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Performance of Pearl Millet (pennisetum glaucum (l) r. br.) Based Legume Intercropping Systems at Hamelmalo

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Abstract:- The experiment was conducted with general objective of, "To study the effect of pearl millet based intercropping systems on total productivity of pearl millet and legumes" and specific objectives i) to study the performance of pearl millet varieties under sole and intercropping systems, ii) to study the performance of cowpea, green gram and ground nut under sole and intercropping systems, iii) to study the comparative efficiency of pearl millet varieties and legume crops to manage weeds under sole and intercropping systems and iv) to study the comparative economics of different pearl millet based cropping systems. The experiment was conducted in Randomized Complete Block Design (RCBD) with 15 treatment combinations each replicated thrice. The fifteen treatment combinations consists of three pearl millet varieties vize, Kona, Hagaz and Tokroray and three legumes viz, Green gram, Cowpea and Groundnut grown under sole and intercropping system. Periodic biometric observations of all the crops and weed studies were recorded. The data obtained were subjected to various mathematical formulas and statistical analysis by GEN STAT software to test the efficiency of different varieties of pearl millet, legumes alone and their intercropping systems to utilize the resources efficiently, manage weeds and increase the total productivity. Intercropping of legumes with pearl millet gave complimentary advantage of yield, Gross returns and net returns over sole cropping. Among all the combinations intercropping of groundnut with Kona produced higher grain yield (3076 kg ha -1), total grain productivity (3737), gross returns (106355 kg ha-2) and net returns (71825 Nakfa ha 2). Groundnut Among the legumes gave highest net return and B: C (3.7). Because of lesser cost of cultivation and higher gross return due to its higher selling price.

Keywords:- *Pearl Millet, Legumes, Sole Cropping, Intercropping.*

I. INTRODUCTION

Pearl millet (*Pennisetum glaucum (L.) R. Br*.) is the world's fourth most important food cereal crop in the tropics (The Syngenta Foundation for Sustainable Agriculture, 2002). It is considered to be an orphan crop and is widely grown for food and fodder under semi arid tropics of Africa and India. In semiarid tropics the crop is mostly grown as mono crop under rain fed conditions without use of fertilizer and cultivation is almost by hand or animals. Yet its yields are high and more reliable than other possible tropical dry cereal crops such as Sorghum and Maize. Primarily a tropical plant, it is also often referred to as the "Camel" of crops, because of its exceptional ability to tolerate drought. It is predominantly grown in less favorable environments where rainfall is variable and low (250-300 mm). It grows in hostile (hot and dry) environments where no other crops can be cultivated particularly in West Africa, Sahlian region and the Indian sub continent (Andrews et al., 1985). World wide it is grown on a total area of 36288 million hectare with average total production of 298006 tones and average productivity of 821 kg per hectare. Whereas in Africa it is cultivated in an area of 20774 hectare, with total production of 14606 tones and productivity of 703 kg per hectare. In Eritrea it occupies an area of 40,000 hectares, with total 17 tones and average productivity of 423 kg ha-1 (FAO, 2003).

The major constraints of its low productivity in Eritrea are monocropping, poor soil fertility, imbalance use of fertilizers, low and erratic distribution of rainfall, lack of adoption of improved varieties, infestation by weeds, attack of diseases (downy mildew and smut) and insect pests. Most of these constraints can be overcome by adoption of improved short duration varieties and resistant to drought and diseases varieties and inclusion of legumes as intercrops. Landraces currently grown contain the traits that farmers have selected over the past generations, and thus represent a very valuable resource. One of the most important aspects is to define the best intercropping system for specific areas, as well as the genotypes (crop combination) best adapted to the drought conditions in those areas. Intercropping provides stability and ensures adequate yields of one of the component crops (Rao *et*

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al., 1983) under aberrant weather situations. Legumes due to their deep tap root system and ability to fix atmospheric nitrogen not only stabilize yields but also maximize total productivity per unit area. The intercropping component not only benefitted the associated non – legume but also left some fixed nitrogen in the soil. Legumes like Green gram and Cow pea as pulses and Ground nut as an oilseed crop have unique built in mechanism to fix atmospheric nitrogen in their root nodule. Their cultivation with the cereals economizes nitrogen to the tune of 30-40 kg ha^{-1} for succeeding crop and also improves soil health (Giller *et al*., 1993). Moreover because of their tap root system they have inherent quality to trap the moisture from lower layers of the soil and can tolerate moisture stress under dry land conditions.

Although intercropping is an age long practice in Eritrea farming system, it is more of traditional and the knowledge of the appropriate planting pattern and crop plant proportion to be adopted is not wildly scientifically studied for maximum attainment of production and land utilization. Moreover they do not cultivate the promising varieties for this purpose. Keeping in view the above facts, the present investigation entitled "Performance of Pearl millet Based Legume Intercropping systems at Hamelmalo" was undertaken with the below mentioned objective. To study the effect of Pearl millet based intercropping systems on productivity of pearl millet and legumes.

II. MATERIALS AND METHODS

❖ *Site Description*

Hamelmalo Agricultural College (HAC) is located in Anseba zone, at about 12 kilometers north of the Keren town. The college is situated adjacent to the river Anseba at 15^0 52' 18'' N latitude and 38^0 27' 55'' E longitudes and at an altitude of 1,280 meter above mean sea level. The area receives average annual total rainfall of 468 mm and falls under semi-arid mid-land region of Eritrea. The area experiences average annual maximum and minimum temperatures of 34.8 ^oC and 10.35 ^0C respectively (MOA branch of Hamelmalo, 2014). The present field experiment was conducted during summer, 2014 at the research farm of department of Agronomy Hamelmalo Agricultural College located near the Anseba River.

❖ *Plant Materials and Experiment Details*

The current study during summer, 2014 was conducted in Randomized Complete Block. Design (RCBD) with 3 replications and fifteen treatment combinations consisting of three Pearl millet varieties as sole viz, V_1- Kona (improved) variety,V_2 –Hagaz (improved) varietyand V_3 - Tokroray (local land race), 3 legume crops as sole viz, L_1 - Cow pea variety M66 (improved variety), L_2- Green gram variety Filsan *(*improved variety) and L_3-Ground nut variety Valencia (local) and their 9 intercropping combinations was as follows viz, V_1L_1, V_1L_2, V_1L_3, V_2L_1, V_2L_2, V_2L_3, V_3L_1, V_3L_2 and V_3L_3. These varieties of both pearl millets and Legumes were obtained from National Agricultural Research Institute, Halhale, Eritrea.

Field was ploughed with tractor drawn disc plough following by a disc harrow on 27 June, 2014. The weeds and previous crop stubbles were removed manually. The field was leveled manually with hoes and shovels on 3 July, 2014. The Layout of experiment was done on 4 July, 2014. The gross plot size of each plot was kept as 3m x 4.5m=13.5m. The distance between the plots was made by making 0.5m bunds between the plots. The distance between the replications was maintained by leaving a space of one meter. The whole experiment covered an area of 32m x 24.5m= 784 square meter. Randomization of 15 treatments was done with the help of random number tables as depicted in the layout.

➢ *Sowing of both the main and intercrops was done on 7 July, 2014 manually.*

Pearl millet was sown at two row distance of 60cm and plant to plant distance of 30cm. as per treatment in layout row to row distance of 60cm and plant to plant distance of 16cm. The Legumes as per layout were sown in sole plots at row to row distance of 30cm and in between two rows of Pearl millet in intercropping plots by keeping plant to plant distance of 16cm. After complete emergence plants were thinned to maintain appropriate plant density i.e. 16 cm between plants and 60 cm between rows for pearl millet and legumes (sole crop) and in the intercropping the distance between main crop and component crop was 30 cm. After thinning, number of plants per plot was counted for both pearl millet and legumes.

➢ *Observations Recorded*

Immediately after sowing two sampling areas each of one meter row length were marked randomly in each of the net plot area with the help of wooden pegs and following observations were recorded from 5 randomly marked plants at periodic intervals of 25 days.

❖ *The main parameters recorded were as follows:*

➢ *Plant height (cm):*

Height of 5 randomly selected plants of pearl millet was recorded with meter scale at 25 days interval after sowing. The height was recorded from the soil surface to the base of top most fully opened leaf before flowering and up to tip of spike after emergence of Spike. In case of legume crops height of 5 randomly selected plants was measured soil surface to tip of the growing point. The average plant height was calculated by dividing the total height of 5 plants by 5.

➢ *Leaf Area Index (per plant):*

Leaf Area Index (LAI) of respective crops from each plot was calculated at 25 days interval of sowing.

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➢ *Days taken for 50 per cent spike emergence in Pearl millet and flowering in legume crops:*

The date when 50 per cent of the plants in sampling area produced spikes in pearl millet and flowers in legume crops was recorded and the number of days were calculated from date of sowing up to the date of 50 per cent of spike emergence in pearl millet and flowering in legume crops.

➢ *Days taken for maturity:*

Number of days taken for maturity of pearl millet varieties and legume crops was recorded from the randomly selected plants. Maturity was assessed by visual. When the leaves and stem of Pearl millet dried and the spikes became hard. The Cowpea and Green gram pods were picked when the color of pods turned brownish in color. Groundnut was considered mature when the vegetative portion dried completely.

➢ *Number of effective tillers per plant:*

The number of spike bearing tillers of randomly marked 5 Pearl millet plants was counted and the total tillers of five plants was divided by 5 to get average number of effective tillers per plant.

➢ *Number of pods per plant:*

Number of pods of 5 randomly selected plants of each of the three legume crops in each plot was counted and via total pods of 5 plants was divided by 5 to get average number of pods per plant.

➢ *Thousand grain weights (g)*

Randomly 100 pearl millet grains were manually counted from each of the net plot produce and weight was recorded. The weight so recorded was multiplied by 10 to work out 1000 grain weight

➢ *Thousand seed weight (g):*

Randomly 100 legume seeds were manually counted from each of the net plot produce and weight was recorded. The weight so recorded was multiplied by 10 to work out 1000 seed weight.

➢ *Grain yield (g)*

The grains yield Pearl millet of each net plot was air dried and weight was recorded. The net plot grain yield was multiplied by 1388.89 factors to get grain yield per hectare

➢ *Seed yield:*

The seed yield of each legume from the net plot dried and weight was recorded. The net plot seed yield was multiplied by 1388.89 to get seed yield per hectare.

➢ *Statistical Analysis*

The data obtained of each of the parameters under the study was subjected to statistical analysis by using the Edition 4 Genstate software as per following.

III. RESULTS AND DISCUSSION

➢ *Plant height (cm)*

Plant height of different Pearl millet varieties and legume crops sown as sole and in intercropping systems at different observation stages. A cursory glance of the results in indicate that Pearl millet varieties Kona and Hagaz having almost similar height at almost all the observation stages were taller than Tokroray variety. Their height increased at increasing rate up to 50 DAS and thereafter increased at decreasing rate up to harvest both in sole and intercropping systems. But the height of Tokroray variety increased at increasing up to harvest in both sole and intercropping systems. These variations could be ascribed to their genetic makeup. The data presented in table 1 at harvest (75 DAS) showed that there was significant difference in plant height of pearl millet varieties.

The data effect of treatments on Plant height, Dry matter, Leaf number, Leaf area and Leaf Area Index at harvest has been presented in Table 4. The plant height data showed that there was significant difference among pearl millet varieties in sole and intercropping systems.

Among pearl millet Hagaz and Kona varieties being statistically at par produced significantly taller plants with height of 184.1 and 178.5 cm respectively when sown as sole. The data further reviled that plant height of both Hagaz and Kona varieties was considerably increased when Groundnut was intercropped with them. Similarly plant height of Hagaz variety increased numerically when intercropped with cowpea. Significant reduction in plant height of variety Kona was observed when it was intercropped with Cowpea and Green gram. The plant height of local variety Tokroray increased significantly when it was with Groundnut. The increase in plant height of all the varieties when intercropped with Groundnut may be ascribed to stimulating effect of Groundnut in the form of Nitrogen fixation and release of some growth substances. These results are in direct conformity with these of Roden *et al*. (2006) who also reported higher plant height of Hagaz and Kona varieties. The poor performance of Tokroray variety could be ascribed to its susceptibility to downy mildew in Hamelmalo conditions.

Legume crops studied in this experiment were bushy in nature except that of Cowpea having some climbing habit as a result no significant differences in their plant height was recorded. Moreover the legume crops when intercropped with pearl millet were numerically poor in plant height as compared to their soles. Due to the shading effect by the main crop that grown taller than that of legume crops.

➢ *Leaf Area Index*

LAI of Pearl millet varieties was significantly affecting various treatments. Hagaz as sole being at par with its intercropping with groundnut produced significantly higher LAI. LAI of legumes was significantly affected different

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treatments, except groundnut sole and in intercrop all other legumes produced higher LAI.

➢ *Days taken for 50% spike emergence/ flowering and days to maturity*

The effect of treatments on development stages of pearl millet and intercrops has been presented in Table 1.

Among pearl millet varieties significantly earlier 50% days taken for spike emergence was recorded in Hagaz and Kona varieties with 47 and 48 days respectively when sown as sole. In intercropping systems Kona intercropped with all legumes and Hagaz intercropped with Green gram statistically at par took significantly less days for 50 per cent spike emergence. Tokroray as sole and in intercropping systems significantly higher number of days for 50% spike emergence.

Among the legumes earlier days to 50% flowering was obtained from groundnut as sole and intercropping systems took significantly less number of days for flowering over green gram and cowpea.

Pearl millet varieties Hagaz and Kona both as sole and in intercropping system and Kona when intercropped with cowpea being statistically at par significantly took less number of days for maturity. Roden *et al.*, (2006) stated that the two new improved Pearl millet varieties in Eritrea show earliness to flowering than the local variety Tokroray. This is in agreement with the present experiment.

Among the legumes, Groundnut in intercropping system with all the pearl millet varieties being at par took higher number of days over its sole cropping and other legumes as sole and in intercropping systems.

Treatments	Plant height(cm)		Leaf Area Index		Days to 50% spike emergence/flowering		Days to maturity	
	Pearl millet	Legume	Pearl millet	Legume	Pearl millet	Legume	Pearl millet	Legume
V_1-Kona	178.5a	-	0.1189	-	48	-	75	-
V_2-Hagaz	184.1a	-	0.15	-	47	-	74	-
V_3-Tokroray	146.3c	-	0.11	-	52	-	87	-
L_1-Cow pea	-	94.5	-	0.11	-	50	-	71
L_2-Greengram	-	88.3	-	0.12	-	49	-	75
L_3-Groundnut	-	59.6	-	0.041	-	38	-	74
V_1L_1	139.8c	92.7	0.15	0.022	48	49	78	73
V_1L_2	152.8bc	49.3	0.10	0.028	45	48	76	69
V_1L_3	185.6a	30.8	0.15	0.034	47	37	77	81
V_2L_1	187.6a	113.7	0.12	0.051	49	50	78	71
V_2L_2	176.6ab	51.1	0.17	0.042	48	47	78	69
V_2L_3	193.9a	28.9	0.14	0.045	49	39	76	81
V_3L_1	129.4c	106.7	0.09	0.05	53	48	79	70
V_3L_2	135.3c	50	0.09	0.05	54	49	81	70
V_3L_3	153.4b	33.4	0.11	0.06	54	33	82	81
CV%	10.3	42.17	21.7	54.3	3.8	11.3	4.2	3.6
SE(d)	13.82	34.43	0.022	0.041	1.53	4.078	2.7	2.14
LSD(0.05)	28.65	NS	0.046	NS	3.9	8.46	5.61	4.44

Table 1:- Effect of Treatments on Plant height, Leaf Area Index, Days taken for 50% spike emergence/ flowering and days to maturity

➢ *Number of effective tillers, Number of pods per plant and thousand grain/ Seed weights (g):*

Both sole and intercropping systems significantly influenced number of effective tillers per plan, number of pods and 1000 grain/seed weight. Higher tillers were produced by Tokroray variety when sown alone by or intercropped by Groundnut and Green gram, Groundnut increased the effective tillers of Kona variety, all the three legumes reduced the effective tillers of Hagaz. 1000 grain weight (table 2). The results presented in the table reveal that, Kona and Hagaz varieties being statistically at par both when grown as sole and intercropping systems with all the three legumes produced significantly higher weight, 1000 grain weight of pearl millet over Tokroray local variety because of increase in growth parameters.. The effective tillers per plant significantly influenced by various treatments. The reduction in yield attributes of pearl millet by the intercrop legume could be ascribed to their competitive effect with the main crop and increase on growth parameters due to annidation in space.

Legume crops in general produced higher values of yield attributes when sown alone as compared to when grown in intercropping systems due to variable competition by different Pearl millet varieties (Table 2). Pod weight per plant, 1000 seed weight of respective legumes was significantly reduced when intercropped with different varieties of Pearl millet.

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MOA (2007) reviled that Tokroray has good tillering ability. This is in agreement with the present experiment. Number of effective tillers has more impact on yield. But for that case almost shows no positive impact towards grain yield, this could be the spikes of main plant of land races were very small which producing small seeds, and similarly tillers produce very small spikes.

➢ *Grain/Seed yield (g):*

Data on grain/seed yield which was significantly influenced by various treatments been presented table 2. A perusal of the data reveals that Kona and Hagaz varieties as sole being statistically at par with intercropping of Kona and Groundnut, Hagaz and Green gram. Hagaz and Green gram and of Hagaz and resulted in significantly higher grain because of significantly higher harvest index. However yield of all the Pearl millet varieties reduced numerically in intercropping systems over their sole cultivation.

These results are on direct conformity with these of Roden *et al* (2006) reported that improved Pearl millet varieties produce higher yield than local land races. This is in agreement with resent experiment that Kona and Hagaz out yield local Pearl millet variety Tokroray see table (2). Willey (1979) proposed that sole pearl millet crop produced higher grain yield than its average yield in intercrop. Low intercrop pearl millet grain yield was partly due to the reduced pearl millet plant population in the intercrop treatments compared to sole. This is consistent with the present study. Cereal yield reduction due to intercropping grain or fodder legumes has been reported by (Mandal, *et al*., 1990)

Treatments	Effective no of tillers/plant	No pods/plant	100 grain/seed (g)		Grain/seed yield (g)	
	Pearl millet	Legume	Pearl millet	Legume	Pearl millet	Legume
V_1-Kona	17	-	13.7	-	3069.0	-
V_2-Hagaz	2	-	14.7	-	2981.0	-
V_3-Tokroray	2.5	-	9.18	-	799.0	-
L_1-Cow pea	-	5	-	130	-	1304
L_2-Greengram	-	26.3	-	54	-	1309
L_3-Groundnut	-	25.7	-	333.3	-	1412
V_1L_1	2	6.7	12.33	127.3	2010	733
V_1L_2	1	14	15.33	50	2443	463
V_1L_3	2.4	7	14.33	286.7	3507	230
V_2L_1	1	4.3	11	120	2095	474
V_2L_2	1.8	15.7	11.62	53.7	2762	500
V_2L_3	1.13	7	11.2	283.3	2952	159
V_3L_1	1.93	9.3	7.17	126.0	333	663
V_3L_2	2.4	20.7	8	56.7	432	819
V_3L_3	2.7	6	6.62	293.3	813	232
CV%	48.9	72.2	27.7	13.3	22	29.6
SE(d)	0.722	7.25	2.46	17.29	376.5	167.1
LSD(0.05)	NS	15.04	5.149	35.83	788.1	346.5

Table 2. Effect of treatments on Number of effective tillers, Number of pods per plant, thousand grain/ Seed weights and grain/seed yield

❖ *Analysis of competitive relations*

➢ *Land Equivalent Ratio (LER)*

The data on the effect of different intercropping systems on LER has been depicted in fig.1. The different intercropping systems did not significantly influence LER. However numerically, highest of LER 1.32 was obtained from intercropping of groundnut with Kona indicating 32% complimentary advantages of growing groundnut as intercrop with Kona variety of pearl millet otherwise 32% land was required to produce the same yield from its sole cultivation. Next highest in intercropping systems was green gram intercropped with Hagaz variety with LER 1.3. Lowest LER was obtained by growing Cowpea as intercrop with Tokroray variety, indicating the competitive effect of Cowpea with Tokroray leading to yield disadvantage. In the case of Tokroray intercropped with Cowpea there was yield disadvantage. All legumes under study intercrops with the three varieties of pearl millet except Cowpea intercropped with Kona resulted in LER of more than 1 indicating complimentary yield advantages of legumes in increasing the total productivity with least competition with the main crop.

Mandal *et al*., (1990) reported that yield advantage from intercrop as compared to sole cropping are often attributed to mutual complementary effects of component crops, such as

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better total use of available resources. Generally, monoculture legume have high yield compared to an intercropping system. However, in most cases, land productivity, measured by land equivalent ratio (LER), clearly show the advantage of intercropping of cereals and legume. This statement is in direct agreement with the present experiment.

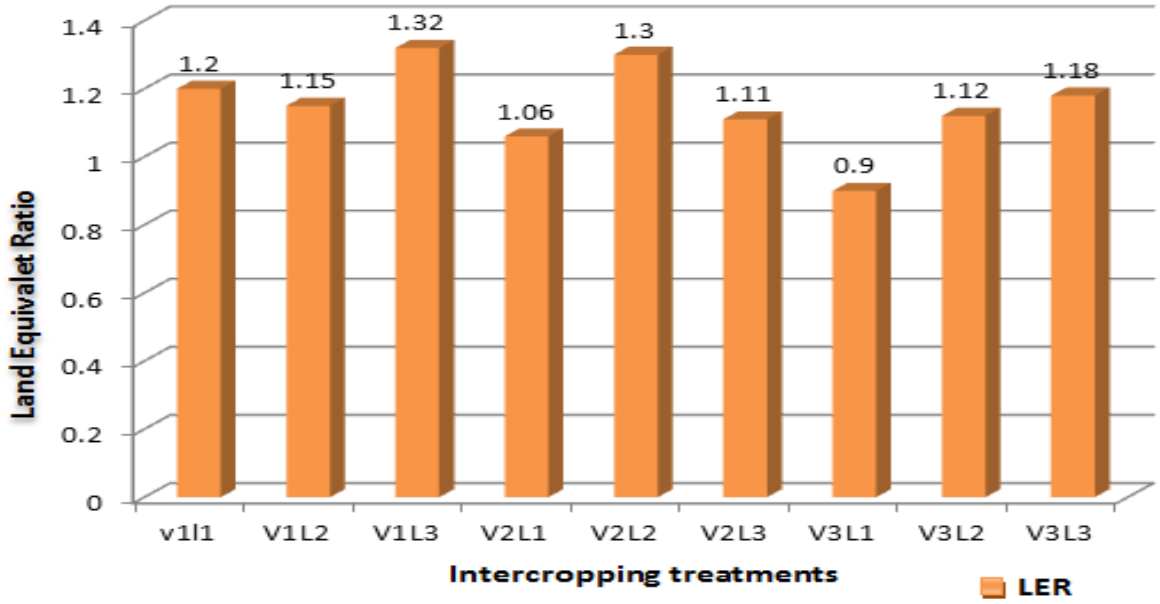

Fig.1:- Effect of intercropping combinations on Land Equivalent Ratio (LER)

IV. CONCLUSION

To improve the pearl millet productivity under sole in semiarid tropics of Hamelmalo:

- Pearl millet varieties Kona and Hagaz produced significantly higher grain yield net return and B: C over Tokroray local variety.
- All the three legumes were equally effective is seed yield under sole cropping, but Groundnut Among the legumes gave highest net return and B: C.
- Intercropping of legumes with pearl millet gave complimentary advantage of yield, Gross return and net returns over sole cropping. Among all the combinations intercropping of groundnut with Kona produced higher grain yield (3076 kg ha^{1}), total grain productivity (3737kg ha-1), gross returns (106355 ERN ha^{-1}) and net returns (71825 ERN ha^{-1})

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