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Zeru Yimer
Pawe Research Center, Ethiopian Institute of Agricultural Research, P.O. Box, 25, Pawe, Ethiopia

Wasihun Yaregal
Pawe Research Center, Ethiopian Institute of Agricultural Research, P.O. Box, 25, Pawe, Ethiopia

Asnake Fikre
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT-Ethiopia), Addis-Ababa. International Livestock Research Institute, P.O. Box 5689, Addis Ababa, Ethiopia

Tulu Degefu
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT-Ethiopia), Addis-Ababa. International Livestock Research Institute, P.O. Box 5689, Addis Ababa, Ethiopia

Ganga Rao
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), P.O.Box:39063, Nairobi, Kenya

Corresponding Author:
Zeru Yimer
Pawe Research Center, Ethiopian Institute of Agricultural Research, P.O.Box, 25, Pawe, Ethiopia

Large-plot based performance evaluation of pigeon pea (*Cajanus cajan* L. Millsp.) Varieties for grain yield and agronomic traits under irrigation condition in Mandura District, North-West, Ethiopia

Zeru Yimer, Wasihun Yaregal, Asnake Fikre, Tulu Degefu and Ganga Rao

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Abstract
The experiment was conducted during the offseason at Mandura district, North-West, Ethiopia under irrigation condition with the objective, to test and evaluate the adaptability and performance of seven introduced ESA pigeonpea varieties for grain yield and other agronomic traits with standard check during 2017/2018 cropping season. The agronomic traits evaluated and tested were stand count at initial, days to flowering, days to maturity, plant height, and stand count at harvest, seeds per pod, seeds per plant, wilt score, hundred seed weight and usable grain yield per hectare. The evaluated materials showed three maturity class i.e. early, medium, and long durations. Among the tested materials, ICEAP-00557 scored the highest grain yield (2349 kg/ha), followed by ICEAP-00576-1 (1737 kg/ha), however, the standard check ICEAP-87091 score was comparatively inferior (1390kg/ha). At times there was great variability in the biomass of the varieties which deserves serious attention for the producers. Thus, it was suggested the existence of sufficient variability for key economic yield that gives an option for promoting for high socio-economic performance through adaptation and commercialization.

Keywords: Agronomic traits, *Cajanus cajan*, Maturity class, Performance, Pigeonpea

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millspaugh] is the sixth most important legume crop in the world. The top ten producer countries are India, Myanmar, Tanzania, Kenya, Mozambique, Malawi, Haiti, Uganda, Dominican Republic, and Nepal (Table 1). It is a tropical grain legume and is among important pulses grown for food, feed and soil fertility improvement. Apart from the use of grain, farmers make use of pigeonpea in various ways depending on their ethnic groups and locality [1]. Pigeon pea is fast growing, hardy, widely adaptable, and drought resistant [3]. The extensive root system of *Cajanus cajan* improves soil structure by breaking plow pans, and enhances water holding capacity of the soil. Though mainly cultivated for its edible seeds, *Cajanus cajan* can be considered a multipurpose species [10]. Pigeon pea stems are a good fuel source, valued for its fast growing habit though their energy value is half that of charcoal. Stems and branches of pigeon pea are also used for basketry. In Colombia, pigeon peas are cultivated for feed but once for beans and once for forage [4]. Medicinal uses of pigeonpea to treat ailments such as dizziness, snake bite, measles are determined by farmers' location and ethnic group [1].

It is often cross pollinated (20-70%) out crosses crop with 2n=2x=22 diploid chromosome number belongs to the family Leguminoseae. India is considered as the native of pigeonpea (Van der Maesen, 1980) because of its natural genetic variability available in the local germplasm and the presence of its wild relatives in the country [2].

Pigeon pea is a prolific seed producer: seed yield varies from 0.5 to 2 t/ha in the world [3]. World production of pigeon peas was 4.85 million t in 2014 [3].The main producers were India (3.29 million t, 65% of world production), Myanmar (0.57 million t), Malawi (0.3 million t), Kenya (0.28 million t), Tanzania (0.25 million t). Most of the production occurred in Asia (79.1%), followed by Africa (17.6%) and the Americas (2.5%) [3]. Even if there is no systematic scoring and national data base, in Ethiopia the crop is found distributed all over the geographies in North (Wollo), South East (Bale), Southern Region, Western regions and central parts of the country growing in patches and intercropped.

It has an estimated 30-45000 ha of land coverage (Asnake, field assessment observation). Pigeon pea is used as a contour hedge in erosion control [3]. An N-fixing legume does not need inoculation before sowing. However, rhizobial population nodulating *Cajanus cajan on the study area were phenotypically diverse and symbiotically effective* [5].

Pigeonpea research in Ethiopia started early in the 1970s by the Institute of Agricultural Research (IAR) at Nazret National Horticultural Centre, with short-duration cultivars introduced from Makerere University, the Dominican Republic and later from Guyana, IITA and ICRISAT-India (Amare Belay, personal communication). The pigeonpea improvement program started with germplasm introduction from ICRISAT and neighboring countries with the objective to identify high yielding, disease and pest tolerant cultivars [7]. Production in Eastern and Southern Africa (ESA) is however faced with many challenges [6].

Table 1: Global top ten pigeonpea producers in 2014

Country	Area (ha)	Production (t)	Productivity (kg/ha)
India	5,062,000	3,290,000	650
Myanmar	611,600	575,100	940
Tanzania	276,400	249,250	902
Kenya	276,124	274,523	994
Mozambique	248,000	120,979	486
Malawi	229,790	301,010	1309
Haiti	111,950	90,480	808
Uganda *	101,540	93,645	922
Dominican R	23,088	24,615	1066
Nepal	17,006	16,415	965

Source: FAO Stat 2014, TIA national surveys for Mozambique-2012, *2011 FAO

Metekel zone is potential for the production of major food crops, such as maize, sorghum, finger millet, rice and major pulses like common bean, soybean, mungbean, pigeonpea, and cowpea. So far, at national level, three pigeonpea varieties have been officially registered / released since 2009 either for feed or food. However, the production of seed pigeonpea in the current agroecological area is limited, due to shortage of widely adapted improved pigeonpea varieties, both biotic and abiotic factors, and limited scale up and/or popularization of pigeonpea varieties. Therefore, the evaluation of seven introduced pigeonpea varieties, particularly for the study area (mandura district) can be taken as one key step of tackling for the shortage of improved pigeonpea varieties and technologies.

2. Materials and Method

2. 1 Description of study area

Mandura district is located at, metekel zone, North-Western part of Ethiopia, with elevation of above sea level 1195 meter, It lies between 36^0 20.264′ East longitudes and 11^0 02.344 ′ North latitudes, with mean average temperature of 33.3 ºC and 15.3 ºC (maximum & minimum) respectively. It receives a maximum of 950 mm rainfall per annum. However, the rainfall pattern was uni-modal. The area is suitable for the production and/or cultivation of cereals and lowland crop species including pigeon pea. The land was sown corn last season (year): hence, crop rotation practice undertaken purposely. Site and associated environmental variables where pigeon pea genotypes tested were presented (Table 2).

Table 2. Site and associated environmental variables where pigeon pea genotypes tested

Site	Annual T º C Ranges	Annual rainfall ranges (mm)	Elevation in (M.A.S.L)	Major crops	Major Soil type	Latitude (‘º N)	Longitude (º E’)
Mandura	15.3 – 33.3	950 – 1150	1195	Maize, Soybean, Common bean, Sorghum, Finger millet	Clay loam	11^0 02.344	36^0 20.264′

2.2 Test materials

The performance evaluation of seven introduced pigeonpea genotypes was, received from ICRISAT, during 2017/2018 cropping season under irrigation condition. The materials were medium to late maturity types, however, the standard check, ICEAP-87091, was an early maturing variety (Table 3).

Table 3. List of experimental materials with their merits

No.	Variety name	Source	Special merit	Growth habit
1	ICEAP-00040	ICRISAT	Long duration	Indeterminate
2	ICEAP-00932	ICRISAT	Long duration	Indeterminate
3	ICEAP-00554	ICRISAT	Medium duration	Indeterminate
4	ICEAP-00068	ICRISAT	Medium duration	Indeterminate
5	ICEAP-00850	ICRISAT	Medium duration	Indeterminate
6	ICEAP-00557	ICRISAT	Medium duration	Indeterminate
7	ICEAP-00576-1	ICRISAT	Long duration	Indeterminate
8	ICEAP-87091(Check)	Ethiopia/ICRISAT	Short duration	Determinate

2.3 Measured parameters

Sowing of planting materials (entries) was conducted on December 08, 2017. All agronomic practices implemented properly. NPS fertilizer was applied at a rate of 25 kg per hectare. Frequency of irrigation was applied every seven days.

The agronomic characters/traits/ evaluated under this study were stand count at emergence, stand count at harvest, days to 50% flowering, days to 75% maturity, wilt disease score (1-3) Scale, plant height, pods $^{-1}$ plant, seeds $^{-1}$ pod, harvested usable grain yield $^{-1}$-hectare, hundred seed weight(g). The average numbers of seeds in a pod, pods per plant, seeds per plant, plant height (cm) were determined from randomly selected five plants per plot. For the rest of the cases, standardized experimental procedure was followed in scoring and sampling for parameters.

$$\text{Usable grain yield}^{-1}\text{ hectare (q/ha)} = \frac{\text{Usable grain yield}^{-1}\text{plot (g)}}{\text{(Net plot area)*(10)}}$$

2.4 Field layout and design

The experimental materials were laid out in non-replicated single plot design, with plot size of 5.0 meter *10.0-meter-long (50m^2), Spacing between experimental plots was 1.0 meter, spacing between planting rows was 1.0 meter, spacing between seeds/planting materials was 0.5 meter, and seed depth at planting was 3-5centimeters. The net plot area used for data generation was 3.0 meter * 10.0 meter long (30.0 m^2).

2.5 Data analysis and interpretation

Descriptive statistics was employed using Excel-2010 and XLSTAT 2014 in analyzing the parameters

3. Results and Discussion

The result of the simple statistics (descriptive) analysis revealed that there are high variabilities in economic yield among the tested pigeonpea genotypes. A yield variability of more than double magnitude was recorded in the test materials, which gave an opportunity in selecting best adapted materials for the test and similar agroecologies. Thus, highest usable grain yield was scored by ICEAP-00557 (2348.21 kg/ha) (Figure 1:) and (Table 4.). The result revealed the new super technologies had 153% advantage over the poor performing variety and 68% over the standard check Dursa (ICEAP-87091). The current result was among the highest score of pigeonpea globally (Figure 1:). In the other cases, the number of seeds per plant varied from 721.2 (ICEAP-00932) to 1281.2 (ICEAP-00850) (Figure 4:), the plant height ranged between 91.2 cm (ICEAP-87091) to 212 cm (ICEAP-00932). (Figure 5). Long to medium duration varieties had large value hundred seed mass (Table 4.) and [9].

Table 4: Descriptive statistics of quantitative characters

Characters	Range	Min.	Max.	Mean	SE	SD	CV %
Days to 50% flowering	9	109	118.00	116.00	1.101946	3.116774	2.69
Days to 75% maturity	27	124	151.00	141.75	3.004460	8.497898	5.99
Number of seeds per plant	560	721.2	1281.20	988.175	78.802596	222.88740	22.56
Plant height (cm)	120.80	91.20	212.00	174.025	12.867424	36.394573	20.91
Hundred seed weight	6	12.5	18.5	14.642857	0.80706910	2.13530414	14.58
Usable grain yield	1420.88	927.33	2348.21	1587.755	151.17104	427.57628	26.93

Note: Min = minimum, Max = maximum, SE = standard error, SD = standard deviation, CV = coefficient of variation

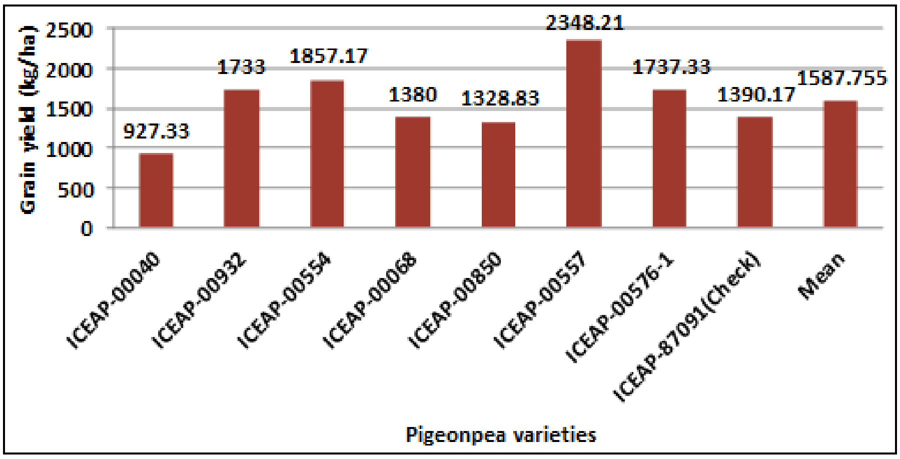

Fig 1: Usable grain yield (kg/ha)

ICEAP-00040, ICEAP-00932, ICEAP-00850, and ICEAP 00557 took 118 days to 50% flowering. However, ICEAP-87091 (Check) took 109 days to 50% flowering (Figure 2:).

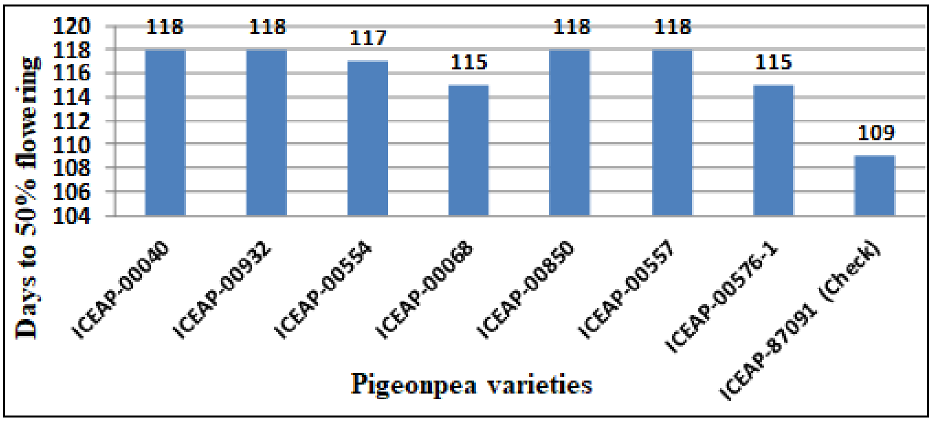

Fig 2: Days to 50% flowering

There was substantial difference for days to 75% maturity among the materials implying the materials grouped under short, medium and long duration types (Figure 3), and can be used in different resource areas. ICEAP-00040, ICEAP-00932, and ICEAP-00576-1 have took 151 days to 75% maturity (long duration), whereas ICEAP-00554, ICEAP-00068, ICEAP-00850, and ICEAP-00557 took 140 days (medium duration) (Figure 3). However, the check, Dursa (ICEAP-87091), took only 124 days to mature, which was an early type variety. Pigeonpea is an often-cross pollinated crop (20-70%) by agent of insects. 1

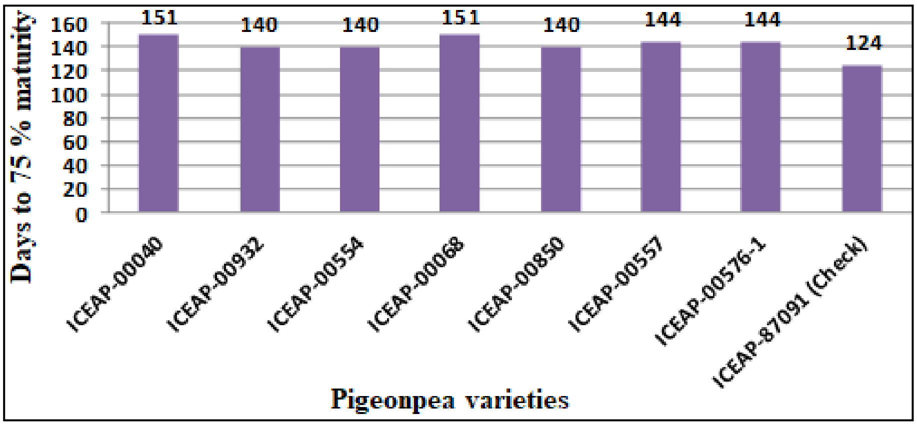

Fig 3: Days to 75% maturity

Disease score at early stage of the plant, using 1-3 scale, accordingly showed no high damage occurred, this indicated no severe attack by wilt disease during 2017 cropping season (Pigeonpea data 2018.xls). The genotype ICEAP 00040 consistently showed a high (<20.0%) level of resistance to the disease [8].

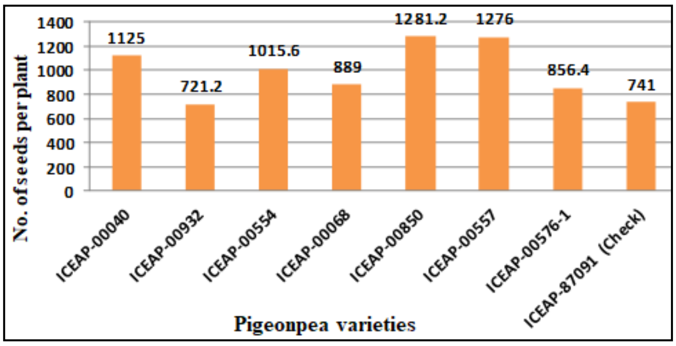

Fig 4: Number of seeds per plant

The medium to long duration matured varieties had high canopy, with large volume of biomass, proving pigeonpea as multipurpose plant, its leaves: sources of fodder, and nutrition, pod wall/seed coat: sources of feed, seeds, and food, etc.

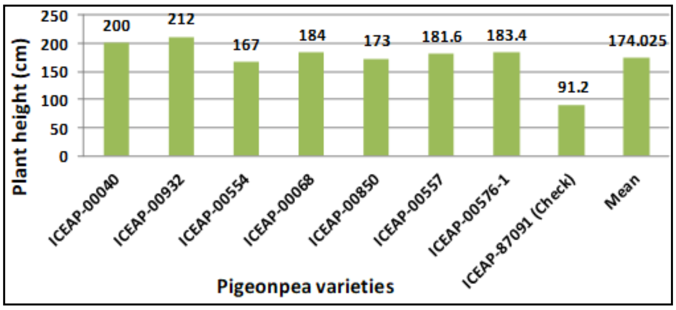

Fig 5: Pigeon pea varieties average plant height (cm)

The variation of stand count at harvest inICEAP-00040 was lower than others due to damage by wild animals at night however; any variation other than this was linked to initial seed germination (viability) (Pigeon pea data 2018.xls).

Fig 6: Pigeonpea variety adaptation trial field performance, Mandura district, 2018

Fig 7: High biomass performance of pigeon pea varieties, Mandura district, 2018

4. Conclusion

The current large plot based performance evaluation of East African released pigeon pea cultivars confirmed adaptation test can be applied for fast track technology promotion and adoption in the region. Based on the performance, at field condition variation occurred among the tested materials. Usable grain yield ranged from 927kg/ha (ICEAP-00040) to 2349kg/ha (ICEAP-00557), while the standard local check gave 1390kg/ha. A 68% yield advantage over the locally adapted cultivars is substantially feasible indicator of the test values for the new technologies. Due to multipurpose (food, fodder, feed, fuel, fence, soil fertility improvement, etc.) nature of pigeonpea; research and development work should be one part of lowland pulses research program. Pigeonpea genetic resource need to be exploited for further characterization and identification of useful traits in the crop improvement programs as commended [1].Therefore, we recommend the introduction, test validation and commercialization of public domain cultivars in different geographies for commercial production and future improvement of pigeonpea and its ultimate impact in the livelihood of farmers and stakeholders in the country.

5. Abbreviations
ESA: Eastern and Southern Africa
IAR: Institute of Agricultural Research
ICRISAT: International Crops Research Institute for the Semi-Arid Tropics
IITA: International Institute of Tropical Agriculture
NPS: Nitrogen, Phosphorus, and Sulphur

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