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RESEARCH ARTICLE

EVALUATION OF EARLY MATURING SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] AND COWPEA [*VIGNA UNGUICULATA* (L.) WALP.] VARIETIES INTERCROPPING FOR BIOMASS YIELD IN FEDIS DISTRICT, EASTERN ETHIOPIA

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Abstract

The shortage of arable land and shortage of livestock feed are major constraints in East Hararghe Zone. Thus, a field study was conducted to evaluate early maturing sorghum and cowpea varieties intercropping for feed production at Fedis Agricultural Research Center, eastern Ethiopia in 2018 cropping season. With a total of 11 treatments; Two cowpea varieties (9333 and 9334) and three varieties of early maturing sorghum (Teshale, Birhan and Melkam) and their intercropping compared with sole cropping of all the varieties, which were laid out in a randomized complete block design with three replications. The result showed aboveground dry biomass of sorghum was highly significantly ($p < 0.01$) affected due to sorghum varieties. The highest aboveground dry biomass of sorghum (6.99 t ha^{-1}) was obtained from sorghum Melkam + cowpea (9334) intercropping. The aboveground dry biomass yield of cowpea was significantly ($p < 0.01$) different due to intercropping. The maximum aboveground dry biomass yield of cowpea (8.19 t ha^{-1}) was recorded for sole cowpea (9333). Generally, the results of this study showed that intercropping of sorghum-cowpea were increased the production of biomass yield of sorghum varieties. Based on the results of this study, it concluded that intercropping sorghum with forage cowpea; preferably, sorghum Melkam + cowpea (9333) to appropriate to increase Biomass yield in the study area.

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Introduction:-

Ethiopia has a large livestock population and diverse agro-ecological zones suitable for livestock production and growing diverse types of food and fodder crops. However, livestock production has mostly been subsistence-oriented and characterized by very low reproductive and production performance due to primarily shortages of quality and quantity of animal feed (Maleda, 2013), due to land degradation, land shortage and poor soil fertility (Tewodros et al., 2007) and due to rapidly increasing human population pressure, cropping is expanding and grazing areas are shrinking (Adugna, 2007).

Intercropping provides an opportunity to harness available resources by the cultivation of two or more crops planted simultaneously in the same land that provides the possibility of yield benefit and minimize crop failure (Bhatti et al.,

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2006). A major benefit of intercropping is an increase in production per unit area compared to sole cropping through the effective use of resources (water, nutrients, and solar energy), which reduces weed competitions and stabilizes the yield (Nasriet al. 2014). Farmer generally takes decisions on the technologies to adopt on the bases of cost, risk and return calculation. In small-scale farms, the farmers raise as risk-minimizing measures against total crop failures and the Intercroppingsystemhas long been practiced by smallholder farmers in various tropical and sub-tropical regions worldwide (Brookeret al., 2016).

Sorghum is potential crops in the study area and the average yield production of sorghum is 2.05 t ha⁻¹ in Ethiopia and 2.19 t ha⁻¹ in the region. The low productivity of sorghum in developing countries including Ethiopia could be attributed to many biotic and abiotic factors, like erratic rain full, disease and pest and low soil fertility (CSA, 2017). It considered one means of alleviating the challenges of recurrent drought in Ethiopia. The released varieties have a yield potential of 4.0 to 6.0 t ha⁻¹, which are two to three-fold higher from the national average yield (Taye, 2017). However, there has been limited adoption rate of the improved varieties mainly due to lower biomass production of these varieties in comparison to the landraces (late matured). In order to address the demand for food, feed and fuel farmers predominantly prefer to grow the late maturing sorghum landraces in the majority of dry lowland sorghum growing areas of the country, which requires more than seven months to reach maturity and on the other hand, the released early maturing sorghum varieties have the capacity to escape and/or resist terminal drought stress (Taye, 2017).

Cowpea is among the most widely used legumes in the tropical world. It can be incorporated into the cereal cropping system to address soil fertility decline and cereals to the provision of better legume/stover to cereal (Cooket al., 2005). Food production systems, particularly in cropping systems with limited external inputs, this may be due to some of the potential benefits for intercropping systems such high productivity and profitability (Yildirim and Guyenc, 2005), and farmers can cut and store cowpea fodder for sale at the peak of the dry season Cowpea can be grown under rainfed conditions as well as by using irrigation or residual moisture along river or lake flood plains during the dry season, provided that the range of minimum and maximum temperatures is between 28 and 30 °C (night and day) during the growing season. Cowpea performs well in agro-ecological zones where the rainfall range is between 500 and 1200 mm/year (Madambaet al., 2006).

In East Hararghe Zone, livestock is greatly dependent on crop residues for feed and the farmers usually harvest fodder from thinned crop plants, weeds, and defoliated leaves (Kassa, 2003). However, plants could suffer from severe competition during the early growth stages due to overpopulation and fodder production could be at the expense of grain yield, is thus desirable to generate alternative technologies that enable to produce forage for livestock and enhance efficient utilization of sorghum residue without significant change in sorghum grain yields. In general, intercropping is more productive than mono-cropping (Iqbalet al., 2018). In a study as a whole, intercropping is the main and indigenous activity of the farmers due to land shortage. Most of the farmers are practicing intercropping of different crops for different reasons like to minimize total crop failure and efficient land utilization is the main target. Mixtures of sorghum-legume showed advantages in land-use efficiency expressed as LER than monoculture sorghum (Iqbalet al., 2018). Areas where intercropping is practiced, crop yield is enhanced simply by growing two or more compatible crops without using costly agricultural inputs. Therefore, the objective of this study was to evaluate an early maturing sorghum and cowpea varieties intercropping for both food and feed production with the following specific objectives:

To evaluate stover yield of sorghum and herbage yield of cowpea under intercropping conditions

Materials and Methods:-

Description of the Study Area:

The study was conducted under rain-fed conditions in Fedis Agricultural Research Center, in Fedis District on Boko station, which is 550 km to the East of Addis Ababa and 24 km southeast of Harari city. The Fedis district is situated at an altitude of 1200 to 1600 m and 1500 m of Boko station above sea level, (Fuadet al., 2018). The amount of rainfall varies between 650 and 750 mm, while the average temperature of the district ranges between 25 and 30°C (Zenna, 2016). In the vicinity of the site; Vertisols and Afisols soil type are common to the area. Soil is loam (FARC, 2013)

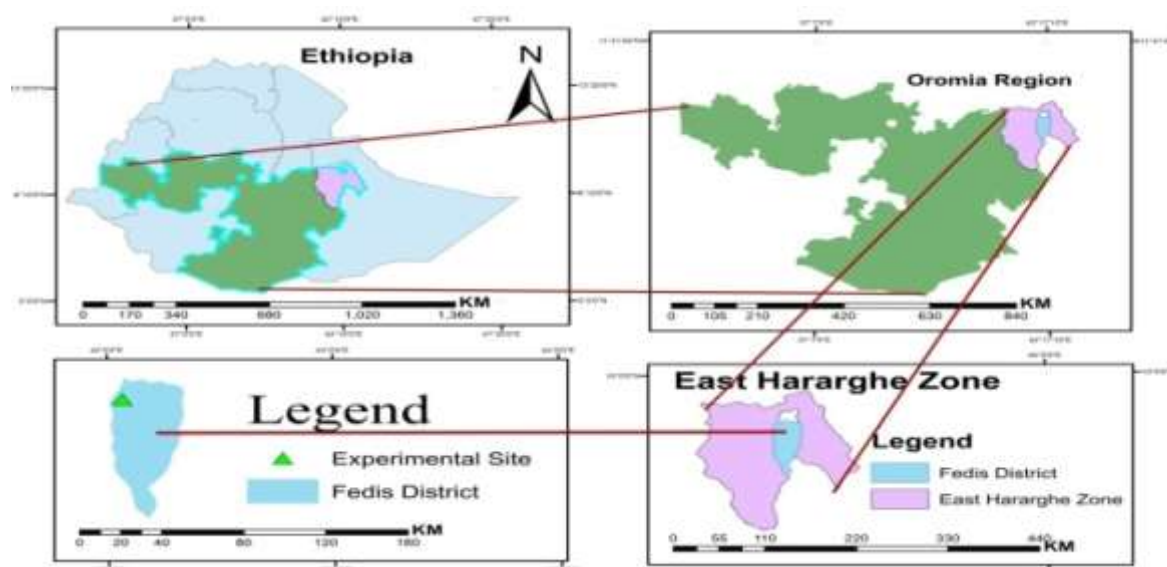


Fig 1:- Map of the experimental site.

The livelihoods in the district comprise of agro-pastoralists and pastoralists the rainfall is bimodal with the Kiremt rain being important in the crop-dependent areas. Fedis is one of the lowland districts with a total population estimated to be 133,382 persons, of which the estimated urban population was 26,575 and the estimated rural population was about 127,877. The main sources of income are agriculture (particularly chat and livestock sales), self-employment (firewood sales) and local labor (harvesting and packing chat). Sorghum and maize are grown for home consumption (ACLF, 2014).

Description of Experimental Materials:

Two-cowpea varieties (9334 and 9333) were used with three varieties of early maturing sorghum (Teshale, Birhan and Melkam). The experimental materials were selected based on their current and potential importance and mainly on their productivity and heights of the plants. Thus, all experimental materials were obtained from Fedis Agricultural Research Center and well performed under the agro-climatic condition of the area. The experiment was done under rain fed conditions.

Treatments and Experimental Design:

Sole cowpea and sorghum, under sorghum-cowpea intercropping, was laid out in a randomized complete block design (RCBD) with three replications in a plot area of $(3 \times 3) \text{ m}^2$, 1m between plot and 1.5m between block. Sorghum was planted on June 28, 2018 at a spacing of 75 cm between rows and 20 cm between plants for sole and intercropping, while cowpea which planted twenty days later (on July 18, 2018) after sorghum was sown. Sole and intercropped cowpea were planted at a spacing of 37.5cm between rows and 10 cm between plants. Sorghum-Cowpea intercropping were planted 1:1 row arrangement as a recommended of Tajudeen and Aliyu (2010) with seed proportion of intercropping 100:100 sorghum + cowpea respectively

Treatment descriptions; T1=Cowpea (9334) + Sorghum (Teshale), T2=Cowpea (9334) + Sorghum (Birhan), T3=Cowpea (9334) + Sorghum (Melkam), T4=Cowpea (9333) + Sorghum (Teshale), T5=Cowpea (9333) + Sorghum (Birhan), T6=Cowpea (9333) + Sorghum (Melkam), T7=Cowpea (9334) sole, T8=Cowpea (9333) sole, T9=Sorghum (Teshale) sole, T10=Sorghum (Melkam) sole, T11=Sorghum (Birhan) sole

Experimental Procedure and Field Management:

Land preparation was done in the middle of April with a tractor, harrowed and leveled before planting. The seed rate of 12 kg ha^{-1} for sole and intercropping sorghum was planted at a row spacing of 75 cm through drip sowing with 5cm deeps when the soil has enough moisture for seed germination then later after 20 days of planted sorghum were sown cowpea varieties the seed rate of 30 kg ha^{-1} for sole and intercropping with a spacing of 37.5 cm for all sole and intercropping. NPS (19% N, 38% P_2O_5 and 7% S) and Urea (46% N) each at the rate of 100 kg ha^{-1} and NPS during planting and Urea after plants emerged 2-3 leaves were used. After emerged of two-three leaves it was

thinned and manual weeding or hoeing was done frequently when the weed emerged and hoeing two times at early stage and after heading of the panicles. The forage samples preparation for quality parameters was done in well precaution manners.

Data Collection and Measurement:

Sorghum component:

Phenology and growth parameters:

Days to 50% flowering:

it was recorded as the number of days from planting to 50% of plants per net plot produced a flower

Days to 90% physiological maturity:

it was recorded as the number of days from planting up to 90% of plants in each net plot formed a black layer on the base of the kernels, which was an indication of maturity.

Leaf area (LA):

Five plants per net plot were randomly taken to measure leaf area per plant (cm^2) at 50% heading using the method described by Sticker et al. (1961) as leaf area = length of the leaves $\times$ maximum width of leaf $\times$ 0.75 where 0.75 is the correction factor for sorghum.

Leaf area index (LAI):

the leaf area index was calculated as the ratio of unit leaf area per plant to the ground area covered by the plant

Plant height:

it was measured at physiological maturity which when the plants became harvesting from the ground level to the tip of panicle from five randomly taken plants and was averaged on per plant basis by using 5m scaled meter.

Aboveground (stover and dry) biomass (g):

it was taken by used 10 plants from the net plot area of plants after grain yield was harvested as soon for herbage and chopping into 5 cm-8 cm length and then sun-dried till constant weight for dry biomass and then converted tone per hectare based by $(10 \times \text{TotFW} \times (\text{DWss}/\text{HA} \times \text{FWss}))$ (Tarawali et al., 1995). Where; TotFW = total fresh weight from a plot in kg, DWss = dry weight of the sample in grams, FWss = fresh weight of the sample in grams, HA = Harvest area meter square and, 10 = is a constant for conversion of yields in kg per m^2 to t ha^{-1}

Cowpea component:

Phenological and growth parameters:

Days to 50% flowering:

It was recorded as the number of days from the date of emergence to when 50% of plants in a plot produced a flower.

Days to 90% physiological maturity:

It was recorded as the number of days from the date of emergence when 90% of plant leaves and pods changed to yellow

Plant height (cm):

Was measured from the middle rows on five randomly taken plants at the flowering stage from the ground to the tip of the plant using 5 m tape.

Aboveground dry biomass weight (g):

It was measured from one row randomly selected from net rows of the plot at 50% flowering stage as soon cutting, then converted to per hectare based; by using the sensitive balance. The dry matter production (t ha^{-1}) was calculated as: $-(10 \times \text{TotFW} \times (\text{DWss}/\text{HA} \times \text{FWss}))$ (Tarawali et al., 1995). Where: TotFW = total fresh weight from a plot in kg, DWss = dry weight of the sample in grams, FWss = fresh weight of the sample in grams, HA = Harvest area meter square and, 10 = is a constant for conversion of yields in kg m^2 to t ha^{-1}

Statistical Analysis:

Data were analyzed using the Statistical Analysis Software to perform ANOVA (SAS 9.1, 2004) in a randomized complete block design. Means of all treatments were calculated and the difference was tested for significance using the least significant difference (LSD) test at $p < 0.05$ (Gomez and Gomez, 1984).

Statistical model was: $Y_{ij} = \mu + \tau_i + \beta_j + \epsilon_{ijk}$, where μ = the overall mean, τ_i = the treatment effect i^{th} , β_j = the block (replication) effect of j^{th} replication and ϵ_{ijk} = error effect

Results and Discussion:-**Sorghum Component:****Crop phenology, Growth parameters and Biomass yield:****Days to 50% flowering:**

of sorghum was recorded and obtained as in Table (1) shows that a significantly different ($p < 0.05$) level of significance among the varieties of sorghum Birhan and Teshale, Birhan and Melkam but statistically not significant among Teshale and Melkam, also not significantly different among cropping systems (intercropping). The maximum days to 50% flowering (79.67 days), that obtained from sorghum melkam. Whereas early flowering was obtained from sorghum Birhan (72 days). The intercropping was not affected days to 50% flowering may due to the gap of planting date of sorghum and cowpea (20 days) so that the planting cowpea was not covered in a good manner under the sorghum for further moisture conservation, nitrogen fixation of the soil and not protect the entrance of solar radiation during the flowered of sorghum.

Days to 90% physiological maturity (Dm):

was highly significant different ($p < 0.01$) among sole and intercropping and varieties of sorghum. In Table (1) result shows that treatments (sole Teshale and sole Melkam) were early matured (140 days) then followed cowpea (9333) + sorghum (Teshale), cowpea (9334) + sorghum (Teshale), cowpea (9334) + sorghum (Mekam), Cowpea (9333) + Sorghum (Mekam) and Sorghum (Birhan) sole (142.33, 143.33, 143.67, 144 and 144.33 days) respectively. Whereas late matured (145.67 days) was obtained from Cowpea (9334) + Sorghum (Birhan) and cowpea (9333) + sorghum (Birhan). Intercropping affects the Days to maturity of sorghum by delaying may be due to moisture conservation and protection of solar radiation. Days to 50% flowering and days maturity disagrees with the reported of Fuadet al. (2018) evaluation of early maturing sorghum east HarargeFedis district in 2015 cropping season reported with the same sorghum varieties the minimum and maximum of those crop ranges from (68.67 to 72.67 days) days of 50% flowering and 117 to 122.7 days taken for maturity. The variation this result may be due to cropping season and cropping systems.

Leaf area index (LAI):

the result indicated that the individual effect of had a significant difference among varieties of sorghum; (Teshale with Birhan, Melkam with Birhan ($p < 0.05$), but not Teshale with Melkam). However, intercropping systems for these characters was not significantly affected. The maximum leaf area index per plant (2.51) was recorded from (T3) cowpea (9334) + sorghum Melkam and the minimum leaf area index plant⁻¹ (1.71) was recorded for (T2) cowpea (9333) + sorghum Birhan. A variety of sorghum Birhan was low LAI in all cases of cropping systems. This result was lined with the result reported by Berhane (2016) the LAI ranges (1.48 to 1.99)

Plant height:

It was observed that plant height of sorghum was significantly ($p < 0.05$) increased in cropping systems among Sorghum Teshale (Cowpea (9334) + Sorghum Teshale (T1), Cowpea (9333) + Sorghum Teshale (T4) and Sorghum (Teshale) sole (T9)) and although significant differences among varieties of sorghum, but not among cropping systems except sorghum Teshale. Intercropping even though statistically not significant numerically increases plant height in all treatments in addition to sorghum Teshale. The maximum plant heights were recorded from T4 (sorghum Teshale + cowpea (9333)) (175.90 cm). The minimum was recorded from T11 (sorghum Birhan sole) (113.40 cm).

The incremental of plant height of sorghum under intercropping of cowpea might be due to soil moisture conservation. Thus, Result disagrees with the result that reported of Islamet al. (2018) in Pakistan intercropping reduced plant height, sole millet gave maximum height (250.33 cm) and the minimum produced plants of (241 cm) one row of millet alternating with one row of cowpea. The difference may be due to the behaviors (varieties) of the plants and seed proportion.

Table 1:- Phenological, growth parameters and biomass yield of sorghum varieties under intercropping with cowpea varieties and sole cropping .

Cropping systems	Trts	Df	Dm	LAI	Plh	AGHY	ADBM	GY
		-50%	-90%		(cm)	(t ha ⁻¹)	(t ha ⁻¹)	(kg ha ⁻¹)
Intercropped	T1	79.33 ^a	143.33 ^b	2.21 ^{ab}	175.40 ^a	13.66 ^a	6.37 ^a	3928.30 ^{bc}
Sorghum	T2	72.00 ^b	145.67 ^a	1.71 ^c	116.33 ^d	7.54 ^c	4.02 ^{bcd}	2511.10 ^d
	T3	79.67 ^a	143.67 ^{ab}	2.51 ^a	167.13 ^{bc}	14.23 ^a	6.99 ^a	4752.60 ^{ab}
	T4	77.00 ^a	142.33 ^b	2.41 ^a	175.93 ^a	11.88 ^{ab}	5.82 ^{ab}	4410.10 ^{ab}
	T5	72.00 ^b	145.67 ^a	1.83 ^{bc}	117.20 ^d	7.62 ^c	3.43 ^d	2670.90 ^d
	T6	79.00 ^a	144.00 ^{ab}	2.22 ^{ab}	165.60 ^{bc}	14.47 ^a	6.61 ^a	4867.30 ^a
	T7	79.33 ^a	140.00 ^c	2.32 ^a	170.60 ^b	11.60 ^{ab}	5.64 ^{abc}	4491.60 ^{ab}
Sole sorghum	T8	77.33 ^a	140.00 ^c	2.48 ^a	165.27 ^{bc}	14.05 ^a	6.62 ^a	5080.10 ^a
	T9	72.00 ^b	144.33 ^{ab}	1.85 ^{bc}	113.40 ^d	8.01 ^c	4.18 ^{cd}	3055.90 ^{cd}
CV (%)		3.1	0.93	10.89	4.96	15.99	18.39	13.31
P		**	**	*	**	**	**	**
LSD (0.05)		4.06	2.29	0.41	8.52	3.195	1.76	915.5

Means within the same column followed by the same letter or by no letters of each factor do not differ * = significant different (0.05), ** = significant different (0.01) significantly at 5% probability level, Df = days to 50% flowering; Dm = days to 90% maturity; LAI = leaf area index, plh= plant height in centimeter, LSD = Least significant difference; CV= coefficient of variance T1 = Cowpea (9334) + Sorghum (Teshale); T2 = Cowpea (9334) + Sorghum (Birhan); T3 = Cowpea (9334) + Sorghum (Melkam); T4 = Cowpea (9333) + Sorghum (Teshale); T5 = Cowpea (9333) + Sorghum (Birhan); T6 = Cowpea (9333) + Sorghum (Melkam); T7 = Cowpea (9334) sole; T8 = Cowpea (9333) sole; T9 = Sorghum (Teshale) sole; T10 = Sorghum (Melkam) sole and T11 = Sorghum (Birhan) sole

Aboveground stover and dry biomass yields (t ha⁻¹):

the result that obtained dry biomass and stover yields of sorghum in Table (1) was highly significant among sorghum varieties. However, it was non-significant between sole and intercropping of sorghum stover. However, intercropping was numerically increased above ground stover yield and dry biomass yield except Sorghum Birhan intercropping. The highest aboveground stover herbage biomass yield was obtained from T6 (14.47 t ha⁻¹), T3 (14.22 t ha⁻¹) and T10 (14.05 t ha⁻¹) and the highest aboveground dry biomass yield was obtained from sorghum T3 (6.99 t ha⁻¹), T6 (6.61 t ha⁻¹) and T1 (6.37 t ha⁻¹). The minimum was obtained from sorghum Birhan+ cowpea (9333) (T5) (3.43 t ha⁻¹). Which result disagrees with the result reported by Azrafet al. (2007) during 2005, the average forage yield of 40.70 t ha⁻¹ thus match greater than the result that was obtained (11.55) t ha⁻¹, although sorghum is grown alone produced statistically similar forage yield under all the planting patterns it was significantly higher than the intercropped sorghum except that intercropped with cluster bean or cowpea. The reason sorghum Birhan Aboveground herbage and dry biomass yield reduction under intercropping was because the height of sorghum Birhan might interactive with the height of cowpea.

The incremental of Aboveground herbage and dry biomass yield under intercropping of sorghum Melkam and sorghum Teshale may due to incremental of plant height of sorghum moisture conservation and water use efficiency so maximum vegetative growth of the plant's availability for plant growth process including chlorophyll which is responsible for the dark green color of stem and leaves which enhance vigorous vegetative growth. Thus result similarly with Gerenet al. (2008), when maize was planted in alternate rows (1:1) with cowpea, comparatively better agronomic growth of component crops led to the highest fresh and dry biomass owing to more number of plants per unit land area but disagreed with the finding of Berhane (2016) intercropping highly significantly affected dry biomass yield of sorghum.

Cowpea Component:

Phenological, growth parameters and Yield components and yield:

Days to 50% flowering:

the result that was obtained in Table (2) indicated that (p < 0.01) a significantly different among the Varieties of cowpea. However except T6 (Cowpea (9333) + sorghum Melkam; intercropping did not affect the days to 50% flowered of cowpea. The maximum days were taken by the varieties of cowpea (9334) sole, and there intercropped

with sorghum varieties as shown in a Table (2) the maximum Df 50% was recorded of T1, T3 and T7 (68 days), followed by T2 and T6 (67 days and 65 days) respectively. The minimum days to 50% flowering of was recorded of cowpea varieties (9333) sole and there intercropped of (T4, T5 and T8 (61.33, 61.67 and 61.67) days) respectively. Because of early maturing sorghum (main crops) had a shorter height, smaller leaf area and leaf area index so not much protection as a shade from solar radiation especially at this stage except T6; intercropping was increased days of flowering by 5.35% because sorghum Melkam had leaf area was highest than the main tasted crops.

Days to physiological maturity:

The result showed highly significant differences among cowpea varieties and within their intercropped. The result in Table (2) of sole cowpea (9334) (T7) and cowpea (9334) + sorghum Melkam (T3) had a significant. However except T3 among sole and intercropping, there was no statistically significant, but numerically intercropping increased days to maturity. The late days to maturity recorded of T3 (109.33 days) T2 (108 days) and T1(106.33) where the early days of maturity were obtained from sole cowpea(T8), cowpea (9333) + sorghum Birhan (94 days) and T4 (94.67days). Days to maturity of cowpea affected by plant height of the sorghum

Table 2:- Phenology, growth parameters, Yield components and yield of cowpea varieties under intercropping with sorghum varieties.

Cropping systems	Trts	Df	Dm	Pth	NP/P	NS/P	HSW	AHY	ADBY	GY
		(50%)	(75%)	(cm)			(g)	(t ha ⁻¹)	(t ha ⁻¹)	(kg ha ⁻¹)
Intercropped	T1	68.00 ^a	106.33 ^{ab}	66.07 ^{bc}	9.53 ^{bc}	12.07	7.70 ^c	16.29 ^b	2.8 ^b	298 ^b
Cowpea	T2	67.00 ^{ab}	108.00 ^{ab}	68.37 ^b	12.53 ^a	10.47	8.07 ^c	22.7 ^b	3.86 ^b	430.4 ^b
	T3	68.00 ^a	109.33 ^a	64.57 ^c	9.27 ^{bcd}	12	7.77 ^c	15.8 ^b	2.66 ^b	317.2 ^b
	T4	61.30 ^c	94.67 ^c	78.47 ^a	7.07 ^d	11.73	14.8 ^b	18.22 ^b	3.44 ^b	360.2 ^b
	T5	61.70 ^c	94.00 ^c	80.13 ^a	8.13 ^{cd}	10.2	15.87 ^a	23.7 ^b	4.19 ^b	486 ^b
	T6	65.00 ^b	96.00 ^c	75.07 ^{abc}	8.13 ^{cd}	10.93	14.43 ^b	18.39 ^b	3.11 ^b	319.1 ^b
Sole Cowpea	T7	68.00 ^a	105.00 ^b	65.20 ^{bc}	11.67 ^{ab}	11.6	8.10 ^c	46.7 ^a	7.21 ^a	873.3 ^a
	T8	61.70 ^c	94.00 ^c	75.67 ^{ab}	7.67 ^{cd}	10.67	16.10 ^a	45.47 ^a	8.19 ^a	1000.8 ^a
CV (%)		2.2	1.9	8.7	18.95	10.32	5.18	24.3	28.57	31.05
P		**	**	**	*	Ns	*	**	**	**
LSD (0.05)		2.45	3.36	5.13	3.11		1.05	11	2.22	277.62

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level, * = significant different (0.05), ** = significant different (0.01) LSD= Least significant difference; CV= coefficient of variance; Df=days to flowering; Dm=days NP/P = number of pods per plant; NS/P = number of seeds per pod, HSW = hundred seed weight in; maturity and pth=plant heights, Ns= none significant(0.05),), AHY = above ground herbage yield; ADBY = aboveground dry biomass yield; GY = grain yield;

Plant height:

It was observed that the plant height of among cowpea varieties was significantly different ($p < 0.05$) level of significance. However, cropping systems (intercropping) were not affected by plant height statistically. The maximum height recorded by cowpea varieties (9333) of T5 (80.13 cm). The minimum cowpea height obtained from cowpea varieties (9334) of T3 (64.57 cm). In addition to the height; cowpea (9333) had the ability to climbing and supported by sorghum. As the height of main crops increased, the height of cowpea was decreased due to shading ability and competitions of main crops increased. Thus, phenomena observed in cowpea (9334) genotype

Pods per plant:

the sole cowpea varieties and intercropped were significant differences in Table (2) the highest pods per plant were observed cowpea (9334) while the least number of pods per plant was recorded of T8 The highest number of pods per plant was recorded T2 and T7 (12.53 and 11.67), respectively. The lowest pods plant⁻¹ recorded by cowpea (9333)(T4) + sorghum Teshale (7.07). This result indicates that the pods per plant of cowpea (9334) significantly affected by sorghum varieties than cowpea (9333) because of the behaviors and compatibility of the plant. Cowpea (9333) (T8) was taller, had the ability of climbing and compatible also not affected by intercropping. Even if cowpea (9334) had the highest pods per plant, as sorghum height increased the pods per plant was decreased. This result

agreed with the finding of Thomas and Eliakira (2014) cowpea intercropping with maize, pods per plant differed significantly obtained in cowpea planted in the sole and those obtained from the intercropping system.

Seeds per pod and 100 seed weight:

the data pertaining to the number of seeds per pod not influenced by varieties and cropping system indicated no significant differences ($p > 0.05$) among all treatments. Table (2) showed that there was a significant effect of varieties and cropping systems on the 100 seed weight of cowpea at ($p < 0.01$) level significant difference. Cropping system showed significant effect among treatments of cowpea (9333) of Cowpea (9333) + Sorghum Teshale(T4) and Cowpea (9333) + Sorghum Melkam(T6) with Cowpea (9333) + Sorghum Birhan (T5) and sole Cowpea (9333) (T8) also among cowpea varieties (9334 and 9333) highly significant difference. The highest 100 seed weight was recorded sole cowpea (9333)(16.10 g) and cowpea (9333) + sorghum Birhan (15.87g). Nearest followed by cowpea (9333) + sorghumMelkam (14.43) and Teshale (14.80 g).

The lowest 100 seed weights were obtained from cowpea (9334) under sole and intercropping ranges (8.10 g to 7.70 g). Thus result indicated that plant height of the main crop affected hundred seed weights of cowpea (9333) statistically and thus result in variations was may be due to the size of a seed, relative dominancy among the main crops and competition of environmental growth resource and the shading effect of sorghum.

Above ground herbage (fresh) yield of cowpea:

The result indicated that in (Table 2) a highly significant difference ($p < 0.01$) among cropping systems (sole and intercropping cowpea) but aboveground herbage yield not significantly affected by cowpea varieties. The maximum above ground herbage yield of cowpea recorded from T7 (sole cowpea (9334)) and T8 (sole cowpea (9333)); (46.7 t ha⁻¹ and 45.47 t ha⁻¹) in a consecutive manner. The minimum herbage yield obtained of T1 and T3;(16.29 t ha⁻¹ and 15.8 t ha⁻¹) respectively. Thus major significant variation mainly due to the distances between rows of cowpea among sole cowpea and under cowpea-sorghum intercropped and the entrance of solar radiation for photosynthesis due to shading effect. Similarity with the finding of Surveet al. (2011) when the row proportion of the legume intercrop was increased, enhanced but overall biomass production was decreased.

For smallholder farmers' perspective and selection availability; in addition to statistically, numerically which cowpea better compatible with sorghum varieties in a constant manner must issue. Based on this idea cowpea (9334) herbage yield affected by plant heights and leaf broadness of sorghum than cowpea (9333). In Table (2) showed that cowpea (9334) the average of aboveground herbage yield was 18.63 t ha⁻¹ under sorghum intercropping whereas cowpea (9333) the average above ground herbage yield was 20.11 t ha⁻¹ the variation between two cowpea varieties herbage yield was accounted 1.47 t ha⁻¹. Therefore, cowpea (9333) suitable under sorghum-cowpea intercropped for herbage yield. A similar finding on Maize-cowpea reported by Dhonde, (2014) mean green fodder yield of cowpea was recorded 103.21 q ha⁻¹. The sole crop of cowpea was recorded highest green fodder yield of 315.00 q ha⁻¹

Dry biomass yield:

the result showed that dry biomass yield of intercropped cowpea was highly significantly affected by cropping systems. The maximum dry biomass yield of cowpea recorded from T8 (sole cowpea (9333)) and T7 (sole cowpea (9334)); (8.19 t ha⁻¹ and 7.21 t ha⁻¹) in a consecutive manner. The minimum dry biomass yield obtained of T3 (Cowpea (9334) + sorghum Melkam) and T1 (cowpea (9334) + sorghum Teshale); (2.66 t ha⁻¹ and 2.80 t ha⁻¹) followed by Cowpea (9333) + Sorghum Melkam (T6), Cowpea (9334) + Sorghum Teshale(T4), Cowpea (9334) + Sorghum Melkam (T3) and Cowpea (9333) + Sorghum Birhan (T5); (3.11, 3.44, 3.86 and 4.19) t ha⁻¹ respectively. This increment order of dry biomass yield might be due to the shading and solar radiation entry attributed by sorghum. The increment in dry biomass production of sole cropped cowpea might be attributed to seed proportion of cowpea varieties, absence of competition and thus, more dry matter accumulation in stem, branches and leaves matter because of its good vegetative cover to harvest ample solar radiation important for its photosynthesis. This result confirmed with the findings of Karanja et al. (2014) who reported that sole cropped gave higher dry biomass yield than the intercropped. Likewise, Getachew et al. (2013) reported that dry biomass of forage legumes was significantly affected due to sole and intercropping when intercropped with maize. Iqbal et al. (2012) conducted a field experiment on the productivity of summer legume forage intercropped with maizethe highest dry matter yield (2.039 t ha⁻¹) was obtained from cowpea.

Summary and Conclusion:-

Ethiopian has a large livestock population and diverse agro-ecological zones suitable for livestock production and growing diverse types of food and fodder crops. However, livestock production has mostly been subsistence-oriented and characterized by very low reproductive and production performance; due to primarily shortages of quality and quantity of animal feed. Mainly due to land degradation, land shortage and poor soil fertility and rapidly increasing human population pressure and as a result, cropping was expanding and grazing areas are shrinking through time to time with including East Hararghe Zone. Therefore, the study was conducted to evaluate an early maturing sorghum and cowpea varieties intercropping for their herbage, grain and stover yields in Fedis District East Hararghe, Ethiopia in 2018 cropping season under rainfed conditions. Therefore, it concluded that use intercropping of sorghum with forage legumes preferably sorghum Melkam + cowpea (9333) recommended for farmers for the production of forage in the study area and other areas with similar agro-ecological conditions.

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References:-

1. ACLFE (Action Contre La Faim Ethiopia report). 2014. Final report: nutrition causal analysis, East Hararghe Zone, Fedis and Kersa District, Ethiopia.
2. Adugna Tolera. 2007. Feed resources for producing export quality meat and livestock in Ethiopia. Ethiopia Sanitary and Phytosanitary Standards and Livestock and Meat Marketing project (SPS-LMM). 77
3. Azraf-Ul-Haq Ahmad, Riaz Ahmad, Naeem Mahmood and Tanveer.A. 2007. Performance of Forage Sorghum Intercropped with Forage Legumes under different planting patterns Pakistan. *Journal of Biotechnology*, 39(2): 431-439.
4. Berhane Sibhatu, Ketema Belete and Taye Tessema. 2015. Effect of Cowpea Density and Nitrogen Fertilizer on a Sorghum-Cowpea Intercropping System in Kobo, Northern Ethiopia *International Journal of Agriculture and Forestry*, 5(6): 305-317
5. Berhane Sibhatu. 2016. Evaluation of Cowpea Plant Density and Nitrogen Fertilizer for Productivity of Sorghum/Cowpea Intercrops at Abergelle, Northern Ethiopia. *Journal of Natural Sciences Research*
6. Bhatti, I.H., Ahmad, R.I.A.Z., Jabbar, A.B.D.U.L., Nazir, M.S. and Mahmood, T. 2006. Competitive behavior of component crops in different sesame-legume intercropping systems. *International Journal of Agriculture and Biology (Pakistan)*.
7. Brooker, R.W., Karley, A.J. Newton, A.C. Pakeman, R.J. Schöb C. 2016. Facilitation and sustainable agriculture: a mechanistic approach to reconciling crop production and conservation. *Function of Ecology*. 30(1): 98-107.
8. Cook, D.R., Zhu, H., Choi, H.K. and Shoemaker, R.C. 2005. Bridging model and crop legumes through comparative genomics. *Plant Physiology*, 137(4): 1189-1196.
9. CSA (Central Statistical Agency). 2017. Sorghum production in Ethiopia
10. Dhonde A.S. 2014. Intercropping of Maize (*Zea Mays* L.) + Cowpea (*Vigna Unguiculata*) For Higher Production of Green Fodder. MSc Thesis
11. Fuad Abduselam, Samuel Tegene, Zeleqe Legese, Fikadu Tadesse, Alemayehu Biri and Taye Tessema. 2018. Evaluation of Early Maturing Sorghum (*Sorghum bicolor* (L.) Moench) Varieties, for Yield and Yield Components in the Lowlands of Eastern Hararghe. *Asian Journal of Plant Science and Research*, 8(1): 40-43
12. Geren, H., Avcioglu, R., Soya, H. and Kir, B., 2008. Intercropping of corn with cowpea and bean: Biomass yield and silage quality. *African Journal of Biotechnology*, 7(22).
13. Getachew B., Ketema B. and Sharma J.J. 2013. System Productivity of Forage Legumes Intercropped with Maize and Performance of the Component Crops in Kombolcha, Eastern Ethiopia. *East African Journal of Sciences*, 7(2): 99-108.
14. Iqbal A., Akbar N., Khan H. Z., Abbas R. N. and Ahmad. 2012. The productivity of summer legume forage intercropping with maize as affected by mixed cropping in different sowing techniques. *Journal of plant of animal science*, 22(3): 758-763.

15. Iqbal M. 2018. Comparative performance of forage cowpea accessions as companion crops with sorghum under varied harvesting times. *Bragantia*, 77: 476-484. <http://dx.doi.org/10.1590/1678-4499.2017247>
16. Iqbal M., Iqbal A., Maqbool Z., Ahmad Z., Ali E., Siddiqui M. and Ali S. 2018. Revamping soil quality and correlation studies for yield and yield attributes in sorghum-legumes intercropping systems. *Bioscience Journal*, 34: 1165-1176
17. Islam, N., Zamir, M.S.I., Din, S.M.U., Farooq, U., Arshad, H., Bilal, A. and Sajjad, M.T. 2018. Evaluating the Intercropping of Millet with Cowpea for Forage Yield and Quality. *American Journal of Plant Sciences*, 9: 1781-1793. <https://doi.org/10.4236/ajps.2018.99130>
18. Karanja, S. M., Kibe, A. M., Karogo, P. N. and Mwangi, M. 2014. Effects of Intercrop Population Density and Row Orientation on Growth and Yields of Sorghum - Cowpea Cropping Systems in Semi-Arid Rongai, Kenya. *Journal of Agricultural Science*, 6 (5): 1-43.
19. Kassa, Belay H. 2003. Livestock and livelihood security in the Highlands of Ethiopia. Implications for Research and Development. PhD Thesis, Swedish University of Agricultural Sciences, Uppsala, Sweden.
20. Madamba, R., Grubben, G. J. H., Asante, I. K., Akromah, R. 2006. *Vigna unguiculata* (L.) Walp record from protabase. Brink, M. and Belay, G. (Eds). PROTA (Plant Resources of Tropical Africa), Wageningen, Netherlands.
21. Maleda Birhan. 2013. Role of Seeding Rates and Cutting Stages on Yield and Quality of Forage Intercropping in the Case of North Gondar, Ethiopia, LAP, LAMBERT Academic Publishing, Germany, ISBN: 978-3-659-25690-5-1.
22. Mohammed I., Olufajo O., Singh B., Miko S. and Mohammed S. 2008. Evaluation of Yield and Yield Components of Sorghum/Cowpea Intercrops in the Sudan Savanna Ecological Zone. *Asian Journal of Agricultural and Biological Science (ARPN)*, 3(3):22-24
23. Nasri, R., Kashani, A., Barary, M., Paknejad, F., and Vazan, S. 2014. Nitrogen uptake and utilization efficiency and the productivity of wheat in double cropping system under different rates of nitrogen. *International Journal of Biological science*, 4(4):184-193.
24. Tajudeen O. and Aliyu, I. 2010. Effect of row arrangements on sorghum-cowpea intercrops in the semi-arid savannah of Nigeria. *International Journal of Agriculture and Biology*, 12:137-140.
25. Tarawali, S.A., G. Tarawali, A. Lirbi and J. Hanson, 1995. Method for the evaluation of Forage legumes, Grasses and Fodder Trees for Feed Use as Livestock Feed. *International Livestock Research Institute*; Nairobi, Kenya.
26. Taye Tadesse. 2017. Improved sorghum varieties for better livelihood <http://www.ethpress.gov.et/herald/index.php/technology/item/7369-improved-sorghum-varieties-or-better-livelihood>
27. Tewodros Tefera, Kebebe Ergano and Waktola Tiki, 2007. Operational Research and Capacity Building for Food Security and Sustainable Livelihoods. Proceeding of Irish Supported Operational Research Project review Workshop. 2007. Hawassa
28. Wondimu Bekele, Ketema Belete and Tamado Tana. 2016. Effect of Soybean Varieties and Nitrogen Fertilizer Rates on Yield, Yield Components and Productivity of Associated Crops Under Maize/Soybean Intercropping at Mechara, Eastern Ethiopia. *Agriculture, Forestry and Fisheries*, 5 (1): 1-7.
29. Yildirim, E. and Guvenc, I. 2005. Intercropping based on cauliflower: more productive, profitable and highly sustainable. *European Journal of Agronomy*, 22(1):11-18.
30. Zenna T. 2016. Business and management consultancy (TZBMC), CARE ABDISHE/linking initiatives, stakeholders to achieve gender-sensitive livelihood security (LINKAGES) project end line evaluation report.