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Evaluation of Pigeon Pea Varieties and Cultivars for Soil Nutrient Addition and Fertility Level in Case of Fadis District of Eastern Hararghe Zone

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Abstract: The study was conducted at Fadis research station of Fadis district in the eastern hararghe zone during 2019, 2020 and 2021. Pigeon pea is a deep-rooted and drought tolerant grain legume that adds substantial amount of organic matter to the soil and has the ability to fix up to 235 kg N/ha and produces more N per unit area from plant biomass than many other legumes. Seven pigeon pea cultivars and four variety were used as treatment materials. The objective of study was to quantify amount of soil nutrient (N) obtained/fixed because of the pigeon pea cultivars or varieties. Treatments of the experiments were pigeon pea cultivars and variety, ELR16555, ILRI16526, ELR16524, ILRI 11575, Tsegas variety, Local, Danda'a variety, ELR 11566, Belabas, ELR 16537 and ELR 11563 respectively. The experiment was laid out in randomized complete block design with three replications of each. Data like Plant height, Total biomass, canopy area, soil sample before and after were collected and analyzed using SAS version 9.1 (SAS, 2002). Different Pigeon pea cultivars shows highly significant difference among the treatment in terms of plant height at 5% significance level. Different Pigeon pea cultivars and variety shows highly significant difference among the treatment in terms of plant height at 5% significance level (table 2). The highest plant height (331.5cm) was recorded from Belabas variety followed by Tsegas (308.6 cm) and Danda'a variety (294.4cm). On the other hand, ELRI 16555 cultivars shows the shortest plant height (213.0cm) followed by local check (221.7cm). The highest biomass (125000 kg/ha) was recorded from Tsegas variety and the lowest biomass (45000 kg/ha) was recorded from ELRI 16537 cultivars. The highest %OC, %TN and available phosphorus and CEC were recorded from the soil under the Tsegas pigeon pea variety followed by Belabas pigeon pea variety. On the contrary the lowest were recorded from ELR11575 and local check. Generally, from the result it is possible to conclude that the highest biomass yield and almost all of the highest desired soil parameters were recorded by Tsegas variety and it is possible to recommend for the farmers of Fadis District and similar agro- ecologies.

Keywords: Pigeon Pea, Soil Nutrient, Cultivars, Fixation, Variety, Soil Fertility

1. Introduction

Globally pigeon pea (Cajuns *Cajun* (L.) Millsp) is the fifth most important pulse crop mainly grown in the developing countries by resource-poor farmers in drought prone areas and on degraded soils. It is a multipurpose leguminous crop that can provide food, forage, fuel wood and fodder for the small-scale farmer in subsistence agriculture [4]. Pigeon pea is a deep-rooted and drought tolerant grain legume that adds substantial amount of organic matter to the soil [10] and has the ability to fix up to 235 kg N/ha [1] and produces more N per unit area from plant biomass than many other legumes. In a situation in which the farmer uses little or no fertilizer and the soil is very low in organic matter, the issue of transfer of N from legume to cereal assumes great importance. Nitrogen is an essential plant nutrient. It is the nutrient that is most commonly deficient in Ethiopian soils, contributing to reduced yields of crops in the country. Pigeon pea is a drought-tolerant leguminous crop with vast potentials for cultivation for food, feed, and fuel wood and as soil-

ameliorant [5, 6] had documented that pigeon pea fixe approximately between 37.52 – 164.82 kg/ha under intercropping with sorghum.

It has also been reported that long duration pigeon pea is one legume which has considerable potential to improve soil fertility when grown as an intercrop [20]. Biological nitrogen fixation has become very important not only because of its reduction of energy costs but also in seeking more sustainable way of crop production [3]. Also, the benefits of improving legume N fixation include reduced reliance on soil N, leading to more sustainable agricultural systems [13] and reduced requirements for fertilizer N, enhanced residual benefits to subsequent crops, and increased legume crop yields [11]. The main goal of this study is to enhance soil nutrients through sustainable way, improve soil fertility and the productivity of the intercropping systems with consequent enhancement of food security of the region. Not only for nitrogen fixing but also pigeon pea can be used as forage in eastern Hararghe zone. Thus why, this system/ practice can compensate/ solve the problem of low availability of forage for livestock in this low land area. For this sake, this activity is designed with the following objectives. To quantify amount of soil nutrient (N) obtained/fixed because of the pigeon pea cultivar or variety, to identify the best nitrogen fixing cultivar or variety and to recommend the best nitrogen fixer pigeon pea accessions.

Below are the objectives:

1) To quantify amount of soil nutrient (N) obtained/fixed because of the pigeon pea cultivar or variety.
2) To identify the best nitrogen fixing cultivars or variety.
3) To recommend the best nitrogen fixer pigeon pea cultivar or variety.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Fadis research station of Fadis district in the eastern hararghe zone, Oromia regional state. It is located in the eastern part of the country at 550 km from Addis Ababa the capital city of Ethiopia and 24 km from Harar town. The geographical location of the research station is and 9° 07’ 56.2” N and 42° 04’ 26.2” E. The altitude of the research station is 1698m above sea level. The district experience mean annual maximum and minimum rainfall, mean annual maximum and minimum temperature in the area were 850 to 650mm, 30.4°C, and 10.0°C, respectively. The soil of the study area was dominantly sandy clay soils.

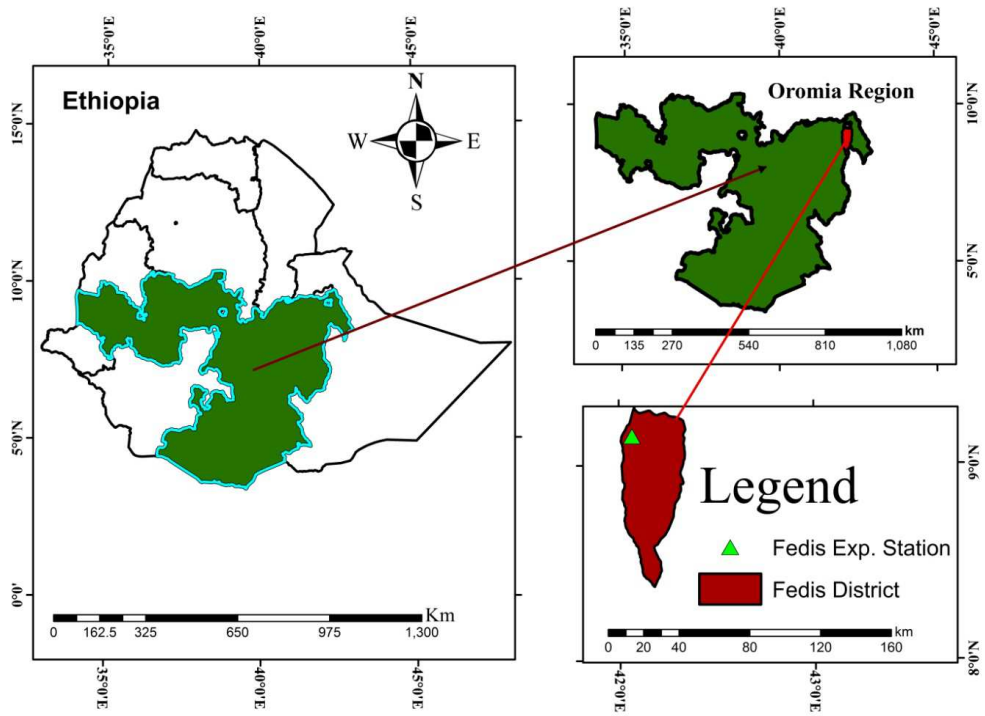

Figure 1. *Map of the study area.*

2.2. Materials Used for Treatments

Pigeon pea cultivars and varieties like ELR6526, ELR16526, ELR 11575, Tsegas Variety, local variety, Belabas, ELR 11566, Danda’a, and ELR1537 and ELR115663 were used as the treatments. And also materials like, strings, meters, rags and hoe were used for land preparation 3.2.1. Experimental design and Treatments.

2.3. Parameters and Testing Methods

The pH and Electrical Conductivity (EC) was analyzed using the - potentiometer (1:2.5) methods. And organic carbon was analyzed by using - Walkley and Black methods.

Total nitrogen - Kjeldahal method. Available phosphorus

by - Olsen method. Cation Exchange Capacity (CEC) and Exchangeable cations K was analyzed by - neutral 1M ammonium acetate, neutral 1M ammonium acetate (by flame photometer) respectively [19]. And Available K by - Morgan methods.

2.4. Experimental Design and Treatments

Design: RCBD with three replication of each

The experiment was laid out in randomized complete block design with three replications of each. And 4 m long and 3m wide plots (12 m^2), was used. Land preparation was done manually using traditional implements. Formula [12] was used for Estimation of N fixation and to determine the N-difference. The estimation of the apparent net amount of atmospheric N_2 fixed by legumes in short- and long-term cropping systems and used by [8].

$$N_2 = (L\text{-}M) + (fi - fm)$$

Where N_2 = amount of nitrogen fixed by systems; L = N harvested in a N_2-fixing legume; M = the amount of N in a non-fixing crop grown under the same condition as the legume; fi = soil N after the legume; fm = soil N under the non-N_2-fixing crop. Seven cultivars and four variety of pigeon pea were raised and the Space between plant and between rows were 0.5m and 1m respectively. And space between block was 1.5m. With three seeds per hole and later thinned to one plant/stand (26,667 plants /ha).

2.5. Treatments

Table 1. *Treatments of experiments.*

No	Treatments
1	ELR16555
2	ELR16526
3	ELR16524
4	ELR 11575
5	Tsegas variety
6	Local
7	Belabas
8	ELR 11566
9	Danda'a
10	ELR 16537
11	ELR 11563

2.6. Data Collection and Soil Sampling

Plant height, above ground biomass and canopy area was collected to determine treatment effect. The composite soil sample was collected from each experimental plot at depth of 0-20 cm in zigzag movement before planting and after harvest and analyzed for pH, TN, OC, Ec, Available P, Exchangeable K, Na, CEC and Soil texture. The samples were air dried, grinded and sieved at particle size of less than 2mm.

2.7. Data Analysis

Data were analyzed using SAS version 9.1 computer software and were [17].

Subjected to ANOVA to determine significant differences among factors and their interactions. Means were separated using LSD test. For all analyzed parameters, $P<0.05$ was interpreted as statistically significant.

3. Result and Discussion

3.1. Pigeon Pea Component

Table 2. *Combined mean of Plant height, Biomass and Canopy of three years as affected by different Pigeon pea verities and Cultivars.*

No	Treatments/ cultivars	Plant height (cm)	Biomass in kg/ha	Canopy Area in m² per plant
1	ELRI 16555	213.0^{d}	65000^{bcd}	0.73^{cde}
2	ELRI 16526	223.5^{cd}	55000^{cd}	0.73^{cde}
3	ELRI 16524	246.5^{c}	63333^{bcd}	0.97^{bcd}
4	ELRI 11575	285.8^{b}	50000^{cd}	0.99^{bc}
5	Tsigas variety	308.6^{ab}	125000^{a}	1.8^{a}
6	Local variety	221.7^{c}	58333^{bcd}	0.45^{e}
7	Belabas variety	331.5^{a}	88333^{b}	1.4^{ab}
8	ELRI 11566	285.1^{b}	63333^{bcd}	0.47^{e}
9	Danda'a variety	294.4^{b}	83333^{b}	0.33^{e}
10	ELRI 16537	230.9^{cd}	45000^{d}	0.53^{e}
11	ELRI 11563	227.3^{cd}	65000^{bcd}	0.34^{e}
	LSD	15.42	344.35	0.44
	CV (%)	6.7	28.4	32.8

3.1.1. Plant Height

Different Pigeon pea cultivars and variety showed highly significant difference in terms of plant height at 5% significance level (table 2). The highest plant height (331.5cm) was recorded from the Belabas variety followed by Tsegas (308.6 cm) and Danda'a variety (294.4cm) at P<.001, this was in statistical parity with ELRI 11575 and 11566 cultivars. On the other hand, ELRI 16555 cultivars shows the shortest plant height (213.0cm) followed by local chek (221.7cm) and ELRI 16526 (223.5cm). Plant height, canopy cover and biomass yield have direct relationship with soil organic matter and soil fertility. The highest plant and biomass yield it is, the highest organic matter it can accumulate and influence soil fertility. This result was in line with [16], states that, The higher plant height varieties had high canopy, with the large volume of biomass, proving pigeon pea as multipurpose plant, its leaves: sources of fodder, and nutrition, pod wall/seed coat: sources of feed, seeds, and food. Study [2] was also in line with the current study, who reported that the pigeon pea plant is a shrub with woody stems and has a height ranging from 50-500 cm.

3.1.2. Biomass

Different Pigeon pea cultivars showed highly significant difference among the treatment in terms of total biomass production at 5% significance level (table 2). The highest total biomass (125000 kg/ha) was recorded from Tsegas variety and followed by Belabas (88333^{b}kg/ha) and Danda'a variety (83333b kg/ha) Pigeon pea with large volume of biomass, proving as multipurpose plant, its leaves: sources of fodder, and nutrition, pod wall/seed coat: sources of feed, seeds, and food S. The lowest biomass (45000 kg/ha) was recorded from ELRI 16537 cultivars, this was statistical parity with the rest treatment except Tsegas variety. Robe Elema et al. [14] reported that, the

total fresh weight of pigeon pea showed an increasing trend across sites throughout three years from the constructed soil bund with integrated system as 8200kg/ha, 9620kg/ha, 13800kg/ha. S. Adjei-Nsiah [18] also reported that pigeon pea yielded about 25.5 tons of shoot biomass which have high nutrient quality and is used for livestock forage within 16 months.

3.1.3. Canopy Area

Different Pigeon pea cultivars shows highly significant difference among the treatment in terms of canopy area at 5% significance level (table 2). The highest canopy area (1.8 m^2 per plant) was recorded from Tsegas variety, this was statistical parity with ILRI 16528 cultivars. Pigeon pea form canopy after one year and shades out obnoxious weeds by suppressing their growth [18]. The lowest canopy area (0.33 m^2 per plant) was recorded from Danda'a, this was statistical parity with the rest treatment except Tsegas variety, ELRI 16524, ELRI 11575 and Belabas variety. Plant height, canopy cover and biomass yield has direct relationship with soil organic matter and soil fertility. The highest plant and biomass yield it is, the highest organic matter it can accumulate and influence soil fertility.

Table 3. *Soil analysis result of before experimentation.*

Treatments	EC Ds/m	PH H_2O	OC%	TN%	Available p	Available k	CEC	Exch. Na	textural class
Before Experiment	1.194'	7.95	1.35	0.078	1.2	400	19.08	0.484	clay

According to the result above (table 3), EC of the soil was fall under less alkaline range and the PH of soil was also in alkaline range. Organic carbon, TN% available p and k, and CEC of the soil before the experiment were falls under the low range.

3.2. Soil Component

Table 4. *Average soil sample analysis results of three years after experimentation.*

Treatments	EC Ds/m	PH H_2O	OC%	TN%	Available p	Available k	CEC	Exch. Na	textural class
ELRI1655	0.267	7.8	1.51	0.15	2.33	1250	47.05	0.26	clay
ELRI16526	0.269	7.9	1.52	0.15	1.84	1200	48.32	0.2	clay
ELR16524	0.268	7.8	1.56	0.22	2.01	900	47.61	0.22	clay
ELR11575	0.25	8	1.5	0.12	1.84	1500	47.38	0.2	clay
Tsegas variety	0.26	7.8	2.46	0.36	2.86	1500	50.92	0.15	clay
Local	0.283	8	1.53	0.12	2.61	1350	45.79	0.17	clay
Belabas variety	0.268	8	1.73	0.25	2.82	1700	48.89	0.2	clay
ELR11566	0.255	8	1.5	0.14	2.61	1500	48.64	0.22	clay
Danda'a variety	0.28	8	1.71	0.14	2.23	1800	48.12	0.2	clay
ELR16537	0.331	7.9	1.61	0.12	1.9	950	48.84	0.17	clay
ELR1163	0.276	8	1.51	0.12	2.06	1300	47.55	0.15	clay

3.2.1. Total Nitrogen

According to the laboratory result (table 2), the highest (0.36TN%) was obtained from Tsegas variety of pigeon pea, followed Belabas variety (0.25TN%). Pigeon pea can fix and add about to 235kg/ha N the soil, When compared to that of control (plot without pigeon pea) plot, pigeon can increase the total nitrogen of the soil by 0.282TN% than control. And also, the soil under the treatments of Tsegas variety showed good results in terms of EC, %OC, Available P, and Available and K, CEC by Belabas cultivars.

3.2.2. Soil Reaction

The soil pH is an important indicator of the level of plant nutrient availability in the soil. The initial pH of the study site before experimentation fall in moderately alkaline range. It's significantly improved from moderately alkaline to slightly alkaline due to regardless of Tsegas variety. The soil pH is an important indicator of the status of plant nutrient availability in the soil because of its positive and significant correlations with many of the plant nutrients. It had a strong and positive relationship of soil pH with exchangeable Ca, K and CEC and with extractable Mn, Cu and Zn [9].

3.2.3. Soil Organic Carbon (%OC)

According to the result (table 3), the highest soil organic carbon (2.46%OC) was recorded from the Tsegas pigeon pea variety followed by ELRI16528 (1.73%OC) and ELR11563 cultivars. On the other hands the lowest 1.35%OC was recorded from the absolute control (with no pigeon pea treatments, followed by ELR11575 (1.5%OC) and ELR11566 (1.5%OC) respectively. Based these result, pigeon pea can add about 1.11%OC and play a crucial role in soil organic matter restoration. The current study was in line with the findings of [7] who states that, pigeon pea can add substantial amount of organic matter to soil. And also according to [15], organic carbon build up is favored by conservation agriculture, standing biomass, long term harvested products and living biomass in the soil.

3.2.4. Cation Exchange Capacity (CEC)

The highest cation exchange capacity (50.92**)** of soil was recorded from the soil with Tsegas pigeon pea variety treatments followed by ELRI16528 (48.89) cultivar. On the other hand, the lowest CEC was obtained from absolute control without no pigeon pea cultivars. As showed in the result above (table 3), the CEC of soil was increased by

62.5% because of pigeon pea variety, since pigeon could be decomposed easily.

3.2.5. Soil Available Phosphorus

The highest available phosphorus was recorded from the soil under the treatments with Tsegas variety and ELRI16528 cultivar respectively. This was because of the up taken phosphorus by pigeon pea could return back to the soil through faster decomposition of pigeon pea's leaf, root, stems and branches. On the other hand, the lowest available P was obtained from the plot without pigeon pea (before experimentation). The variation of P across the pigeon pea cultivars might be attributed to the biomass and ability to extract insoluble p. this study was in agreement with the findings of [21] who states that, the highest available P was found when all lower branches were removed leaving upper 4 followed by leaving upper 6 branches on the main stem.

4. Conclusion and Recommendation

Generally, the highest plant height and total biomass was recorded from ELRI 16520 and Tsesgas pigeon pea variety respectively. The highest amount of TN% from Tsegas pigeon pea variety and ELRI16528 cultivar. Pigeon pea can increase, TN%, soil organic carbon, CEC, available P and improve soil fertility. The highest available phosphorus was recorded from the soil under the treatments with Tsegas variety and ELRI16528 cultivar respectively. This was because of the up taken phosphorus by pigeon pea could return back to the soil through faster decomposition of pigeon pea's leaf, root, stems and branches. The highest cation exchange capacity (50.92) of soil was recorded from the soil with Tsegas pigeon pea variety treatments followed by ELRI16528 (48.89) cultivar. On the other hand, the lowest CEC was obtained from absolute control without no pigeon pea cultivars. The initial pH of the study site before experimentation fall in moderately alkaline range. It's significantly improved from moderately alkaline to slightly alkaline due to regardless of Tsegas variety.

This study recommend that, Farmers, NGOs, research centers and universities, should use, Tsegas pigeon pea variety, for soil fertility management, for degraded land rehabilitation and as additional source of fertilizers (organic). Research extension should popularize Tsegas pigeon pea variety as both, soil nutrient fixer and animal feed, through demonstration and scaling up.

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