

Adaptation Trial of pigeon pea (*Cajanus cajan*) varieties in low land areas of Bale Zone South East Ethiopia

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Abstract

The shortage of livestock feed are major constraints in Ethiopia particularly in lowlands of Bale Zone in terms of quality and quantity through a year. A study was conducted at Sinana Agricultural Research Center (SARC), South East Ethiopia for Three consecutive cropping season (2020/21-2022/23) in two locations (Delo Menna sub-site and Ginnir on farm) to evaluate the adaptability of Five Varieties of *Pigeon pea* (Belabas, Degagsa, Dursa, Kibret and Tsegab). Experimental plots were laid out in a randomized complete block design with three replications. All varieties were performed well. However, there is significant variation among the varieties of *Pigeon pea*. The combined result over locations over years indicated that, Belabas Followed by Gegagsa Varieties gives the highest leaf fresh biomass yield (6.1 t ha^{-1}) and (5.7 t ha^{-1}), leaf dry biomass yield (1.87 t ha^{-1}) and (1.95 t ha^{-1}) respectively. In addition to biomass yield Belabas and Degagsa varieties of pigeon pea had obtained higher in plant height (145.87 cm and 149.97 cm) and leaf to stem ratio (2.65 and 2.57) respectively. Based on the results of this study, it is concluded that the *Pigeon pea* Belabas and Degagsa varieties were found a promising in terms of all major parameters than others. It is concluded that Belabas and Degagsa varieties to demonstrated and popularized as an alternative feed resources under smallholder conditions in the study areas and with similar climatic and conditions of lowlands of Bale Zone

Keywords: Cajanus cajan, Improved Forage, livestock feed

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1. Introduction

Feed is the most important input in livestock production and its adequate supply throughout the year is an essential prerequisite for any substantial and sustained expansion in livestock production (Samuel *et al*., 2008; Legesse *et al*., 2010). Animal feeds including; natural pasture, fodder crops, fodder trees, crop residues and non-conventional feeds are used in different parts of Ethiopia (Sefa, 2017). Green fodder (grazing) is the major type of feed (54.59%) followed by crop residues (31.60%), hay (6.81%) and industrial byproducts (1.53%) (CSA, 2017). Feed in terms of both quantity and quality is bottleneck to livestock production in Ethiopia (Alemayehu *et al*., 2017). This problem of feed shortage is more aggravated during the dry season (Zewdie, 2010).

Pigeon pea (*Cajanus cajan L.*) ranked sixth globally after peas, broad beans, lentils, chickpeas, and common beans Samuel *et al*., 2008). Globally, it is cultivated on a 5.4 million hectare land area with an annual production of 4.49 million tons. It is grown in about eighty-two countries in the world. India accounts for about 72 m^2 of the area grown for pigeon peas Legesse et al., 2010). In Africa (Eastern and Southern), pigeon pea is grown on 0.56 million hectares (Sefa, 2017). Pigeon pea is an important crop in Malawi, Kenya, Uganda, Mozambique, and Tanzania. It is generally cultivated in association with yam, millet, sorghum, and cassava, among other crops CSA, 2017)

Pigeon pea offers great potential as an economic crop in the economy of some nations, and it constitutes their major cash crop, especially in India and Malawi Alemayehu *et al*., 2017) It does not only serve as protein for both humans and livestock but also is very useful in the pharmaceutical industry as medicine (Zewdie, 2010).. Additionally, it is useful in food processing due to its ability to be processed into many forms, such as biscuits, noodles, cookies, our, and bread, among others (Gwata and S. N. Silim, 2009), thus making it to be highly relevant economically. It is highly attractive to smallholder farmers of rural areas in many developing countries such as Nigeria (Kaoneka *et al*., 2016). Pigeon pea can be a source of income for men and women and function as feed for livestock, fencing material for rural dwellers, and uniquely serve as food during the lean period with little or no value addition Ayenan *et al*., 2017).

The shortage of green forage throughout the year is the major constraints of livestock production in lowlands particularly in study area. So that in order to solve this critical problem in the area adapted and generated the alternative technologies e.i improved multipurpose forage trees. However, improved forage varieties were not well adopted in country; particularly in the study area. Therefore, the objective of this study was to select high biomass yield Pigeon pea for lowlands Bale Zone and similar agro-ecologies

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in Low lands of Bale and East Bale Zone, from Bale Zone in Dello Mena Sub site that lies latitudes 5°51' N and 6°45' N, and longitudes 39°35' Eand 40°30' E that 555 km far from Addis Ababa at southeast and 125 km from Robe City to south with the altitude ranges from 1314 to 1508 m.a.s.l. The mean annual rainfall of the area 819.3mm

From East Bale Zone in Ginir Woreda latitude of 7° 04' 60.00" N longitude 40° 39' 59.99" E on farm and 516 km far from Addis Ababa and 118.2 km from Robe City to Southeast with the altitude ranges 1750 to 1986 m.a.s.l and the mean annual rainfall of the area 864.3m (Mehadi *et al.*, 2016).

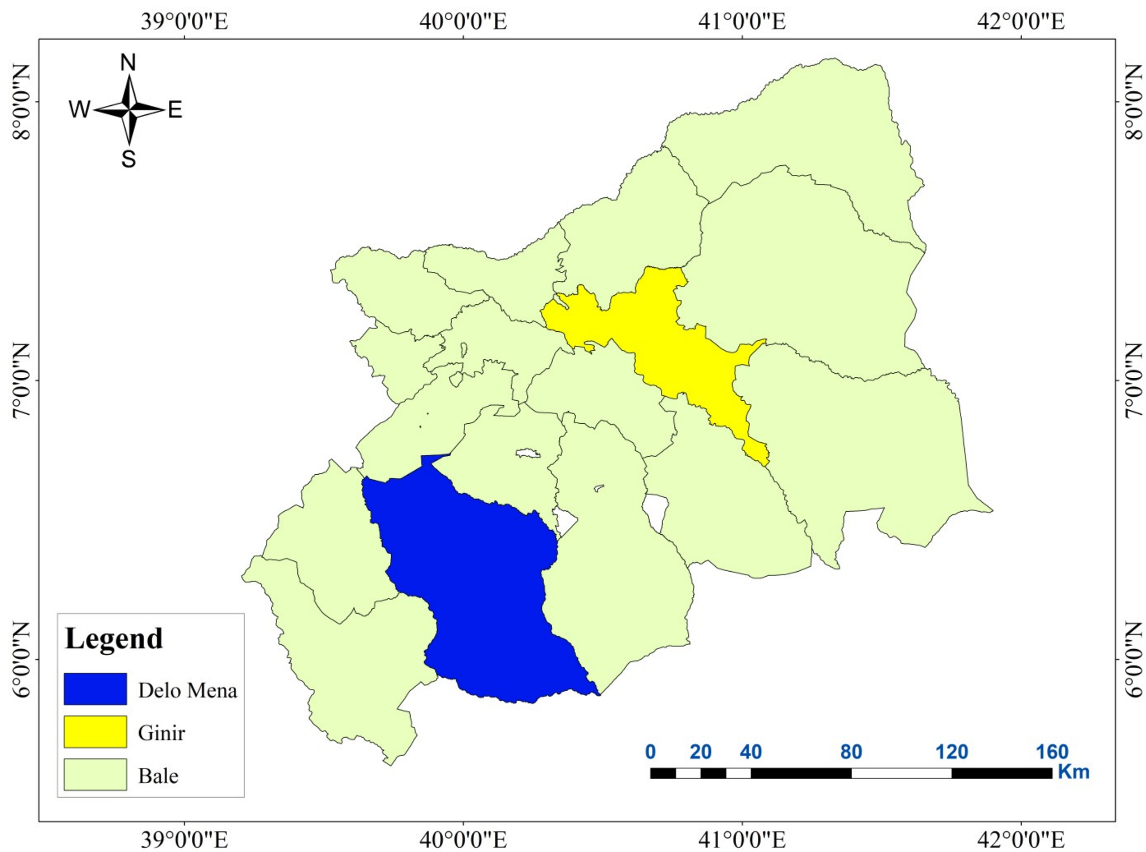

Fig 1. Map of the study areas Delo Menna and Ginir Woreda

2.2. Experimental Materials, Treatments and Experimental Design

Randomized Complete Block Design (RCBD) with three replications was used. Plot size of 6 m x 3 m^2 was used. A total of five (5) Varieties of Pigeon pea were evaluated. Seed was sown to well-prepared arable land at spacing of 1m between plants and 1.5 m between rows. Weeding and Hoeing was done accordingly.

Plant height: it was measured at 50% flowering stage when Biomass was taken from ground to tip of the plant from five randomly taken plants from middle rows and was averaged on per plant basis by using 5m scaled meter.

Dry Leaf biomass and stem weight: it was taken after chopping into 5 cm - 8 cm length of 500g samples and then oven dry at 35 ^{o}c for 48hrs weight and then converted tone per hectare based The dry matter production (t ha-1) was calculated as: - (10 x TotFWx (DWss/ HA x FWss)) (Tarawali et al., 1995). Where: TotFW = total fresh weight from a plot in kg, DWss = dry weight of the sample in grams, FWss = fresh weight of the sample in grams, HA = Harvest area meter square and, 10 = is a constant for conversion of yields in kg /m^2 to t ha^{-1}

2.3. 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).

Statistical model was: $Yij = \mu + \tau i + \beta j + \varepsilon ijk$, where μ = the overall mean, τi = the treatment effect ith, βj = the block (replication) effect of jth replication and ∈ijk = error effect

3. RESULTS AND DISCUSSION

3.1. Growth parameters, yield components and yields

The results analysis of variance indicated significant different for Fresh biomass yield, Dry herbage yield plant height of the five varieties over two sites is shown in Table 1. major parameters; such as total pant height, total dry biomass and Leaf dry biomass yield were significantly affected by the variety, location, and year with a significant interaction, so data for individual locations in each year are presented

Table 1. Mean squares of ANOVA for yields and yield components of Pigeon pea

Source of variations	DF	Mean squares							
		PHt (cm)	Ser.Rat (%)	LFBMY (t ha^{-1})	LDBMY (t ha^{-1})	SDW (t ha^{-1})	TotDBMY (t ha^{-1})	LSR	SY (Qu ha^{-1})
Rep	2	215**	2.782**	0.19148	0.19148**	1.9476**	0.0309	0.3638	76270**
Trts	4	4401**	23.919**	3.46735**	3.46735**	1.0521**	4.4714**	2.1257**	74487**
Yrs	1	8467**	41.75**	1.75393**	1.75393**	0.6574**	38.7408**	79.7872**	919853**
Loc	1	162597**	305.33**	7.01431*	7.01431**	53.0642**	3.7251**	20.5434**	1359754**
TRts*Yrs	4	587**	0.262NS	0.12152NS	0.1215**	0.1269**	0.2728	0.6767NS	13747**
Trts*Loc	4	1433**	14.438**	1.93475NS	1.93475**	0.6553**	3.5668**	0.9743*	63606**
Years*Loc	1	4967**	39.417**	0.20274NS	0.20274**	0.0671**	52.5062	75.5108**	60478**
Trts*Yrs*Loc	4	777**	0.31NS	0.05326NS	0.05326**	0.0533*	0.2751NS	0.5849NS	20873**
Error	68	26	0.183	0.01828	0.01828	0.0201	0.2033	0.3223	1426
GM		134.16	4.9632	1.5216	1.5216	1.426	2.1808	2.0929	453.77
CV		3.77	8.63	8.89	8.89	9.95	20.67	27.12	8.32

Where, *, **: Significant at 5% and 1%, respectively. DF: Degree of freedom, LDBMY: leaf herbage yield in Dry mater

Plant Height

Plant height is a major factor contributing towards forage yield of different crops. The data showed that there was significance ($p < 0.05$) variation among varieties (table 2). The study result obtained the maximum plant height of 219.67 cm was recorded from Belabas at Delo Menna location Followed by Degagsa variety (207.67 cm) at Delo Menna while the minimum plant height of 90.5cm and 86.83 cm was recorded from Tsigab variety at Ginir location in first year and second year respectively. The combined overall Result the maximum plant height obtained from Delo menna sub site (170.97 cm) and the minimum plant height recorded from Ginnir on farm(97.35) might be due to the variations of among location, rainfall different and sites. The result was in line with (Teshale and Ketema, 2021, Ezeaku et al., 2016), but not agreed with the result obtained by (Denbela *et al.*, 2020)

Green Fodder Yield/fresh biomass

The result from this study revealed that the green fodder yield in table 2, the maximum fresh biomass yield obtained from Degagsa varieties (9.67 t ha^{-1}) Followed by Belabas varieties (8.67 t ha^{-1}) in first year at Delo

Menna location were as the minimum green fodder yield recorded from Tsigab variety at Ginnir loctatio(2.67 t ha^{-1}).

Table 2. The Mean of Growth parameters, yield components and yields of Pigeon pea at Dello Menna sub-site

	Dello menna/1st year								Dello Menna 2nd year						
Treatments	PHt (cm)	SR (%)	Leaf FBMY (t ha^{-1})	Leaf DBMY (t ha^{-1})	SDW (t ha^{-1})	Tot DBMY (t ha^{-1})	LSR	Seed Yield (t ha^{-1})	PHt (cm)	Leaf FBMY (t ha^{-1})	leaf DBM (t ha^{-1})	stem DW (t ha^{-1})	Tot DBMY(t ha^{-1})	LSR	Seed Yield (t ha^{-1})
Belabas	219.67a	77.78a	8.67ab	2.05ab	2.59	4.64	0.93ab	505.55b	164.53b	6.17b	1.71ab	2.27	3.98ab	0.93	338.88b
Degagsa	207.67b	75.00ab	9.67a	2.70a	1.97	4.6733	1.70a	656.11ab	179.0a	7.17a	2.30a	2.13	4.40a3	1.09	556.11a
Dursa	170.33c	65.74c	7.44bc	1.76b	2.3	4.06	1.02ab	655.00ab	124.53d	4.63c	1.67ab	2.17	3.82ab	1.02	388.33ab
Kibret	165.33c	70.37bc	7,00bc	1.83b	2.39	4.2167	0.66b	894.44a	160.73bc	4.87c	1.18b	1.93	3.11ab	0.66	527.77ab
Tsegab	166.00c	75.00ab	5.83c	1.28b	1.70	2.99	0.08ab	640.00ab	151.87c	4.14c	1.16b	1.47	2.63b	0.80	440ab
GM	**185.8**	**72.78**	**7.72**	**1.93**	**2.19**	**4.12**	**0.89**	**450.22**	**156.13**	**5.4**	**1.601**	**1.99**	**3.59**	**0.898**	**450.22**
CV (%)	**3.99**	**7.48**	**19.25**	**24.73**	**25.48**	**20.18**	**22.9**	**15.52**	**4.99**	**12.11**	**24.37**	**28.72**	**21.03**	**22.89**	**18.52**
LSD(0.05)	**4.28**	**3.14**	**0.86**	**0.39**	**NS**	**NS**	**0.42**	**131.97**	**4.49**	**0.38**	**0.35**	**NS**	**0.81**	**NS**	**92.33**
P Value	**< 0.001**	**0.01**	**0.0018**	**0.02**	**0.73**	**0.95**	**0.05**	**0.05**	**< 0.001**	**<0.00**	**0.03**	**0.64**	**0.04**	**0.24**	**0.03**

PHt=plant height in centimeter, SR=survival rate, FBMY(t ha^{-1})=fresh biomass yield tone per hectare, DW=dry weight, DBMY= dry biomass yield, LSR= leaf to stem ratio
(Means with the same letter (a, b, c) in a column for dry matter yield and plant height at 50% flowering stage are not significantly different (p>.05)

Table 2. The Mean of Growth parameters, yield components and yields of Pigeon pea at Ginnir on farm

	Ginnir/1st year								Ginnir 2nd year						
Treatments	PHt (cm)	SR (%)	Leaf FBMY (t ha^{-1})	Leaf DBMY (t ha^{-1})	Stem DW (t ha^{-1})	Total DBMY (t ha^{-1})	LSR	Seed Yield (t ha^{-1})	PHt (cm)	Leaf FBMY (t ha^{-1})	leaf DBM (t ha^{-1})	stem DW (t ha^{-1})	Tot DBMY(t ha^{-1})	LSR	Seed Yield (t ha^{-1})
Belabas	99.97ab	70.71b	4.783a	1.99a	0.92b	2.91a	2.13a	438.66	99.3a	4.78a	1.72a	0.79a	2.51a	2.18a	248
Degagsa	111.07a	65.61bc	2.99b	1.31b	0.80bc	2.11bc	1.79ab	456.34	102.17a	4.27a	1.37b	0.73b	2.10ab	1.88b	306.1
Dursa	91.2b	56.54d	1.96b	0.67c	0.49d	1.16d	1.44b	399.13	89.17b	1.96b	0.57d	0.49d	1.06c	1.16c	278.4
Kibret	103.83a	82.50a	4.43a	1.70a	1.14a	2.51ab	1.55b	427.67	99.43a	2.99b	1.34b	0.94a	2.28a	1.43bc	227.8
Tsegab	90.5b	62.96c	2.76b	1.10b	0.71c	1.81c	1.59b	340.33	86.83b	2.76b	1.00c	0.61c	1.61b	1.64b	350.8
GM	99.313	**67.66**	3.3847	**1.3533**	**0.8113**	2.099	**1.702**	**412.43**	**95.38**	**3.3513**	**1.2**	**0.7107**	**1.66**	**1.657**	**280.2**
CV (%)	10.58	**6.68**	28.23	**20.69**	**13.38**	18.41	**22.46**	**22.52**	**6.59**	**28.06**	**21.38**	**11.3**	**13.97**	**24.06**	**25.34**
LSD(0.05)	**6.07**	**2.61**	**0.55**	**0.16**	**0.063**	**0.22**	**0.22**	**NS**	**3.63**	**0.54**	**0.45**	**0.05**	**0.15**	**0.23**	**ns**
P Value	**0.0118**	**< 0.001**	**0.0001**	**< 0.001**	**<0.001**	**< 0.001**	**0.0375**	**0.053**	**0.007**	**0.002**	**<0.001**	**<0.001**	**0.0001**	**0.0022**	**0.13**

PHt=plant height in centimeter, SR=survival rate, FBMY(t ha^{-1})=fresh biomass yield tone per hectare, DW=dry weight, DBMY= dry biomass yield, LSR= leaf to stem ratio
(Means with the same letter (a, b, c) in a column for dry matter yield and plant height at 50% flowering stage are not significantly different (p>.05)

Leaf Dry biomass yield

Varieties over the two sites shown in Table 2. Leaf dry biomass yield was significantly variation ($p < 0.05$) among Varieties, location, and year with a significant interaction, the result revealed the maximum leaf dry biomass yield recorded from Degagsa Varieties(2.70 t ha^{-1}) followed by Belabas varieties(2.05 t ha^{-1}) at Delo Menna sub-site in first year (2020/21), the lowest mean fodder dry biomass yield was recorded in second year (2021/22) at Ginnir location from Dursa varietie(0.57 t ha^{-1}) (Table 2). For combined analysis mean of five varieties in (table 3) revealed that the maximum obtained from Belabas and Degagsa varieties (1.87 and 1.95 t ha^{-1}) respectively. The minimum combined mean obtained from Tsigab varieties (1.14 t ha^{-1}) and the combined result with locations; the maximum result obtained from Delo Menna sub-site (1.76 t ha^{-1}) and the minimum leaf dry biomass yield obtained from Ginnir on farm. Also the combined result with the years; in first year obtained maximum result(1.64 t ha^{-1}) than second(1.4 t ha^{-1}) and third years(-) this descending of biomass yield was might be due to drought occurred in low lands of Ethiopia particularly in Bale and East Bale Zone last two years. The result was in line with (Teshale and Ketema, 2021, Ezeaku *et al*., 2016), but not agreed with the result obtained by (Abuye *et al*., 2021)

Total Dry Weight

The combined mean result shown that over locations and over years in (Table 3) of total dry weight was significantly variation ($p < 0.05$) among Varieties of Pigeon pea. The maximum total dry weight were obtained from Belabas (2.65 t ha^{-1}), Degagsa (2.57 t ha^{-1}) and Kibret (2.19 t ha^{-1}) varieties and the minimum recorded from Tsegab(1.71 t ha^{-1}) and Dursa(1.79 t ha^{-1})

Leaf to Stem Ratio(LSR)

The combined mean result shown that over locations and over years in (Table 3) of total dry weight was significantly variation ($p < 0.05$) among Varieties of Pigeon pea. The maximum leaf to stem ratio were obtained from Belabas (2.48 t ha^{-1}) and Degagsa (2.32 t ha^{-1}) varieties whereas the the minimum LSR recorded from Tsegab(1.77) and Dursa(1.79) and Kibret(1.98) Varieties. This result partially agrees with the result reported by (Teshale and Ketema 2021). However not line with Debela et al 2020) might be due to location, stage of harvesting and year variation.

Table 3: The Combined Mean agronomic data, yield and yield components over location over years

Treatments	PHt (cm)	LFBMY (t ha^{-1})	LDBMY (t ha^{-1})	SDW (t ha^{-1})	Total DW (t ha^{-1})	LSR	SY (Qu ha^{-1})
Belabas	145.87a	6.0999a	1.87a	1.6414	2.65a	2.48a	382.38c
Degagsa	149.97a	5.7017ab	1.95a	1.4076	2.57a	2.32a	481.04ab
Dursa	118.81c	3.9993c	1.16c	1.3618	1.79b	1.92b	435.45bc
Kibret	132.33b	5.1418b	1.49b	1.6001	2.19ab	1.98b	531.31a
Tsegab	123.8bc	3.8733c	1.14c	1.1191	1.71b	1.77b	438.68bc
Grand Mean	**134.16**	**4.9632**	**1.5216**	**1.426**	**2.1808**	**2.0929**	**453.77**
CV (%)	**12.31**	**27.29**	**35.78**	**52.59**	**51.46**	**57.7**	**33**
LSD(0.05)	**9.3823**	**0.7819**	**0.3112**	**NS**	**0.64**	**0.32**	**86.42**
Locations							
Ginir	97.35b	3.3681b	1.28b	0.76b	2.01	1.68b	347.32b
Delo Menna	170.97a	6.5583a	1.76a	2.09a	2.36	2.51a	560.22a
LSD(0.05)	5.9339	0.49	1.97	0.4402	NS	0.44	54.655
Years							
1st year	142.56a	5.5531a	1.6425a	1.5	2.75a	1.61b	541.32
2nd year	125.76b	4.3733b	1.4007b	1.35	2.61b	2.75a	366.22
LSD(0.05)	**5.97**	**0.4945**	**0.1968**	**NS**	**0.4059**	**0.41**	**54.655**

Seed Yield

The combined mean result shown that over locations and over years in (Table 3) of Seed yield was significantly variation ($p < 0.05$) among Varieties of Pigeon pea. The maximum seed yield were obtained from kibret varieties (531.31 Qu ha^{-1}) Followed by Degagsa (481.04 Qu ha^{-1}) varieties whereas the minimum seed yield recorded from Belabas(382.38 Qu ha^{-1}) Varieties.

4. Conclusion and Recommendation

All varieties of pigeon pea were performed in the study areas in first year. However, there is significant variation among years and the varieties. The combined result over locations over years indicated that, Belabas and Degagsa Varieties give the highest leaf dry biomass yield, LSR and plant heights. the result indicated that the performance of pigeon pea decreased from year one to year three due to air conditions; shortage of rainfall so irrigation and ware supply during dry season is very important. Therefore; it is concluded that Belabas and Degagsa varieties were found a promising in terms of biomass yield so that belabas and Degagsa Varieties by water supply during dry period to demonstrated and popularized as an alternative feed resources in the study areas and with similar climatic

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