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Evaluation of Double Cropping System for Sorghum Production at Fedis, Eastern Ethiopia

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Abstract: Mono-cropping of sorghum is usual practice by small holders in Eastern Hararghe zone which aggravates the infestation of striga in case of susceptible varieties and has risk of crop failure in most cases due to erratic and unreliable rainfall. Thus, it was important to undertake research on cropping system which can make the farmers less vulnerable to current changing climate. Thus, an experiment was done to assess the effect of double cropping on yield, and yield components of the sorghum and compare the productivity of the double cropping with the single cropping system. The study was conducted at Fedis Research station, Eastern Hararghe during cropping season of 2015 by including two sowing time the first in April and the other during July using RCBD design. The treatments consisted were twelve including two farmers' practices (long cycle sorghum and July planting of improved sorghum varieties) and the remaining ten treatments were double cropping of common bean and mung bean each with two varieties, lablab, cowpea, buckwheat, pearl millet, sorghum and bread wheat as preceding crops and sorghum variety Gubiye as succeeding crop. Overall, the preceding crops showed highly significant ($p < 0.01$) difference on days to 50% flowering, days to maturity, grain yield and above ground dry biomass. The earliest days to 50% flowering were buckwheat (25.67 days) followed by common bean (var. Batu) 36 days and mung beans (var. Borada and N-26) with 38 and 38.33 days respectively. The highest above ground dry biomass was obtained from lablab (var. 147) (6116 kg ha $^{-1}$) while the highest economic benefit was recorded from mung bean (var. N-26)(30315 ETB ha^{-1}). During succeeding crops days to 50% emergence, days to 50% flowering, days to maturity, plant height, panicle length, grain yield and thousand kernel weight were highly significantly($p < 0.01$)affected by the preceding crop while above ground dry biomass and harvest index were significant ($p < 0.05$) during the study. The latest days to 50% flowering (160.67 day) and highest days to maturity (221 day), above ground dry biomass (6119 kg ha^{-1}) and grain yield (3369 kg ha^{-1}) were observed for the local sorghum. However, highest grain yield was obtained from local sorghum followed by common bean (var. Batu)-Gubiye, common bean (var. Awash melka)-Gubiye and mung bean (var. N-26)-Gubiye sequences with 3369, 2342, 2107 and 2094 kg ha^{-1}, respectively. Thus mung bean (var. N-26)-Gubiye sequence can be considered as profitable cropping sequence and recommended.

Keywords: Cropping Sequence, Diversification, *Sorghum Bicolor* (L.) *Monech*

1. Introduction

Rain-fed agricultural areas of East Africa are often food insecure due to rainfall variability and ongoing soil degradation that negatively impacts crop yields. Agricultural activities and consequently the livelihoods of people reliant on agriculture will be affected by changes in temperature and precipitation conditions in large parts of Sub-Saharan Africa (SSA) [15]. The most influential climatic variables for crop production in East Africa including Ethiopia and Hararghe as well are temperature and rainfall. Low and unreliable rainfall prevalent in many parts of the lowland areas of Hararghe lowlands means a high incidence of drought and crop failure, further contributing to food insecurity and poverty. Small land holdings and shortage of assets of the poor people in the area further limit the choice of crop to sorghum which is long maturing. The smallholder farmers must plant sorghum to the majority of their land to have a chance of providing enough food for their family as sorghum is known to be ‘‘camel of crops ’’ though during harsh seasons even total crop failure can occur.

What so ever, mono-cropping of sorghum whether it is long or early maturing is their usual practice which aggravates the infestation of *striga* in case of susceptible varieties and has risk of crop failure in most cases due to erratic and unreliable rainfall [17]. Basically, the farming system should be revised in the cropping areas of Fedis, and similar dry lowlands of Hararghe. Since eight-month-cycle sorghum being rain-fed, is simply late maturing and too vulnerable to pests and dependent on rainfall patterns. A re-orientation towards shorter cycle crops like early maturing sorghum, pulses and oil crops would help farmer’s better cope with the climatic hazards of the area [17]

However, farmers in Fedis area are accustomed to sow the local varieties from end of March to the middle of April though they know the advantage of using improved sorghum varieties reduce risk of *striga* and yield. This is because farmers do not want to leave their land idle when the rain starts early in March/April until the right planting time of the early maturing *striga* resistant sorghum varieties. Whereas, these improved varieties are sown after the local varieties from middle of June to the beginning of July and farmers who are adopting improved sorghum varieties are forced to leave their land idle to synchronize its maturity with long maturing sorghum varieties to reduce the high bird infestation prevailing in the area.

So, this puts the farmers in a dilemma whether to sow early at the onset of rainfall or leave their land idle until the time of sowing for improved and *striga* resistant sorghum varieties. To alleviate this problem, to use effectively the rainfall before the middle of June to reduce the infestation of *striga*, diversify risk of crop failure and to intensify production of farmers, it is important to undertake research on cropping system which help the farmer by comparing their already accustomed and untimely sorghum planting practice with double cropping of improved and early maturing crop varieties followed by planting of early maturing sorghum varieties and evaluation of the system. This practice is believed to provide more biomass and yield for the growers. With this background, this study was done with the following objectives: to assess the effect of double cropping on yield, and yield components of the sorghum; and to compare the productivity of the double cropping system with the single cropping system.

2. Materials and Methods

2.1. Description of the Experimental Site

The experiment was conducted at Fedis Agricultural Research Center in Fedis district, Boko research station of eastern Hararghe Zone of Oromia region. Fedis district has latitude between 8°22’ and 9°14’ North and longitude between 42°02’ and 42°19’ East, in middle and low land areas: altitude range is from 1200 – 1600 m. a. s. l, with a prevalence of low lands. The district receives average annual rain fall of 400 - 804 mm; the minimum and maximum air temperature of 20 – 25°C and 30 – 35°C, respectively [17]. Boko is 24 km far from Harar town in the South direction. Commonly sorghum is the staple crop cultivated by farmers, in the vicinity of the site. *Vertisols* and *Afilsols* soil type are common to the area [9]. Soil is loam in texture with pH of 7.4 [8]

As in the most of the Horn of Africa, two rainy seasons characterize Fedis woreda’s climate. The first named ‘Belg’ is the shortest one and takes place between March and May, while the second and the most important is ‘Meher’ between July and October. The rainfall distribution during the year is bi-modal, with a dry-spell period during the months of June and July which, depending on its duration, may affect crop growth.

2.2. Treatments and Experimental Design

A field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and twelve treatment combinations consisting of two farmers’ practices as control in sole cropping system which were early planted in April (Local sorghum) and late planted in July (Fallow-Gubiye). Plot size used was 3.75 m x 3 m for each crop during both seasons.

The experimental materials used for this study were divided into two, which were used as preceding and succeeding crops. The crops used as preceding were selected on the basis of their current and potential importance and mainly for their early maturity. The succeeding crop used was sorghum variety ‘Gubiye’.

The crops selected as a preceding crop were: mung bean and common bean each with two varieties from pulses; pearl millet, sorghum and bread wheat each one variety from cereals; lablab, cowpea and buckwheat each with one variety and one fallow and local sorghum (var. Muyra) were included as farmers practice or control, while sorghum variety ‘Gubiye’ was used as succeeding crop.

Di Ammonium Phosphate (18% N and 46% P_2O_5) was used as a source of nitrogen and phosphorus at planting and Urea (46% N) was used as source of nitrogen after one month of planting during both preceding and succeeding crop. The recommended fertilizer rates of phosphorus and nitrogen were used for all crops in the experiment.

2.3. Data Collection

2.3.1. Data Collected for Preceding Crops

Phenological and Growth parameters

Data collected for phenology and growth were the same for all crops. The parameters were days to 50% emergence, days to 50% flowering and days to physiological maturity. The remaining parameters of yield components and yield: grain yield and aboveground dry biomass yield were collected for all preceding crops in the experiment.

2.3.2. Data Collected for Succeeding Crop

Data collected for phenology and growth and yield components and yield were: Days to 50% emergence, Days to 50% flowering, days to maturity, Plant height, Panicle length, Crop stand count, Thousand kernel weights (g), Grain yield (kg ha^{-1}), Aboveground dry biomass yield (kg ha^{-1}), Harvest Index, Total Above Ground Biomass of the Cropping System.

2.4. Statistical Data Analysis

Analysis of variance for the design was carried out using Genstat 15th edition software for the parameters studied following the standard procedures outlined by [10]. The level of significance used in 'F' and 't' test was P =0.05. When the treatment effects were found to be significant, the means were separated using the Fisher's protected least significant difference (LSD) test at 5% level of probability.

3. Result and Discussion

3.1. Preceding Crops

Comparison of crops that have different economic part, growth patterns and yield components is so difficult. However, since one of the objectives was to select the best sequential combination for 'Belg' season to be followed by sorghum which is considered as major crop and grown during 'Meher'. One of the characteristics that are required to be fulfilled is its earliness before time of planting for sorghum for *'Meher'* from end of June up to mid-July. Thus, the major considered data for the preceding crops were days to flowering, days to maturity, above ground biomass and yield obtained as it is summarized in Tables 1.

Table 1. *Days to 50% flowering, days to maturity, above ground dry biomass and grain yield of preceding crops grown during "Belg" season at Fedis in 2015.*

Preceding crops	Days to 50% flowering	Days to maturity	AGDBM (kg ha^{-1})	Grain yield (kg ha^{-1})
Lablab (var. 147)	100.67^{a}	-	6166^{a}	-
Sorghum (var. 76T1#23)	67.67^{b}	111.00^{b}	3680^{bc}	-
Cowpea (var. #12688)	65.67^{b}	126.67^{a}	3782^{bc}	1736^{a}
Bread wheat (Jafferson)	50.00^{c}	78.00^{f}	2151^{d}	-
PM (var. Kola-1)	47.33^{cd}	107.67^{c}	4996^{ab}	-
CB (var. Awash melka)	42.33^{de}	101.67^{d}	3742^{bc}	1519^{b}
MB (var. N-26)	38.33^{ef}	78.00^{f}	3843^{bc}	1213^{cd}
MB (var. Borada)	38.00^{ef}	80.00^{f}	4577^{b}	1188^{d}
CB (var. Batu)	36.00^{f}	83.67^{e}	2877^{cd}	1397^{bc}
Buckwheat (var. Shashe)	25.67^{g}	127.33^{a}	1730^{d}	385^{e}
P	**	**	**	**
LSD (0.05)	6.298	3.019	1511.9	193.5
CV (%)	7.2	1.8	23.5	8.6

**= significant at P = 0.01LSD (0.05) = Least Significant Difference at 5% level; CV= coefficient of variation, PM=pearl millet, CM= common bean, MB=mung bean, Means in column followed by the same letter(s) are not significantly different at 5% level of significance.

Days to 50% flowering and days to 50% maturity were highly significantly varied at (P < 0.01) among the preceding crops used in the study. Days to 50% flowering and days to maturity were not recorded for the local sorghum variety since the local sorghum variety was still at its vegetative growth stage. Similarly, days to maturity was not recorded for the lablab as it was at flowering stage when the succeeding crop was planted. Days to 50% flowering was earliest (25.67 days) for buckwheat, but it stayed for long time before it started to set seed and matured. Buckwheat grows in the shortest time period of all cover crops [2] flowering within 3 to 6 weeks and completely maturing within 11 to 12 weeks and flower continuously for several weeks (Bjorkman *et al.,* 2008). Similarly, common bean (var. Batu), mung bean (var. Borada), mung bean (var. N-26) and common bean (var. Awash Melka) took 36, 38, 38.33 and 42.33 days to 50% flowering, respectively (Table 1). The wide variation in days to flowering was due to differences among the species.

Similarly, common bean varieties Awash Melka and Batu matured early with 101.67 and 83.67 days, respectively, while cowpea and buckwheat were late with days to maturity of 126.67 and 127.33, respectively (Table 1). Pearl millet and mung bean varieties were also early maturing. At the same time forage lablab was also at flowering stage while the other legumes and cereals were ready to harvest during preceding crop however, it was harvested at vegetative stage. The early maturity of legumes especially common bean and mung bean will make them preferable for double cropping system especially where they can be used as food during annual hungry gap as also reported by [5] and also can be used as cash crop.

Overall, days to maturity were highly significantly (P<0.01) different among the species at Boko during the study. Crops that can fit for double cropping were identified in general though the crops are different and their uses also differ. Above ground dry biomass yield and grain yield obtained were highly significantly (P< 0.01) different among the treatments. Lablab produced the highest above ground dry biomass (6166 kg ha^{-1}) which was statistically at par with pearl millet (var. Kola-1) with 4996 kg ha^{-1} (Table 1). The lowest above ground dry biomass yields was obtained from buckwheat (var. Shashe), wheat (var. Jafferson) and common bean (var. Batu) with 1730, 2151 and 2877 kg ha^{-1}, respectively (Table 1) and the low biomass yield obtained from these crops were genetical. However, the various uses of these biomasses from different species needs further study.

The highest grain yield was obtained from cowpea (var.

#12688) 1736 kg ha^{-1} followed by common bean (var. Awash Melka) 1519 kg ha^{-1} and common bean (var. Batu) 1397 kg ha^{-1} (Table 1). However; yields of sorghum variety 76T1#23, pearl millet (var. Kola-1) and wheat (var. Jafferson) were not included in the analysis due to bird damage on the plots and lablab also did not have any grain yield since it was late in starting flowering and did not get time to complete its cycle and its above ground biomass was harvested at the time of planting of the succeeding crop.

In similar study conducted by Fadis Agricultural Research Center [8]it has been reported that on double cropping of common bean varieties followed by main season early maturing *striga* resistant sorghum varieties at Boko, common bean variety Awash Melka was the highest yielder with yield of 1862.8 kg ha^{-1} [8]. In another study, in field experiment conducted at Alduba, South Omo Zone of Southern Ethiopia using three improved mung bean varieties under rain fed condition during 2013 and 2014 cropping season; mung bean variety MH-97-6 (Boreda) gave 257 kg ha^{-1} followed by mung bean (var. N-26) (Rasa) 210 kg ha^{-1} and while variety Shewarobit gave 207 kg ha^{-1} [23]. The better yield obtained might be due to the suitability of the agro-ecology and different agronomic practices followed. However, the yield obtained in our study was far below the potential of the varieties which is 1350 kg ha^{-1} and 800-1500 kg ha^{-1} for mung bean (var. Borada) and mung bean (var. N-26), respectively, on research fields [12, 14]. In general, the yield obtained from mung bean in this study is promising as the crop has high market demand, high price and drought tolerant.

The lowest yield was obtained from buckwheat (385 kg ha^{-1}) which was very low compared to its potential which is 1400-2000 kg ha^{-1} [13]. The reduction in its yield might be due to continuous flowering and seed set combined with continuous shattering. [16] Reported buckwheat seeds mature 10 days after flowering and shatter (fall off the plant) soon after maturing, which reduces yields and causes potential volunteer problems the following year.

3.2. Succeeding Crop

3.2.1. Phenological Parameters

Days to 50% emergence were highly significantly P (< 0.01) affected by the preceding crops. Days to 50% emergence were earlier for the sequences of Buckwheat-Gubiye, Cowpea-Gubiye and Lablab-Gubiye which took 7.33 days which might be benefited from the remaining moisture in the soil due to the nature of dense canopy of preceding crops buckwheat, cowpea and lablab, respectively. Fallow-Gubiye sequence is a practice that is adopted by all early maturing sorghum growers in the area. Similar to this result, [17] reported days to emergence of 8.22 for variety Gubiye.

Days to 50% flowering was also highly significantly (P< 0.01) affected by the preceding crops which could be due to the differences in nutrient utilization by the preceding crops which included legumes and cereals. It was not strange that local sorghum were again late 160.67 days in reaching its 50% flowering which is genetic. The earliest days to 50% flowering were recorded in the sequence of mung bean (var. N-26)-Gubiye and common bean (var. Batu)-Gubiye with 63.33 days followed by Buckwheat-Gubiye, Common bean (var. Awash melka-Gubiye), Bread wheat-Gubiye and mung bean (var. Borada)-Gubiye sequence with 64, 64.33, 64.67 and 64.67 days, respectively (Table 2). The latest 50% flowering were recorded in the sequences of local sorghum, sorghum (var. 76T1#23)-G and lablab (var. 147)-G with 160.67, 67.67 and 67.33 days respectively (Table 2). The variation occurred between treatments consisting Gubiye and local sorghum is genetical while difference among treatments consisting Gubiye were slight and it was due to effect of their respective preceding crops although, it was not significant.

The days to flowering of the variety Gubiye (63.33-67.67 days) in this study was higher than that of the study by [17] which was 59 days at Boko which might be due to the fact that, this year the drought stress which occurred at the area had a negative effect on growth, phenology, yield and yield related parameters of sorghum. Days to maturity of the sorghum was highly significantly (P <0.01) affected by the preceding crop. Except the local sorghum cultivar, there was no significant difference between the treatments where Gubiye was used as succeeding crop. The days to maturity recorded in this study was higher than that of [17] who reported 111 days for variety Gubiye to reach maturity.

3.2.2. Growth Parameters

Plant height and panicle length were highly significantly (P < 0.01) affected by the preceding crops while the stand count at harvest did not show significant difference among the treatments. The tallest plant was observed by local sorghum (225.37 cm) which was observed due to its genotypic expression. The main reason why local sorghum is more preferred by farmers is also related with its length of stalk and as the local sorghum cultivars have plant height ranging from 2-3 meters (personal observation). From the treatments consisting Gubiye relatively taller plant was observed from the sequences mung bean (var. Borada)-Gubiye, mung bean (var. N-26)-Gubiye, common bean (var. Batu)-Gubiye, lablab-Gubiye and wheat (var. Jafferson)-Gubiye with 89.47, 88.20, 87.93, 87.93 and 87.27 cm respectively (Table 2). The shortest plant was recorded in the sequence of Buckwheat-Gubiye (79.40 cm) which might be due to combination of preceding crop buckwheat which had also marked its effects on other crop growth parameters due to buckwheat P scavenger nature.

In experiment conducted at Kako, southern Ethiopia during main cropping season of 2006 Gubiye's height was 118.867 cm [21]. Similarly, [25] reported plant height 106.91 cm for Gubiye in Kile-Bisidimo plain, Harari region during main cropping season of 2014. The difference in results of the two experiments and this study was due to the weather condition during the study and effects of the preceding crops as it was seen in the sequence followed by buckwheat which was negative.

Panicle type of the treatments of local sorghum and '*Gubiye'* are of different types. The local sorghum was

'*Muyra'* and compact type and had lowest panicle length (13.07 cm) while variety Gubiye's head is erect and semi loose. Thus, the difference which is observed between the two is not due to management or any other practice rather it is genetic. The highest panicle length (27.2 cm) was observed from the sequences of lablab-Gubiye followed by cowpea-Gubiye and mung bean (var. N-26)–Gubiye with panicle length of 26.13 and 25.81 cm, respectively (Table 2). However, the lowest panicle length (23.33 cm) was recorded from the sequence of Buckwheat-Gubiye which has significant difference between the six sequences listed above was due to buckwheat effect on its succeeding crop has also seen in other growth parameters (Table 2). In experiment conducted at Kako, southern Ethiopia during main cropping season of 2006 gubiye's panicle length was 20.467 cm [21]. Similarly [25] reported 25.74 cm of panicle length for Gubiye in Kile-Bisidimo plain, Harari region during main cropping season of 2014 which is in the same range to the result obtained in almost all the sequences followed by Gubiye of this study (Table 2).

3.2.3. Yield Components and Yield

Thousand kernels weight was highly significantly ($P < 0.01$) affected by the preceding crops. However, local sorghum was significantly different over all other treatments. Thousand kernel weight were highest in the sequences of local sorghum (20.68 g) followed by common bean (var. Batu)-Gubiye (12.35 g) and mung bean (var. N-26)-Gubiye (11.26 g) while the lowest thousand kernel weight were observed in the sequences of buckwheat-Gubiye (6.19 g) and sorghum (var. 76T1#23)-Gubiye (Table 2). The differences among treatments seen between local sorghum and other treatments containing Gubiye on thousand kernel weight was genetical. However the differences observed among treatments consisting Gubiye were due effects of their preceding crops and weather condition during experimentation period.

This result is lower compared to previous studies conducted on Gubiye in different parts of the country. For instance, [17] has reported 32.60 g at Boko research station, similarly 24.667 g of thousand kernel weight were reported by [21] and [25] reported 25.29 g of thousand kernel weight which were all superior to this study. The main factors that contributed to these low thousand kernel weight could be the overall the rainfall received during succeeding crop was low (249 mm) which was lower by 160.025 mm compared to the mean of previous four years during the same time. Moreover, the rainfall was erratic and ceased at grain filling stage which had significant effect on kernel weight and even yield during succeeding crop [7]. However, apart from the local sorghum which was sole cropping system the treatments practicing of sequential cropping involving Gubiye as succeeding and different crop types as preceding crops were also influenced by their preceding crops. In this case our reference to compare the productivity is the sequence of fallow-Gubiye since it is also adopted practice by farmers growing early maturing *striga* resistant sorghum varieties in the study area of Fedis.

The yield obtained for Gubiye is quite good compared to studies of [21] which was 1654 kg ha^{-1}. However, yield obtained for Gubiye were low when considering its yield potential in research fields 4000 kg ha^{-1} [6] and compared to previous studies reported by [17] which was about 3478 kg ha^{-1} during 2012 cropping season. Similarly, [25] reported grain yield of 2965.56 kg ha^{-1} for Gubiye at Kile-Bisidimo plain. The rainfall pattern during succeeding crop was 249 mm which was less by 160.025 mm compared to the last four years in the area [7].

The lowest grain yield (1196 kg ha^{-1}) of succeeding sorghum variety Gubiye was obtained from the sequence buckwheat-Gubiye which is by far low. The lowest yield obtained in this sequence might be due to high depletion of nutrients by preceding crop buckwheat in the sequence. In line with this it was known that buckwheat is scavenging P which in turn can take up more soil phosphorus efficiently than other plants. In its growing stage, the roots of buckwheat exude substances that help to solubilize P that may otherwise be unavailable to plants [16] (Pavek, 2014).

The improvement of soil structure following legume [22] and breaking of the cycle of pests and diseases and allelopathic effect of legume crop residue [18] may be an additional reason for the extra yield from the sequences of common bean (var. Batu)-G, common bean (var. Awash Melka)-G, mung bean (var. N-26)-G and lablab (var. 147)-G with 2342, 2107, 2094 and 2049 kg ha^{-1} grain yield respectively, compared to the lowest yield of 1196 kg ha^{-1} obtained in the sequence of buckwheat (var. Shashe)-G. These results were in line with earlier studies of [20] and [19], which showed that the addition of a legume in the sequence resulted in higher yield and profitability. Inclusion of legumes in the rotation hastened the N and P transformation [22, 11] and also increased root growth and N use efficiency of cereal crops, resulting in greater productivity of cereal-based production system [4, 24].

Above ground dry biomass yield was significantly ($P<0.05$) affected by the preceding crops. The highest above ground dry biomass obtained was (6119 kg ha^{-1}) from local sorghum which was directly related to plant height as it known local sorghum was taller than early maturing sorghum varieties Gubiye. In treatments consisting Gubiye higher above ground dry biomass were recorded from the sequences of pearl millet (var. Kola-1)-Gubiye and common bean (var. Awash Melka)-Gubiye with values of 4846 and 4716 kg ha^{-1}, respectively which were statistically at par with local sorghum (Table 2).

The lowest above ground dry biomass in this study was obtained from the sequence of Buckwheat-Gubiye (3289 kg ha^{-1}) (Table 2). As also in other parameters the negative effect of buckwheat in this sequence was due to the nature of buckwheat voracious use of nutrient from the soil. It is to be noted that the highest above ground dry biomass yields of local sorghum cultivar obtained during the cropping season does not mean; farmer's practice of mono cropping of local sorghum cultivar is superior to the remaining double cropping system. Thus, there is a need to consider the overall productivity of the double cropping system.

Harvest index were significantly ($P<0.05$) affected by the preceding crops. Harvest index were highest in the sequences of common bean (var. Batu)-Gubiye (55.17 %) followed by local sorghum (55.05 %), mung bean (var. N-26)-Gubiye (53.60 %) and bread wheat (var. Jafferson)-Gubiye (52.53 %) which are all at par (not significant) between them while the lower harvest indices was observed in the sequences of buckwheat-Gubiye (36.03 %), pearl millet (var. koa-1)-Gubiye (41.62 %) and sorghum (var. 76T1#23)-Gubiye (43.89 %) which are also at par (Table 2). The main reason for high values of harvest indices were due to defoliation of leaves at later stages of the plant developments compounded with the stress occurred during reaching maturity which have direct influence on the above ground dry biomass of the crop which intern increase the value of harvest index.

High harvest index in the sequence of common bean (var. Batu)-Gubiye may be due to the presence of good partitioning of dry matter to grain yield which might have benefited from nitrogen fixation and decomposition of root and some other parts of common bean (var. Batu). Lowest harvest index of the sequence of buckwheat-gubiye might be due to poor crop growth of Gubiye which was affected by its preceding buckwheat as its above ground dry biomass was also lowest than others (Table 2) and which in turn have negative effect on partitioning of dry matter to grain yield.

As reported by [21] harvest index for Gubiye were 20.477% which is very low compared to this study. In another study, [1] reported harvest index of 51.1% which is the same range with some of the treatments in this study of sequences (Table 2). Regarding variety, Gubiye has lower harvest index (33.93 %) compared to Tehale and Hormat with 54.51% and 39.67%, respectively [25].

Table 2. *Phenological, growth parameters and Yield components and yield of succeeding sorghum variety Gubiye grown in double cropping system during 'Meher' at Fedis in 2015.*

Crop sequence	DE	DF	DM	PH(cm)	PL(cm)	SCH	TKW(g)	Grain yield (kg ha^{-1})	AGDBM (kg ha^{-1})	Harvest Index (%)
Local sorghum	10.00^{a}	160.67^{a}	221.0^{a}	225.37^{a}	13.07^{d}	85.0	20.68^{a}	3369^{a}	6119^{a}	55.05^{a}
MB(var. Borada)-G	8.00^{b}	64.67^{bcd}	123.3^{bc}	89.47^{b}	25.33^{abc}	83.7	9.50^{bcd}	1826^{bc}	3719^{bc}	49.46^{abc}
MB (var. N-26)-G	8.00^{b}	63.33^{d}	122.3^{c}	88.20^{b}	25.80^{abc}	95.7	11.26^{bc}	2094^{b}	3912^{bc}	53.60^{ab}
CB (var. Batu)-G	8.00^{b}	63.33^{d}	122.3^{c}	87.93^{b}	25.47^{abc}	87.0	12.35^{b}	2342^{b}	4265^{bc}	55.17^{a}
Lablab (var. 147)-G	7.33^{c}	67.33^{bc}	125.0^{bc}	87.93^{b}	27.20^{a}	82.7	10.76^{bc}	2049^{b}	4251^{bc}	48.63^{abc}
Wheat (Jafferson)-G	8.00^{b}	64.67^{bcd}	123.7^{bc}	87.27^{b}	25.47^{abc}	89.3	10.85^{bc}	2052^{b}	3924^{bc}	52.53^{ab}
PM (var. Kola-1)-G	8.00^{b}	65.67^{bcd}	124.0^{bc}	86.20^{bc}	23.60^{bc}	93.7	10.33^{bc}	1961^{bc}	4846^{ab}	41.62^{cd}
CB (var. Awash Melka)-G	8.00^{b}	64.33^{bcd}	122.7^{bc}	85.00^{bc}	25.20^{abc}	99.3	10.91^{bc}	2107^{b}	4716^{abc}	44.78^{abcd}
Cowpea (var. #12688)-G	7.33^{c}	66.00^{bcd}	125.0^{bc}	84.80^{bc}	26.13^{ab}	83.0	9.47^{bcd}	1753^{bc}	3545^{bc}	49.10^{abc}
Fallow-G	8.00^{b}	65.00^{bcd}	124.3^{bc}	83.87^{bc}	23.87^{bc}	96.0	10.64^{bc}	1912^{bc}	3961^{bc}	47.98^{abc}
Sorghum (var. 76T1#23)-G	8.00^{b}	67.67^{b}	125.7^{b}	81.87^{bc}	25.67^{abc}	82.7	8.81^{cd}	1711^{bc}	3912^{bc}	43.89^{bcd}
Buckwheat-Gubiye	7.33^{c}	64.00^{cd}	122.3^{c}	79.40^{c}	23.33^{c}	83.3	6.19^{cd}	1196^{c}	3289^{c}	36.03^{d}
P	**	**	**	**	**	Ns	**	**	*	*
LSD (0.05)	0.49	3.61	3.13	7.861	2.770	-	3.400	780.2	1451.7	10.77
CV (%)	3.6	2.9	1.4	4.8	6.8	13.6	18.3	22.7	20.4	13.2

**= significant at P = 0.01, ns= not significant, LSD (0.05) = Least Significant Difference at 5% level; CV= coefficient of variation, DE= Days to 50% emergency, DF= Days to 50% flowering, DM= days to physiological maturity, PH= plant height, PL= panicle length, SCH= stand count at harvest, TKW= thousand kernel weight, AGDBM= Above ground dry biomass, MB= mung bean, CB= common bean, PM= pearl millet and G=gubiye, Means in column followed by the same letters are not significantly different at 5% level of significance.

4. Conclusion

Farmers in dry lowlands of East Hararghe Zone of Fedis distrct have been practicing mono cropping of sorghum for a long time which is late in maturity taking 7-8 months. Such mono cropping does not ensure the production of adequate food for the family especially under conditions where average land holding is fragmented and rainfall amount is small and the distribution is erratic. These local sorghum varieties are also susceptible to striga, affected by drought when the season is not good and low yielder than improved sorghum varieties under such circumstances which requires different planting season. Though some farmers are adopting improved sorghum varieties, still most of them are hesitating to delay planting even if the rain fall in March or April is good. Therefore, an experiment was conducted during the 2015 cropping season to study the effect double cropping system on yield, and yield components of the sorghum and compare the productivity of the double cropping system with the single cropping in Fedis District, Eastern Hararghe Zone, Ethiopia. However, to reach at conclusive recommendation the experiment must has to be repeated over years and locations focusing on legumes as preceding crops and considering the forage on its quality attributes such as palatability and crude protein values of the preceding crops.

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