Journal of Biodiversity Management & Forestry

Research Article A SCITECHNOL JOURNAL

Effects of Maize/Pigeon Pea Intercropping Systems on Growth and Yield of Component Crops in Wolaita Zone, Ethiopia

Nadew Boto* **and Demelash Bassa**

Department of Agronomy, Southern Agricultural Research Institute (SARI), Areka Agricultural Research Center, Areka, Ethiopia

***Corresponding author:** Nadew Boto, Southern Agricultural Research Institute (SARI), Areka Agricultural Research Center, Areka, Ethiopia; E-mail: demelashbassa2000@gmail.com

Received date: 19 December, 2023, Manuscript No. JBMF-24-123065;

Editor assigned date: 21 December, 2023, PreQC No. JBMF-24-123065 (PQ);

Reviewed date: 04 January, 2024, QC No. JBMF-24-123065;

Revised date: 21 February, 2025, Manuscript No. JBMF-24-123065 (R);

Published date: 28 February, 2025, DOI: 10.4172/2327-4417.1000069

Abstract

Information on the performances of the maize and pigeon pea intercropping systems under dry-land conditions of Wolaita area is rare. Hence, on-farm experiment was conducted in 2021 and 2022 cropping seasons with the objective of evaluating maize/pigeon pea intercropping systems at Humbo district in Wolaita zone, Ethiopia. Five treatments such as sole maize, sole pigeon pea, farmer's intercropping practice, 1 maize row: 1 pigeon pea row and 2 maize rows: 1 pigeon pea row ratios were tested in RCB design with three replications. Improved maize variety, BH-540, and local pigeon pea variety were used as the test plants. Growth parameters and yield and yield attributes of maize and pigeon pea were measured. Combined analysis of variances showed that there were statistically significant differences (P<0.05) observed among treatments regarding to maize and pigeon pea growth parameters, above-ground biomass and grain yield. The highest maize plant height (206.7 cm) and the shortest leaf length (59.4 cm) were recorded with maize grown in 1 maize: 1 pigeon pea intercropping system while the shortest plant height (168.8 cm) and the longest leaf length (93.8 cm) were recorded with sole maize which is statistically at par with farmer's practice. The highest maize biomass (16.73 tha^{-1}) and grain yield (6.47 tha^{-1}) were recorded with maize grown in sole which showed no significant from yields obtained from farmer's intercropping practice. In contrast, the lowest maize biomass (13.36 tha^{-1}) and grain yield (5.25 tha^{-1}) were recorded with maize grown in 1 maize: 1 pigeon pea intercropping system. Regarding to pigeon pea growth parameters, the shortest mean plant height (91.2 cm) and less number of primary branches (5.5) were recorded with farmer's practice of sowing in the same row while the longest plant height (169.8 cm) and more number of primary branches (21.3) were recorded with sole pigeon pea. The lowest pigeon pea biomass yield (7.87 tha^{-1}) and grain yield (0.56 tha^{-1}) were recorded with 2maize rows:1pigeon pea row intercropping while the highest biomass (11.3 tha^{-1}) and grain yield (0.8 tha^{-1}) were recorded with sole pigeon pea. The highest LER (1.77) was obtained from the farmer's intercropping system. Finally, since the growth habits may vary among varieties, further research on compatibility of other improved pigeon pea varieties for intercropping systems with maize is important.

Keywords: Maize; Pigeon pea; Intercropping; Above ground biomass; Grain yield; LER

Introduction

Increasing concern about the future of agriculture in sub-Saharan Africa in light of accelerating soil degradation, have increased the need for new and more adapted cropping systems that increase production, whilst conserving the natural resource base [1]. Intercropping, double cropping and other mixed cropping practices that allow more efficient uses of farm resources are among the agricultural practices associated with sustainable crop production. The goals of such cropping systems must be to increase ecosystem services while simultaneously increasing crop yields and subsequent profitability at the farm level. The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labor. Intercropping is a multiple cropping system that combines the planting of two or more crops species simultaneously in the same field during a growing season [2].

In Ethiopia, intercropping forms part of the smallholder farming systems where maize (*Zea mays* L.) and *Sorghum* (*S. bicolor* L.) dominate as main crops [3]. Maize is the major cereal grown by the smallholder farmers in Ethiopia and it is often intercropped with various legume crops. Pigeon pea, as one of the legume crops and multipurpose shrub, has been used currently as an intercrop with maize in southern parts of the country including the stud areas. However, the relative advantage of the intercropping of maize with pigeon pea and response of the system has not been examined scientifically. Drawing lessons from on farm studies would help to convince and make informed decisions for wider use of improved production systems. Therefore, this research was carried out to evaluate and identify various forms of maize/pigeon pea and the best productive maize/pigeon pea intercropping systems in the study area.

Materials and Methods

Descriptions of the study area

The research was conducted in Humbo district of Wolaita zone in the southern Ethiopia during the cropping seasons of 2021 and 2022. The zone's capital, Soddo, is found 330 km to south of Addis Ababa on the way to Arbaminch through Butajira-Sodo road and the specific study area, Humbo, is found to south of the capital Soddo about 20 km on the way to Arbaminch. The average land holding size per household is 0.5 ha in the district. Its mean annual rainfall is about 1123 mm and mean altitude of 1489 meter above sea level. Geographically it is located at 6.44°N longitude and 37.5°E latitude (Figure 1). Its soil type is Nitisols with sandy loam textural class.

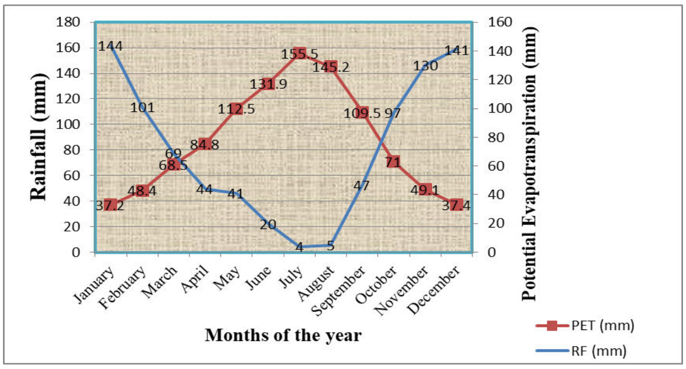

Figure 1: The mean rainfall and temperature of Humbo site, Southern Ethiopia

It has mixed farming system (Crop production and livestock rearing). Major crops grown in the area are; maize, *Sorghum*, sweet potatoes, cassava, pigeon pea, papaya and mango. Most of the lowland kebeles of Humbo woreda are part of the Great East African Rift Valley. Being part of this geographical location and the effect of recurrent drought, mainly due to climate change, poor soil condition and traditional farming system have held back agricultural productivity and production.

Experimental treatments and design

The treatments were: Sole maize, Sole pigeon pea, farmer's practice of intercropping pigeon pea (in the same row, in between two maize holes), 1 maize row: 1pigeon pea row intercropping and 2 maize rows: 1 pigeon pea row intercropping systems were tested in RCB design with three replications. Gross plot size was 4.8 m by 3.2 m holding six maize rows. Spacing of maize was 80 cm between rows and 40 cm between plants.

Planting materials

Maize variety (BH540), an intermediate maturity maize variety and high grain yielder adopted in the area, was used for the experiment. Locally adopted pigeon pea was used as an intercrop and planted simultaneously with maize per the treatments. One hundred twenty two kg NPSB fertilizer was applied to all treatments equally at planting time while 100 kg urea, half at planting and the remaining half at 45 days after planting, was applied uniformly for all treatments (except to pigeon pea) as per the recommendation. Weeding was done manually.

Data collection

Growth and yield parameters of maize: Plant height (cm) was measured as the height from the soil surface to the base of the tassel from five randomly selected plants in the net plot area using measuring meter at physiological maturity and the average was taken for analysis.

Leaf length (cm) was measured from the leave base to the tip of the leaf (three middle leaves per plant) from five randomly selected middle plants per plot and the average was taken for analysis.

Number of seed per row was recorded by counting the number of seed per row per year from five randomly selected pants per plot and the average was taken for analysis.

Ear length (cm) was measured as the length of the ear form the base of the ear to the tip after removing the sheath.

Above ground biomass (kg) was measured from the net plot area including leaves, stems and cobs which were harvested at maturity and weighed after three days of sun drying and the average was taken for analysis.

Grain yield (kg) was measured, after harvesting and shelling from net plot, using electronic balance and then adjusted to 12.5% seed moisture content using a digital moisture tester (model M-3G) and converted to hectare basis.

Pigeon pea yield parameters: Plant height was recorded by measuring the height of the five randomly selected plants from soil surface to the tip of the main stems using meter at physiological maturity.

Primary branch was measured by counting primary branches of emerged from the main stems of five randomly selected plants per plot.

Above ground biomass was obtained after weighing the biomass after harvesting the above ground parts of the randomly selected five plants.

Grain yield was recorded after harvesting the middle rows and weighing total seed mass after threshing. The recorded was converted to hectare base.

Analysis of productivity of the system

Land Equivalent Ratio (LER): The benefit of intercropping and the effect of competition between component crops were calculated by land equivalent ratio. Land equivalent ratio which verifies the effectiveness of intercropping for using the resources of the environment compared to sole planting. The LER value is computed using the following formula:

$$\mathrm{LER} = \frac{\mathrm{Ymp} + \mathrm{Ypm}}{\mathrm{Ym} + \mathrm{Yp}}$$

Where, Ymp and Ypm were yield of maize and pigeon pea in intercropping systems tested respectively, and Ym and Yp were yield of maize and pigeon pea in pure stand of each crop respectively. Therefore, any result above value of 1 would signify an intercrops advantage, and any result that is below one would indicate a monoculture advantage.

Statistical analysis

The collected data were subjected to ANOVA using the SAS GLM procedure. Least Significant Difference (LSD) test at 5% probability was used for mean separation when the analysis of variance indicates the presence of significant differences.

Results and Discussion

Growth and yield responses of maize to intercropping systems with pigeon pea

Growth parameters: Combined analysis of variances indicated that there were very highly significant ($p<0.0001$) differences observed due to treatments on plant height and leaf length. The highest plant height (206.7 cm) was observed from maize crop grown under intercropping system of 1 maize row to 1pigeon pea row. The shortest plant height (168.8 cm) was recorded with sole maize, which was also at par statistically with farmer's intercropping practice. The longest mean leaf length (93.8 cm) was recorded from maize crop grown under sole stand whereas the shortest leaf length (59.4 cm) was recorded with 1 maize row to 1 pigeon pea row intercropping system. However, there was no statistically significant leaf length difference observed among maize crop grown in sole and in farmer's practice of intercropping systems (Table 1). The highest plant height and shortest leaf length observed in the case of 1 maize row to 1 pigeon pea row ratio intercropping system could be attributed to higher plant populations per unit area as well as increased competition of the closely spaced pigeon pea plants for solar radiation that resulted in mutual shading. This situation might have induced the plants to increase their height as a response for shade avoidance, mediated by plant hormones such as auxins and gibberellins. This finding agrees with Vander, et al. and Nadew, et al. who reported that closest spacing increased the potato plant height [4,5].

Treatments	Plant height (cm)	Leaf length (cm)
Sole maize	168.8^{c}	93.8^{a}
Farmer's practice	172.7^{c}	92.2^{a}
1 maize row:1 pigeon pea row	206.7^{a}	59.4^{c}
2 maize rows:1 pigeon pea row	197.5^{b}	72.2^{b}
LSD (0.05)	5.511	3.604
CV (%)	2.39	3.73

Table 1: Combined mean values of maize plant height and leaf length as affected by intercropping systems (2021 and 2022).

Maize yield components: Combined analysis of variances showed that maize ear length (cm) was not affected significantly ($p>0.05$) by treatments while seed number per row was varied highly significantly ($p<0.01$) due to treatments (Table 2). The possible reason for non-significant response of maize ear length could be due to its genetic make-up.

Treatments	Ear length (cm)	Seed number/row
Sole pigeon pea	19.1	34.3^{a}
Farmer's practice	18.8	33.6^{ab}
1 maize row:1 pigeon pea row intercropping	17.9	32.0^{c}
2 maize rows:1 pigeon pea row intercropping	18.4	33.0^{bc}
LSD (0.05)	ns	1.21
CV (%)	5.1	2.98

Table 2: Combined mean values of maize yield components as affected by intercropping systems (2021 and 2022).

Total maize biomass and grain yield: Combined analysis of variances of total biomass of maize showed very highly ($p<0.0001$) while grain yield showed highly ($p<0.001$) significant differences due to treatments. The greatest total biomass yield (16.73 tha^{-1}) and grain yield (6.47 tha^{-1}) were obtained from maize crop in sole stand, though it was at par with yields obtained from farmer's intercropping system. Whereas, the lowest biomass (13.36 tha^{-1}) and grain yields (5.25 tha^{-1})were obtained from 1maize row to 1pigeon pea row intercropping system which was also statistically at par with 2 maize rows to 1pigeon pea row ratios intercropping system (Table 3). The reason for more biomass recorded in the case of sole maize stand might be due to more number of longest leaves and thicker maize stalk with widest diameter. Similarly, the highest grain yield obtained might be due to the variation in yield components not measured in this study such as grain dry matter content and thousand seed weight as well as due to cumulative effects of numerical differences found on measured yield components such as ear length and seed number per row though they were at par statistically. This result agrees with Makumba, et al. who noticed higher maize grain yield and biomass in plots intercropped with Gliricidia sepium than in sole maize plots [6].

Treatments	Biomass yield (tha^{-1})	Grain yield (tha^{-1})
Sole maize	16.73^{a}	6.47^{a}
Farmer's practice	16.31^{a}	6.24^{a}
1 maize row: 1 pigeon pea row intercropping	13.36^{c}	5.25^{b}
2 maize rows: 1 pigeon pea row intercropping	14.65^{b}	5.66^{b}
LSD (0.05)	1.04	0.57
CV (%)	5.6	7.9

Table 3: Combined mean values of maize yields as affected by intercropping systems (2021 and 2022).

Growth and yield responses of pigeon pea to intercropping systems with maize

Growth of pigeon pea: Combined analysis of variances showed that there were very highly significant ($p<0.0001$) differences observed on both plant height and number of primary branches pigeon pea due to treatments. The longest plant height (169.8 cm) recorded with sole maize while the shortest plant height (91.2 cm) was recorded with pigeon pea grown in farmer's intercropping system. Similarly, more primary branches number (21.3) were obtained from sole pigeon pea and less number of primary branches (5.5) were found from pigeon pea grown in farmer's intercropping practice (Table 4). The possible reason for the longest plant height and more primary branches recorded due to sole cropping system may be as a result of less competition among plants for growth resources.

Treatments	Plant height (cm)	Primary branches number
Farmer's intercropping practice	91.2^{d}	5.5^{d}
1 maize row:1 pigeon pea row intercropping	125.7^{c}	11.7^{c}
2 maize rows:1 pigeon pea row intercropping	138.0^{b}	16.5^{b}
Sole pigeon pea	169.8^{a}	21.3^{a}
LSD (0.05)	3.16	1.26
CV (%)	2	7.5

Table 4: Combined mean values of pigeon pea plant height and primary branch number as affected by intercropping systems (2021 and 2022).

Pigeon pea total biomass and grain yields: Combined analysis of variance showed that both biomass yield and grain yield of pigeon pea were very highly significantly ($p<0.0001$) affected by treatments. The highest pigeon pea biomass yield (11.3 tha^{-1}) and grain yield (0.8 tha^{-1}) were obtained from pigeon pea grown in sole stand whereas the lowest biomass (7.87 tha^{-1}) and grain yields (0.56 tha^{-1}) were obtained from pigeon pea grown under 2 maize rows to 1 pigeon pea intercropping system (Table 5). The reduction of both biomass and grain yield in the case of 2 maize rows to 1 pigeon pea row might be due to low plant population per a unit of land, since biomass yield is affected by different plant population densities [7]. The finding of this research agrees with finding of Dasbak, et al. who reported that intercropping significantly depressed pigeon peas grain yield compared to sole cropping system [8].

Treatments	Biomass (tha^{-1})	Grain yield (tha^{-1})
Sole pigeon pea	11.3^{a}	0.8^{a}
Farmer's intercropping practice	9.2^{b}	0.65^{c}
1 maize row:1 pigeon pea row intercropping	10.7^{a}	0.69^{bc}
2 maize rows:1 pigeon pea row intercropping	7.7^{c}	0.56^{d}
LSD (0.05)	0.8	0.07
CV (%)	6.8	11.5

Table 5: Mean pigeon pea yield as affected by intercropping systems (2021 and 2022).

Evaluating productivity of maize/pigeon pea intercropping system: Analysis of variance showed that LER was highly significantly ($p<0.01$) affected by treatments. The highest LER (1.77) was obtained from farmer's intercropping practice whereas the lowest LER (1.58) was obtained from 2 maize rows to 1 pigeon pea row intercropping system (Figure 2). Nevertheless, the LERs of all intercropping systems tested were much greater than one that showed the benefits of intercropping, indicating the efficient utilization of growth resources by growing the crops together. Generally, it can be explained as intercropping maize with pigeon pea showed an advantage over sole cropping in the study area. This agrees with Naudin, et al. who stated that intercropping increases efficiency of land use for crop production compared to sole cropping [9].

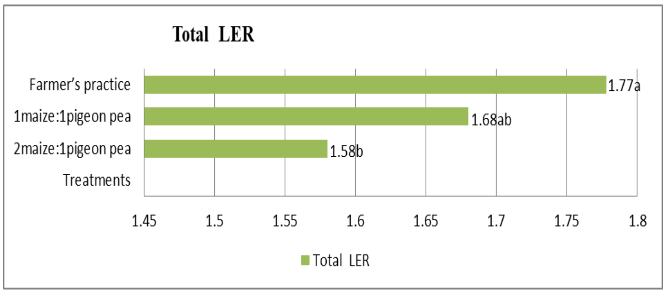

Figure 2: LER of maize/pigeon pea intercropping systems.

Conclusion

The present study indicated the possibility of obtaining additional yields of pigeon pea biomass and grain by intercropping without causing significant yield reduction of maize crop in the study area. This reflects the importance of using intercropping pigeon pea simultaneously with maize for efficient use of land and other plant growth resources. More specifically, it can be concluded that farmer's practice of intercropping maize and pigeon pea in the same row seems the best agronomic practice from the point of view of productivity and ease of inter-cultivations rather than other intercropping systems tested. Therefore, it is better to advice maize producing farmers in the study area as well as in other areas with similar environmental conditions to scale up intercropping local pigeon pea variety in the same row with maize (between two maize holes) simultaneously. Whereas for those who want mainly to produce pigeon pea grain sole planting method is better than intercropping it with maize. Finally, since the growth habits may vary among varieties, further research on compatibility of other improved pigeon pea varieties for intercropping systems with maize is important.

Acknowledgements

The authors are grateful to Southern Agricultural Research Institute and Areka Agricultural Research Center for covering the costs and other logistics supports during the field experiment, though there was no financial support at all for publishing the article. The authors also thank for assistance provided by the crop science research work process of Areka Agricultural Research Center for the accomplishment of this experiment.

Competing Interest

The authors have declared no competing interest exists.

References

1. Thierfelder C, Wall PC (2009) Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe. Soil Tillage Res 105: 217-227.
2. Mousavi SR, Eskandari H (2011) A general overview on intercropping and its advantages in sustainable agriculture. J Appl Environ Biol Sci 1: 482-486.
3. Tarekegn A, Zelalem T (2014) Evaluation of the performance of herbaceous forage legumes under sown with maize under irrigation condition of Megech, North Gondar, Ethiopia. Livest Res Rural Dev 26.
4. Zaag PV, Demagante AL, Ewing EE (1990) Influence of plant spacing on potato (*Solanum tuberosum* L.) morphology, growth and yield under two contrasting environments. Potato Res 33: 313-323.
5. Nadew B, Walelign W, Hussein MB (2022). Effects of nitrogen fertilizer application timing and inter-row spacing on growth and tuber yield of potato (*Solanum tuberosum* L.) in Wolaita Zone, Southern Ethiopia. Adv Crop Sci Tech 10: 533.
6. Makumba W, Akinnifesi FK, Janssen BH (2009) Spatial rooting patterns of gliricidia, pigeon pea and maize intercrops and effect on profile soil N and P distribution in southern Malawi. Afr J Agric Res 4: 278-288.
7. Abuzar MR, Sadozai GU, Baloch MS, Baloch AA, Shah IH, et al. (2011) Effect of plant population densities on yield of maize. J Anim Plant Sci 21: 692-695.
8. Dasbak MA, Asiegbu JE (2009) Performance of pigeon pea genotypes intercropped with maize under humid tropical ultisol conditions. J Anim Plant Sci 4: 329-340.
9. Naudin K, Gozé E, Balarabe O, Giller KE, Scopel E (2010) Impact of no tillage and mulching practices on cotton production in North Cameroon: A multi-locational on-farm assessment. Soil Tillage Res 108: 68-76.