immature stems can be cut and used as a green manure (OAF, 2015). However, this fodder tree was not available in Eastern Oromia; where livestock is greatly dependent on crop residues for feed and the farmers usually harvest fodder from thinned crop plants, weeds, and defoliated leaves. Although this improved fodder tree showed high potential under different research centers, their performance in the study area was not documented. Although pigeon pea can adapt well under drought conditions there is a great variability of different genotypes for yield under the drought conditions (Deshmukh and Mate, 2013). Therefore, the study was conducted to determine the performance of different pigeon pea genotypes and to select/identify the high yielding genotype (s) in dry matter yield and nutritional qualities suited at lowland agro-ecologies of Eastern Oromia.

2. MATERIALS AND METHODS

2.1. Description of the study area

The study was conducted under rain-fed conditions during 2018 and 2019 growing season at Fedis Agricultural Research Center, on Boko station. It is 550 km to the East of Addis Ababa and 24 km southeast of Harari city. The experimental site is situated at an altitude of 1500m above sea level, (Fuad *et al.*, 2018). The amount of rainfall varies between 650 and 750 mm, while the average temperature ranges between 25 and 30 °C (Zenna, 2016). Vertisols and *Afilsols* soil type are common to the area (FARC, 2013).

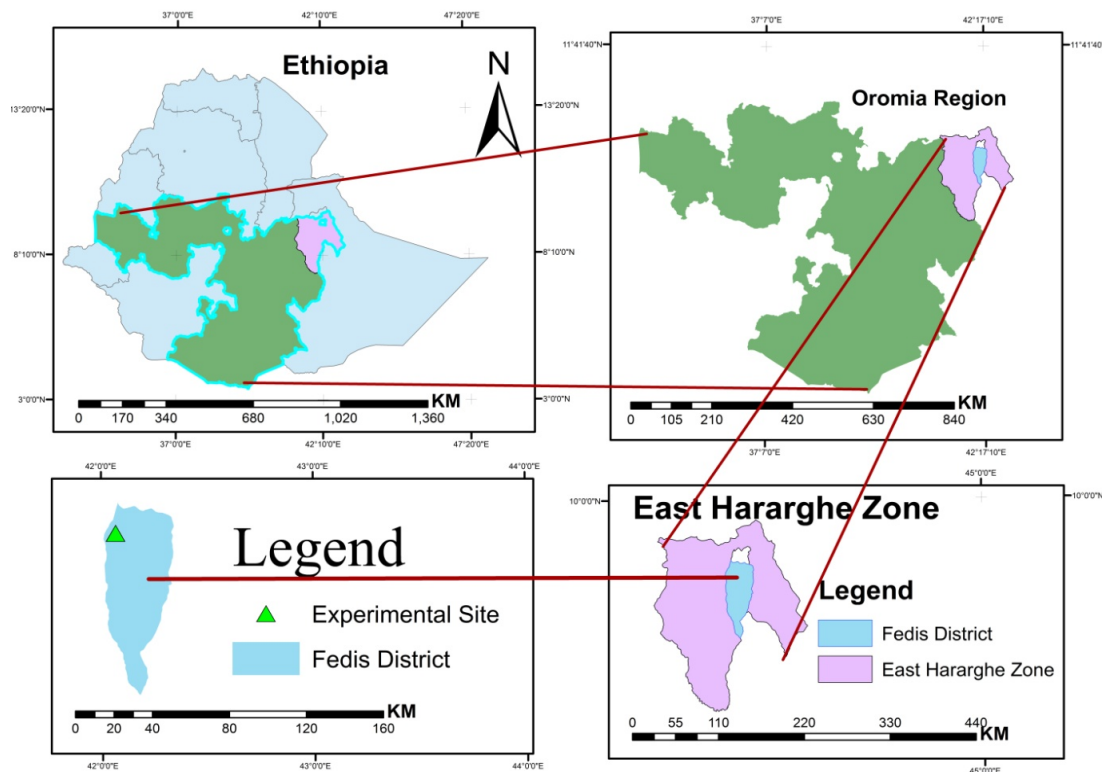


Fig. 1. Map of the experimental site

2.2. Experimental Design and Treatments

The experiment was conducted using randomized complete block design consisting of 3 replications. The plots were 3.75 m² each with a space of one meter from each plot and with a spacing of 0.75 m between rows. The plot size consisted of four rows of 3 m long and inter and intra row spacing of 0.75 x 0.5 m, respectively. The seeds of ten pigeon pea accessions (16555, 16526, 16527, 11575, 16524, 16528, 16520, 11566, 11563 and 16537) were obtained from international livestock research institute (ILRI) and one local check used. Land was ploughed and harrowed, and then two to three seeds of pigeon pea were planted per hole. Seedlings were thinned down to one plant per hole to ensure uniform plant stand per hole. Weeding was done when necessary. Neither fertilizer nor herbicide was applied to the plots.

2.3. Data collection

Days to flowering, plant height and biomass yield were collected when the plants attained 50% flowering. Data were collected from the two middle rows from each plot. The total harvest per two rows of leaf and stem fresh biomass was weight and about 500g of sub sample taken from each plot and chopped in short length for dry matter determination, and also for laboratory analysis. Sub-samples of air-dried harvested forage were bulked and taken to the Nutrition Laboratory of Haramaya University for analysis of dry matter (DM %), ASH%, crude protein (CP %), neutral detergent fiber (NDF %), acid detergent fiber (ADF %) and Acid detergent lignin (ADL %).

The height of plant at each plant was measured by measuring all the samples harvested for dry matter determination and the average height of all the plants taken as a height of plant at each plant. Seed yield and days to maturity were sampled when the pods attained physiological maturity. Seed yield and days to maturity were sampled when the pods attained physiological maturity.

Statistical Analysis

Data was analyzed using the Statistical Analysis Software to perform ANOVA (SAS 9.1) in a randomized complete block design. Means of all treatments were calculated and the difference was tested for significance using the least significant difference (LSD) test at $p < 0.05$ (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

Agronomic Yield Performance of Pigeon Pea Genotypes

The mean agronomic yield performance of pigeon pea genotypes evaluated was shown in table 1. Results showed that, there was significant difference ($P < 0.05$) in some of the genotypes evaluated. Analysis of variance showed significant difference ($P < 0.05$) in leaf and stem dry matter yield among the tested genotypes. The highest leaf dry matter (4.4 t/ha), stem dry matter (38.9 t/ha) and seed yield (3030 kg/ha) were recorded from 16524 genotype, whereas genotype 16528 resulted in the lowest leaf dry matter yield (2 t/ha). Increase in dry matter and seed yield might be attributed to more number of branches and number of pods per plant (Rani and Reddy, 2000; Lal and Raina, 2002). The significant differences in those yield components are further explained by Islam and Fakir (2007) that canopy structure, canopy spreading and degree of branching influences most of the yield components such as number of pods per plant. The significant differences were also might be due to reaction of different landraces in temperature and photoperiod. The photoperiod and temperature effects on flowering and plant canopy development in pigeon pea make agronomists to choose cultivars that adapt and perform well to specific climatic conditions (Silim *et al.*, 2005).

The study showed that there were no significant differences ($P > 0.05$) among pigeon pea genotypes in terms of days to flowering and maturity. Almost all the genotypes tested in this study were found to be short duration genotypes which took 10-150 days to reach physiological maturity. However, significant differences ($P < 0.05$) were observed among genotypes for plant height. Pigeon pea genotypes in this study were generally tall, probably due to influence of exposure to long-day conditions and environment (Egbe and Vange, 2008). The difference in plant heights might be also due to sensitivity to photoperiod among genotypes whereby they reacted differently and exposure to long day condition and temperature sensitivity among genotypes. This is evidenced by Robertson (2001), that genotypic differences are influenced by the temperature in terms of plant height. The results also indicated that leaf to stem ratio of local check was ($p < 0.05$) lower than 11563 genotype but similar to the remaining tested genotypes and seed yield of 16528 genotype was lower than 16524 genotype but similar to the remaining tested genotypes. Significantly lower seed yield was obtained by 16528 genotype, whereas the remaining genotypes not different ($p > 0.05$) in seed yield. In general, genotypes 16524, 11563 and 16537 performed better than local check in most agronomic and yield parameters. The highest herbage dry matter yield performance of 16524 genotype revealed that this genotype is better adapted and performed well as compared to the tested genotypes.

Table 1. Agronomic and yield performances of pigeon pea genotypes tested at Fedis during 2018 and 2019 growing season

Genotypes (treatments)	DF	PH(cm)	LDM t/ha	SDM t/ha	SY kg/ha	DM	LSR
16555	103.7	168cd	2.7b	25.6abc	2510ab	152.3	10.57ab
16526	98.3	169.7bcd	2.8b	26.9abc	2200ab	146	10.4ab
16527	98.3	193.4a	2.8b	34.3ab	1870ab	142.7	8.3ab
11575	108	181ab	2b	21.6bc	1200b	148	9.2ab
16524	111	180.8ab	4.4a	38.9a	3030a	151	12.1a
16528	109.3	143.4f	2b	26.2abc	1270b	142	8.8ab
16520	95.7	163.6df	2.7b	27.3abc	2260ab	144.7	10.1ab
11566	109.3	128.1g	2.3b	21.8bc	1730ab	144.3	10.43ab
11563	103.7	176.5bc	3.06ab	26.1abc	2290ab	148	12a
16537	95.3	152.8ef	2.96ab	27abc	2330ab	145.3	10.87ab
Local check	107	178.8bc	2.8b	38.92a	2280ab	184.3	7.9b
Grand mean	103.61	166.91	2.789	27.75	2.0885	146.67	10.309
CV (%)	12.32	4.46	32.38	31.84	31.99	4.75	21.95
LSD (0.05)	NS	12.681	0.737	7.15	1.49	NS	1.847

Means with the same letter in the same column are not significantly ($p < 0.05$) different. DF= days to flowering, PH=plant height, LDM= leaf dry matter, SDM=stem dry matter, SY=seed yield, DM= day to maturity, LSR=leaf to stem ratio, NS = none significant. LSD = Least significant difference; CV = coefficient of variance

Chemical composition of Pigeon Pea Genotypes

The chemical compositions of eleven pigeon pea genotypes are presented in table 2. The crude protein (CP), ash neutral detergent fiber, acid detergent fiber and acid detergent lignin were significantly ($p < 0.05$) different among genotypes. However, dry matter (DM %) was not different ($p > 0.05$) among genotypes. In the current study, genotypes 11566 and 16524 had significantly higher crude protein content than 16555, 16528 and 16520 genotypes. However, except with these three genotypes the crude protein content of the remaining genotypes was almost similar to 11566 and 16524 genotypes. Significantly the higher ash content was obtained by 16528 and 16527 genotypes whereas the lower content was observed by 11575 and 16555 genotypes.

Contents of NDF was also significantly different ($P < 0.05$) among the evaluated pigeon pea genotypes. The higher NDF was recorded for 16520 and 16528 followed by 16555 genotype while the lower value was observed by 16524 and 11563 genotypes. Similarly, significantly the higher ADF was obtained by 16528 and 16520 genotypes where as the lower value was observed from 11563 genotype. Content of ADL also significantly varied ($P < 0.05$) among genotypes, where significantly higher value was recorded for 11575, 16520, 12.936 and 16528 genotypes and significantly lower value was obtained by the remaining tested pigeon pea genotypes.

In general, genotype 16524 showed significantly higher herbage dry matter and seed yield performance. Moreover this genotype had higher nutritional qualities as compared to the tested pigeon pea genotypes.

Table 2. Herbage Chemical composition of Pigeon pea genotypes

Treatments	DM%	Ash %	CP%	NDF%	ADF%	ADL%
16555	92.422	9.075d	19.234b	63.182ab	36.712c	10.842b
16526	92.33	10.164b	21.78ab	58.606cd	33.22e	11.576b
16527	92.882	10.425ab	21.015ab	57.285d	36.215cd	11.326b
11575	92.212	8.954d	21.94ab	56.643de	41.351b	13.076a
16524	92.45	10.232b	23.282a	48.955f	33.96de	10.705b
16528	92.011	10.706a	19.136b	64.972a	44.411a	12.784a
16520	92.223	9.656c	19.113b	64.985a	43.865a	13.214a
11566	92.324	9.456c	23.578a	61.013bc	33.747e	11.361b
11563	92.427	10.335b	22.01ab	45.612f	30.343f	11.453b
16537	92.625	9.419c	21.799ab	57.629cd	40.115b	11.231b
Local check	91.739	9.454c	21.675ab	53.745e	40.208b	12.936a
Grand mean	92.331	9.807	21.324	57.51	37.65	11.844
CV (%)	0.69	1.41	6.96	2.69	2.86	3.98
LSD (0.05)	NS	0.138	1.48	1.55	1.0765	0.472

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level. DM = dry matter, CP = Crude protein, NDF= neutral detergent fiber; ADF = acid detergent fiber; NS = none significant. LSD = Least significant difference; CV = coefficient of variance

4. Conclusions

The study shows that genotype 16524 performed best in biomass and seed yield and had high nutritional qualities among the tested genotypes. These results suggested that pigeon pea has the potential to provide forage of high quality and adequate quantity for livestock when other summer forages are unproductive. Hence, genotype 16524 is recommended for promotion in lowland environments of East Hararghe zone. Moreover, future research should be focused on breeding programs to identify extra short duration pigeon pea and evaluate its yield potential in lowland areas of Eastern Hararghe zone.

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