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Effects of Pigeon Pea (*Cajanus cajan*) Intercropping on Sorghum Crop Production and Soil Fertility Level in Case of Harari Regional State (Erer Research on Station)

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Abstract: The study was conducted during 2019 main cropping season at Erer research station Babile district PA. Globally pigeon pea (*Cajanus cajan* (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. 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). Harari regional state, farmers didn't accept drought tolerant sorghum variety, because of small harvests of total biomass. Thus why, pigeon pea sorghum intercropping can solve the problem of low availability of forage and low soil fertility in this low land area. The treatments of the experiments were, Sole sorghum (malkam) variety, Sorghum + Accession 16520, Sorghum + Accession 16527, sorghum +Accession 16528, pigeon pea Accession 16520, Pigeon pea Accession 16527 and Accession 16528 respectively. The design of the experiment was, RCBD with three replication. The result showed significant difference statistically, in terms of plant height, panicle length, and panicle diameter at 5% (table 1). The highest plant height was obtained from the treatment with sorghum intercropped with pigeon pea accession 16527 (tsegas variety). The result that obtained was statistically not significant in terms of grain yield ($p < 0.01$) among treatments (both sole and intercropped one). In (Table 1) was indicated that intercropping of pigeon pea Accessions had no negative significant effect on grain yields of sorghum. The maximum grain yields were obtained from T3 (sorghumX16527 pigeon pea accession); (2894) kg ha^{-1}), followed by T2 (16527 pigeon pea accession) (2856) kg ha^{-1} respectively. The minimum grain yield obtained from sole sorghum (2339 kg ha^{-1}). The most probable reason for this variation could be due to leguminous nature of pigeon pea accessions that add nitrogen nutrients to the soil and affect sorghum positively. When observed graphically, there is mean yield difference. Both land equivalent ratio and relative total yield was calculated and the obtained result is about 1.22. So this intercropped experiment is advantageous. Partial budget analysis was conducted and the experiment is economically viable.

Keywords: Pigeon Pea, Soil Fertility, Accession

1. Introduction

Globally pigeon pea (*Cajanus cajan* (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 [16]. 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 [4] and has the ability to fix up to 235 kg N/ha [14] and produces more N per unit area from plant biomass than many other legumes. The effects of intercropping on soil fertility vary with management practice. 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 [11]. Two types of beneficial effects have generally been reported: higher N content and/or higher grain yield of the intercropped cereal in comparison with the cereal alone without any added N. 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]. According to O. Adetiloye et al. and Egbe, O. M. [13, 5], 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 [3]. Cereal-legume cropping system show considerable promise in boosting productivity, helping reverse the decline in soil fertility [6, 8].

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 [7]. And also, [12] reported that benefits of improving legume N fixation include reduced reliance on soil N, leading to more sustainable agricultural systems and reduced requirements for fertilizer N, enhanced residual benefits to subsequent crops, and increased legume crop yields [9]. 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 Cajuns Cajan can be used as forage in Harari regional state [1]. In this area, farmers didn't accept drought tolerant malkam sorghum variety even though it is very promising crop for the area, because of its small harvests of total biomass. 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 deuto intercropping of Cajuns Cajuns, To improve soil fertility and increase production and productivity of the crop and land respectively and To identify economic feasibility of Cajuns cajan intercropping arrangement and recommend the best economic and sustainable intercropping arrangement.

Below are the Objectives:

1. To quantify amount of soil nutrient (N) obtained deuto intercropping of Cajuns Cajuns.
2. To identify good intercropping arrangement that cannot affect sorghum yield and give good yield of both crop.
3. To identify economic feasibility of Cajuns Cajan intercropping arrangement and recommend the best economic and sustainable intercropping arrangement.

2. Material and Methods

2.1. Description of Study Area

The agro-climatic condition of the area is semi-arid, arid. The annual maximum and minimum temperatures are 26 and 20°C, respectively. There is a short rainy season that lasts for about one and a half months and a long rainy season that lasts for more than two months. Even though, the rainfall pattern is not easily predictable and has shown yearly fluctuations. Due to the rainfall pattern, the *woreda* is considered food insecure. Though the area is moderately productive for agriculture, soil degradation, erratic rainfall and farmland fragmentation contribute to lowered productivity in the area. The *woreda* suffers from a food deficit every year.

The experiment was conducted at Babille district, Erer research station. Erer research sub site is located latitude of 09° 10' 41.5" north and longitude of 042° 15' 27.3" east, and the area is in the vicinity of extreme lowlands in the range of altitude of 1200 - 1300 meter above sea level. The area characterized by very short rainy season of 3 to 4 months (single quarter of the year), with all its intermittent condition and erratic distribution. The mean annual temperature was 24°C the soil is clay loam in texture and medium in organic matter content and high in exchangeable potassium.

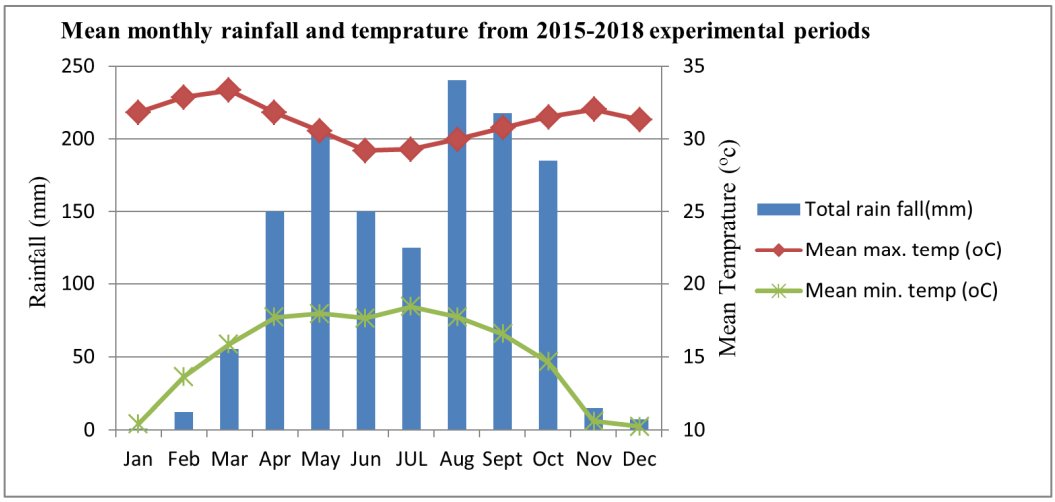

Figure 1. *Mean monthly rainfall and temperature during experimental period of Erer, based on 2015-2018 meteorological data at Fadis Agricultural Research Center.*

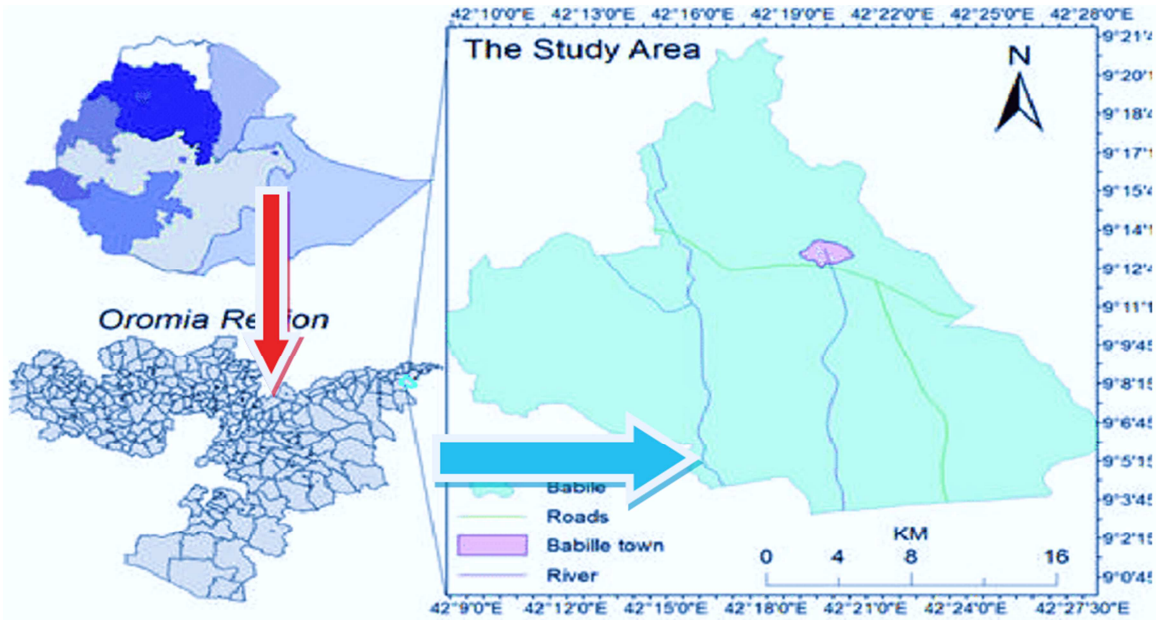

Figure 2. *Map representing the study area (Babille district).*

2.2. Experiment: Pigeon Pea/Sorghum Intercropping Treatments

T1. Sole sorghum (Bran / malkam variety)
T2. Sorghum +pigeon pea (Accession 16520)
T3. Sorghum intercropped with pigeon pea (Accession 16527)
T4. sorghum intercropped with pigeon pea (Accession 16528)
T5. pigeon pea 16520
T6. Pigeon pea (Accession 16527)
T7. (Accession 16528).

The experiment was laid out in randomized complete block design with three replications. Cropping systems at two levels (sole cropping (pigeon pea, sorghum) and intercropping (pigeon pea + sorghum, malkam variety) was constitute the main plot treatments. The sorghum varieties was the early maturing malkam variety. The gross plot was comprise of 3 ridges and 4 m long (12 m^2), while the net plot was made up of the middle ridge (4 m^2). Pigeon pea was planted at a spacing of 1 m x 0.5m with three seeds per hole and later thinned to two plants/stand (66,666 plants /ha), while the sorghum was planted at a spacing of 0.75 m x 0.25 m with three seeds per hole and later thinned to one plants/stand (40,000 plants/ha). The same population of pigeon pea and sorghum was maintained in both intercrop and sole crop treatments. Intercropping will have a 1:1 (pigeon pea:sorghum) row proportion. In the intercrop treatments, both pigeon pea and sorghum will be planted on the same ridge. Pigeon pea will occupy the crest of the ridge, while sorghum will be planted on the side. All plots will receive a basal application of 100 kg of NPS.

2.3. Data Analysis

The collected Data was analyzed using GENSTAT Release 18th, following standard analysis of variance procedures and least significant difference (LSD) test at 5% probability level was used to compare the treatment means.

Table 1. *Effects pigeon pea intercropping on yield and yield components of sorghum at Erer.*

No	Treatments	Plant height in cm	Panicle length (cm)	Panicle diameter (cm)	Biomass Yield kg/ha	Grain yield kg/ha
1	T1	100.2b	23b	5.467b	9806	2339
2	T2	120.4a	24.67ab	6.467a	11141	2856
3	T3	123.1a	27.07a	6.533a	11412	2894
4	T4	114.2ab	24.07b	6.2a	12638	2667
l.s.d.		15.81	2.698	0.6889	3814.1	962.8
cv%		6.9	5.5	5.6	17	17.9

3. Result and Discussion

3.1. Plant Height, Panicle Length and Panicle Diameter

The experiment shows significant difference in terms of plant height, panicle length, and panicle diameter at ($p<0.05$) 5%. The highest plant height was obtained at the treatment, sorghum intercropped with pigeon pea accession 16527 (tsegas variety).

3.2. Grain Yield (kg/ha)

The result that obtained was statistically not significant in terms of grain yield ($p > 0.05$) among treatments (both sole and intercropped one). In (Table 1) was indicated that

intercropping of pigeon pea Accessions had no negative significant effect on grain yields of sorghum. The maximum grain yields were obtained from T3 (sorghumX16527 pigeon pea accession); (2894) kg ha^{-1}), followed by T2 (16527 pigeon pea accession) (2856) kg ha^{-1} respectively. The minimum grain yield obtained from T1 (2339 kg ha^{-1}). The most probable reason for this variation could be due to leguminous nature of pigeon pea accessions that add nitrogen nutrients to the soil and affect sorghum positively. However, sorghum grain yield was not affected negatively by intercropping statistically due to compatible crops and not an interspecific competition among sorghum and pigeon pea.

This result was in line with [10] that, legume crops contributed to the yield of sorghum either intercropped with legume or grown up using residual contribution of legumes after.

This result not agreed with result that was reported by [2] intercropping of sorghum-cowpea was reduced the grain yield of sorghum; intercropped with 100% sole cowpea plant density and further, cropping system sole sorghum exceeded by 43.54% of the intercropped sorghum yield. The result variation was might be the density, environmental factors and season statistically, there is no significant difference among the treatment in terms of grain yield. But there is variation when observed, in mean using graphs.

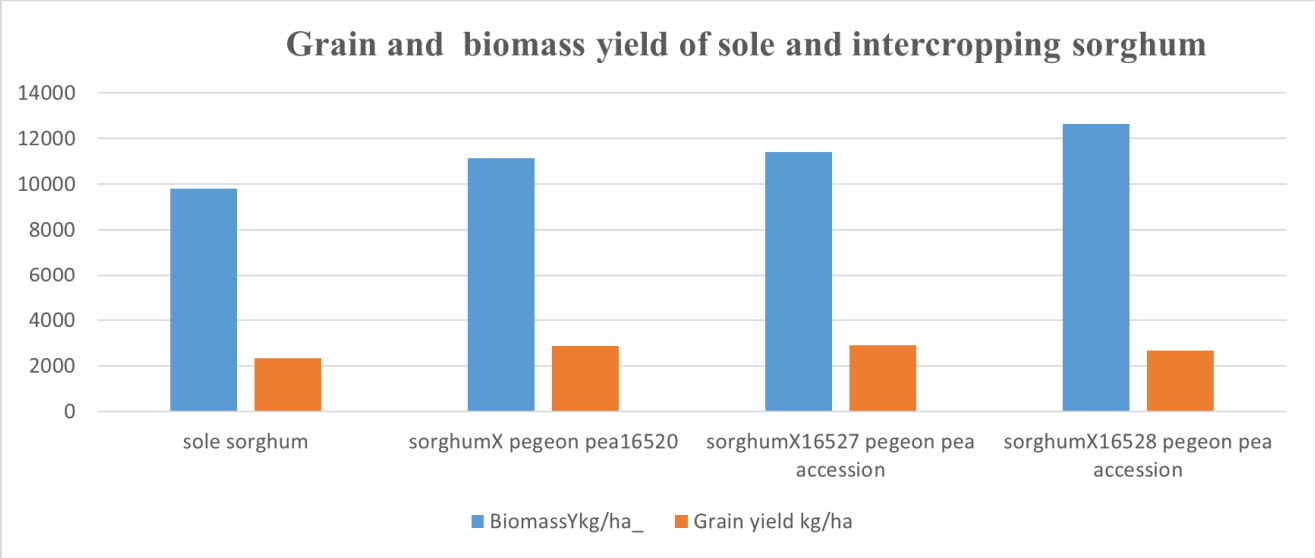

Figure 3. *Graphical comparison of both grain and biomass yield of sole and intercropped sorghum.*

3.3. Biomass Yield

3.3.1. Biomass Yield of Sorghum

The highest biomass yield was obtained from T4 (sorghum intercropped with pigeon pea Accession 16528) 12638kg/ha followed by T3 (Sorghum intercropped with pigeon pea Accession 16527) 11412 kg/ha. On the other hand, the lowest biomass yield was recorded from T1 (Sole sorghum malkam variety) 9806 kg/ha.

3.3.2. Biomass Yield of Pigeon Peas Accessions

Table 2. *Two years average fresh biomass of pigeon pea accessions.*

NO	Treatments	Biomass yield kg/ha
1	T7	25051^{a}
2	T6	24907^{a}
3	T5	23773^{ab}
4	T3	22164^{ab}
5	T4	17067^{ab}
6	T2	14418^{b}
7	l.s.d	9365.7
8	CV%	24.2

There was no that much statistical significant difference among the treatments except among the T7 and T6 vs. T2 at ($p>0.05$). The highest biomass yield was obtained from the T7 (Pigeon pea Accession 16528, $25051^{a\ kg}$/ha) followed by T6 (Pigeon pea (Accession 16527). On the other hand, the lowest biomass yield of pigeon pea was recorded from T2 (Sorghum + 16520 pigeon pea Accession) followed by T4 (sorghum intercropped with 16528 pigeon pea Accession) this was mainly attributed to phenology of pigeon pea and nutrient competition of sorghum crop. This study was in agreement with the study of [17] states that, the Superior biomass yield (not the total biomass yield) was produced from Tsigas cultivar (2170 kg/ha) followed by cultivar 16555 (1270 kg/ha sole pigeon pea).

3.4. Land Equivalent Ration

Land equivalent ratio was greater than 1 which was (1.22) thus why this intercropped experiment is advantageous.

$$LER = (Yab/Yaa) + (Yba/Ybb).$$

Where Yaa and Ybb were yields as sole crops of sorghum and Yab and Yba were yields as intercrops of sorghum and pigeon pea.

Land equivalent coefficient (LEC), is a measure of interaction concerned with the Strength of relationship was collected calculated thus,

$$LEC = La \times L.b,$$

Where, La= LER of main crop and L.b which was 0.5, = LER of intercrop [15]. For a two-crop mixture the minimum expected productivity coefficient (PC) is 25%, i.e. a yield advantage was obtained because LEC value exceeds 0.25. Total plant biomass was used to calculate both LER and LEC.

3.5. Relative Yield Total (RYT)

It was used for intercropping using the equation of RYG= DMYGL/ DMYGG and RYL = DMYLG / DMYLL, Where: DMYGG was dry matter yield of sorghum (G) as a sole crop, DMYLL was dry matter yield of legume (L) as a sole crop, DMYGL the dry matter yields of sorghum/pigeon pea intercropping.

4. Conclusion

Globally pigeon pea (*Cajanus cajan* (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].

The design of the experiment was, RCBD with three replication. The experiment shows significant difference statistically, in terms of plant height, panicle length, and panicle diameter at 5% (table 1). The highest plant height was obtained from the treatment with sorghum intercropped with pigeon pea accession 16527 (tsegas variety). The result that obtained was statistically not significant interms of grain yield ($p < 0.01$) among treatments (both sole and intercropped one). In (Table 1) was indicated that intercropping of pigeon pea Accessions (variety) had no negative significant effect on grain yields of sorghum. The maximum grain yields were obtained from T3 (sorghumX16527 or pigeon pea tsegas variety); (2894) kg ha^{-1}), followed by T2 (16527 pigeon pea accession + sorghum) (2856) kg ha^{-1} respectively. The minimum grain yield obtained from sole sorghum (2339 kg ha^{-1}).

The treatments with Sorghum intercropped with pigeon pea (Accession 16527) showed the productive results in terms of both sorghum grain yield, biomass yield and pigeon pea fresh biomass yield.

5. Recommendation

Farmers should use T3 (Sorghum intercropped with pigeon pea (Accession 16527) since 16527 pigeon pea accession was effective in terms both grain yield of sorghum and biomass as an intercrop and sole.

Farmers of dry lands in General and of Erer PA specifically should use, sorghum pigeon pea intercropping system than sole sorghum. Farmers can be benefitted when they apply intercropping system than producing sorghum alone or mono cropping. Research extension, Office of agriculture and natural resource and other NGO's should create awareness for farmers on sorghum intercropping with pigeon pea tsegas variety.

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