

Effect of Intercropping Maize-Soybean on Grain Quality Traits in Kenya

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Abstract

An experiment was conducted in Kenya to determine the effect of intercropping maize-soybean on soybean grain quality traits. A randomized complete block design replicated three times with seven treatments was used. Data were collected and analysed for soybean protein content, oil content and dry matter while grain size was done for maize and soybean. Data were subjected to ANOVA and means separated using LSD_{0.05}. The results showed that TGX1990-5F variety recorded high protein content ($p \leq 0.05$) in sole crop compared to intercropping with 42.96% and 38.4% respectively while SB19 obtained 36.57% and 40.41% of protein between sites for the first season. A bout the second season, TGX1990-5F gave 40.84% of protein compared to 31.98% for GAZELLE in intercrop at both sites. GAZELLE showed higher oil content followed by TGX1990-5F and SB19 was the last in both seasons. TGX1990-5F showed higher dry matter followed by GAZELLE and SB19 was the last in intercrop. In addition, GAZELLE a local variety showed greater size than SB19 in both rainy seasons. Intercropping affected slightly the protein content, oil content and gain size than sole crop but it did not affect the dry matter in both seasons. Thus, TGX1990-5F can be recommended to small-scale farmers for intercropping with maize because it produced higher value of protein and small-scale farmers could use it to fight mal nutrition. GAZELLE variety can be also recommended for oil production. Maize grain size was not affected by intercropping system.

Keywords: grain size, intercropping system, maize-soybean, oil content, protein content

1. Introduction

Soybeans (*Glycine max*) serve as one of the most important crops in the world, not only as an oil seed crop and feed for livestock and aquaculture, but also as a good source of protein for the human diet and as a biofuel feedstock (Masuda & Goldsmith, 2009). The world soybean production increased by 4.6% annually from 1961 to 2007 and reached average annual production of 217.6 million tons in 2005-2007 (Masuda & Goldsmith, 2014). Weinhold and Killick (2011) reported that, the increase of soy production both reduces poverty indicators and raises median rural incomes. Soybean cultivation is highly concentrated geographically, with only four countries—USA, Brazil, Argentine and China—accounting for almost 90% of world output. Asia—excluding China—and Africa, the two regions where most of the food insecure countries are located, together account for only 5% of production. Among countries classified as undernourished, only India and Bolivia are significant producers of soybeans (Thoenes, 2015). In addition, Bill and Melinda (2011) reported that, for the African countries, the leading production is South Africa (588 k MT), Zambia (112 k MT), Zimbabwe (50 k MT), Malawi (73 k MT), Mozambique (18 k MT), Angola (15 k MT) and DRC (5 k MT). The remarkable success of the soybean in temperate zones is well known, but there is also a good potential role for the crop in many cropping systems of the tropics and subtropics, where farms tend to be smaller and less mechanized (Thoenes, 2015). Among those tropics countries Kenya is included but its percentage soybean production is quite low and is not quoted above as soybean producer country. The cropping system which could help small scale farmers to raise their production could be the intercropping. However, Protein content, oil content and grain size can be affected positively or negatively by growth conditions of crops (Lithourgidis et al., 2011). Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time, is an old and commonly cropping system used which targets to match efficiently crop

demands to the available growth resources and labor (Lithourgidis et al., 2011). The stability under intercropping can be attributed to the partial restoration of diversity that is missed under sole crops. According to this statement of view, intercropping allows high insurance against crop failure, notably in environments known for heavy weather conditions like frost, flood, drought, and overall provides high financial stability for farmers (Lithourgidis et al., 2011). Moreover, legumes enrich soil by fixing the atmospheric nitrogen transforming it and other mineral from an inorganic form to forms that are available for uptake by crops (Li et al., 2012). However, more interaction mechanisms that happen between plant species when intercropped as well as the effect of intercrop on the following crop in the fallow might have effects on grain quality. This has been shown determining the effect of intercropping on a series of quality factors, such as physical grain quality, ratio of nitrogen and sulphur concentrations, protein quality for wheat and fababeans (Erik, 2005). Musa et al. (2011) reported that intercropping increased chemical composition as dry matter, ash, protein, fiber content and tannin content of cowpea in maize-cowpea intercropping. Eskandari and Ghanbari (2009), Yucel and Avci (2009) showed that, intercropping legume-cereal increased crude protein than monocrop, while Jayanta et al. (2015) found that, intercropping maize-soybean increased protein and nitrogen content in both grains, nitrogen content in stover and total nitrogen uptake with 75-100% of recommended nitrogen. Moreover, Abdel et al. (2016) revealed that intercropping soybean-sunflower spaced at 20 cm (soybean) had the highest grain oil yields per ha compared to other spacing. In addition, intercropping maize-soybean affected negatively the value of soybean protein and oil content where in pure crops soybean showed 38.47% compared to 36.76% in intercrop for protein and 19.15% compared to 17.97% for oil content respectively in sole crop compared to the intercrop (Mirela & Roman, 2013). Dragicevic et al. (2017) reported that, some chemicals content (antioxidant) were enhanced mostly by alternating strips in maize grain and by alternating rows in soybean grain, in maize-soybean intercropping system. Furthermore, intercropping maize-soybean with increasing N application can improve grain of maize and soybean physiological characters, but their effects will be decreased with increasing N fertilisation rate (Zhang et al., 2014). However, intercropping of pea-barley like a way of improving complementary N, increases the protein production and reduces weed problem in intercropping systems without herbicide use (Hauggaard et al., 2001). Laurent et al. (2014) reported that, intercropping seems to be an important agronomic solution for organic arable cropping, especially in low-N input systems, by improving yields of environmental competition for resource use, cereal grain protein concentration due to non proportional competition for soil mineral N and other plant growth factors, weed control, compared to sole crops. Nevertheless, analysis of grain quality in cereals-legumes cropping system showed that, crude protein concentration of intercropped cereals increased compared to sole crops in all experimental sites. Pea increased the concentration of crude protein in intercrops yield compared with sole cereals in the Dotnura site (Kadziulienė et al., 2009). Moreover, Staniak et al. (2014) found that, intercropping of cereals-legumes enhances protein content in the grain cereals, increasing also the yield of crude protein in the biomass of the component crops. Šarūnaitė et al. (2010) said that, the increases of crude protein was higher in wheat grain yield when wheat had been grown in intercrop with bean. In addition, intercropping had no significant effect on grain oil content of castor. It was concluded that, castor, could be intercropped efficiently with beans without affecting food crop production and the resultant grain oil content of castor. Hence the need in this study to assess the effect of intercropping maize- soybean on protein, oil content and grain size at Embu and Mwea sites in Kenya.

2. Materials and Methods

The experiments were carried out in two sites during two rain seasons of (2016 and 2017). The first site was KALRO-Embu, located in Embu County in the Eastern part of Kenya and lying between latitudes 0°08'35" S and a longitude 37°27'02" E. KALRO-Mwea is in Kirinyaga county, situated in the Central Region of Kenya at a latitude of 00°37' S and a longitude of 37°20' E (Kirinyaga county, 2014 and Embu county, 2014). Land preparation was done by ploughing using ox-drawn equipment. The varieties of soybean used were: SB19, GAZELLE, TGX1990-5F and one variety of maize (Duma 43) for intercropping with soybean. The experiment was laid out in a randomized complete block design (RCBD) replicated three times with seven treatments including: T₁: SB19 (Hybrid), T₂: GAZELLE (Local), T₃: TGX1990-5F (Hybrid), T₄: SB19+MAIZE, T₅: GAZELLE+MAIZE, T₆: TGX1990-5F+MAIZE, T₇: MAIZE (DUMA 43). The spacing used and densities were: Monocrop soybean: 166,666.66 plants ha⁻¹ (40 cm × 15 cm), Soybean intercropped with maize: 83,333.33 plants ha⁻¹ (80 cm × 15 cm), Monocrop maize: 50,000 plants ha⁻¹ (80 cm × 25 cm), Maize intercropped with soybean: 50,000 plants ha⁻¹ (80 cm × 25 cm). The total area of the experiment was 420 m². In total, the experiment had 2700 plants of soybean in which 900 plants were in intercrop with maize and 1800 plants were in sole crops. The total density in whole experiment for maize was 720 plants in sole crops as in intercrop. The arrangement of intercropping was 1:1 with, one row of maize intercepted by one row of soybean. The experiments received a basal application of 10.5 kg of DAP per site at the rate of 250 kg ha⁻¹, meaning that each plot received 300 g of

fertilizer and the application was done by row (Roy et al., 2006). The dosage of fertilizer used per plant for maize in sole crop was 5 g, 1.5 g for soybean in sole crop and 1.875 g per plant in maize-soybean intercropped. The first season was planted on 9th Jun 2016 at Embu and on 10th at Mwea. The first weeding was done on 24th Jun 2016 in both sites. Harvesting was done on 8th October 2016 at Mwea and on 21 October 2016 at Embu respectively. The second season was planted on 8th November 2016 and the first weeding was done on 28th November 2016. The harvesting was done on 12th at Mwea, while it happened on 25th at Embu. The dosage of fertilizer which was applied in the first season was the same as the second season. Because of insufficient rain fall, the trials received supplement by irrigation but the situation of rain fall was drastic and so bad in the second season. The plants from the middle of the plot were taken in both sites and seasons to determine maize-soybean grain quality. Data were taken on maize grain size, soybean grain size, soybean protein content, soybean oil content and soybean dry matter.

2.1 Intercropping on Grain Quality Traits

2.2.1 Soybean and Maize Grain Size Analysis

The grain size was measured by a stack of sieves with hole-diameter ranging from (5.5 mm to 10 mm) for maize and (4 mm to 8 mm) for soybean and seven size bins were generated from 100 grains taken as sample for maize and soybean each and grain size were assessed in %. The operation was done in the lab of department of Food Science (CAVS) (Shahin & Symons, 2005).



Figure 1. Sieves used for grain size generation

2.2.3 Crude Protein Determination

The crude protein has been determined by the kjedhal method as described by (Katerine, 2012),

$$\% \text{ Protein} = \frac{14 \times 6.25 \times 100 \times 0.1 (\text{NaOH})}{\text{weight} \times 1000} \times \text{Titre} \quad (1)$$

Where, 14 = Molecule weight of nitrogen, 625 = Convention factor to protein, 0.1 = Normality for NaOH, Blank titre: Sample titre.



Figure 2. (a) Digestion of protein in the digester, (b) Distillation of protein, (c) Protein after distillation and titration

2.2.4 Crude Oil Determination

The crude oil has been determined using the soxhlet method as described by (CSIRO and the victorian government, 2006).

$$\% \text{ Fat determination} = \frac{\text{Flask + Oil}}{\text{Sample weight}} \times 100 \quad (2)$$

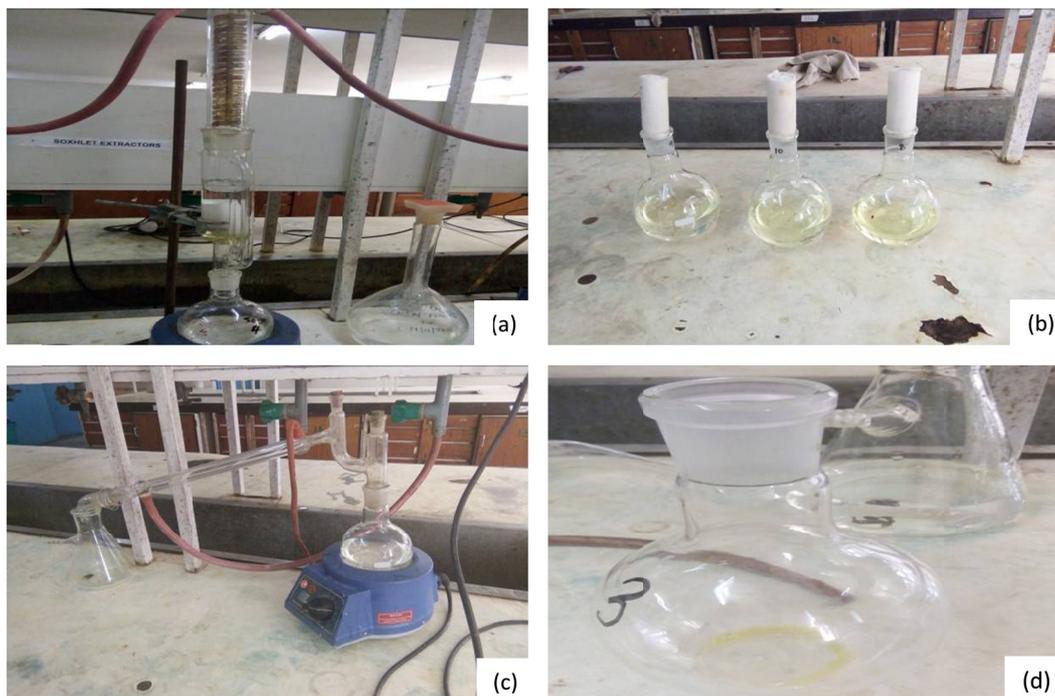


Figure 3. (a) Extraction of the soybean oil with soxhelt method, (b) Soybean oil after extraction, (c) Separation of petroleum with soybean oil with evaporation, (d) Soybean oil after evaporation

2.2.5 Soybean Dry Matter Analysis

The moisture was evaporated from the soybean sample in an air oven tool at 103 °C. Dry matter was calculated as residue remaining during 3 hours.

$$\text{Total DM} = \frac{W6 - W4}{W5 - W4} \times 100 \quad (3)$$

Where, DM = Dry Matter, W4 = Tare weight of dish in grams, W5 = Initial weight of sample and dish in grams, W6 = Dry weight of sample and dish in grams; % Total Moisture = 100 – % DM (PFI, 1978). The data were analyzed by Gen stat program fourth edition, 2013 and the least significant difference (LSD) was used to differentiate the means on threshold of ($p \leq 0.05$). The table of analysis of variance (ANOVA) was important to know the source of variance (ILRI-ICRAF, 2007).

3. Results

3.1 Weather Data during the Experiment Duration Long Rain 2016

The mean rain falls (mm) during the experiment duration were 3.21 mm and 0.007 mm at Embu and Mwea respectively. Rain fall from Mwea were very negligible. However, the mean for temperature and relative humidity were respectively 21.42 °C and 63.54% at Mwea (Figure 4).

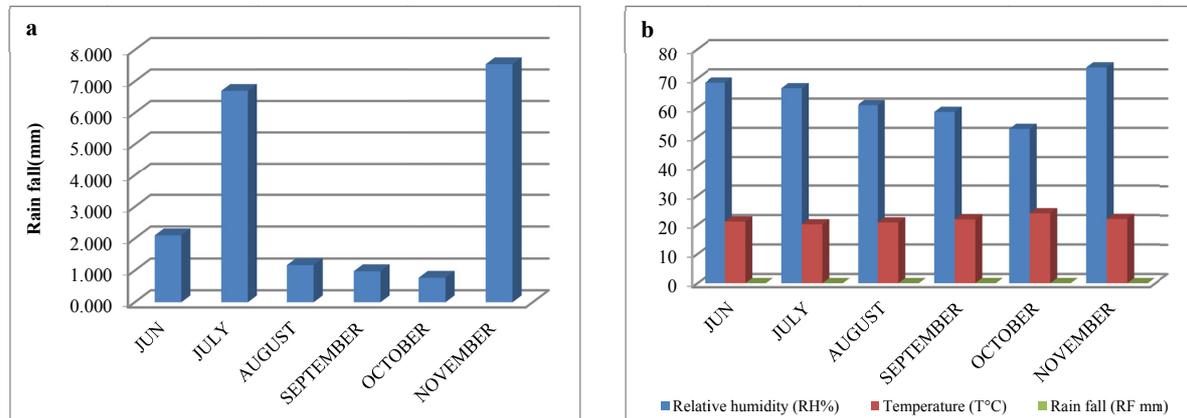


Figure 4. (a) Weather data at EMBU site, (b) Weather data at MWEA site

3.2 Intercropping on Grain Quality Traits

3.2.1 Effect of Intercropping on Soybean and Maize Grain Size

Soybean grains with 6 mm showed significant difference between sites and seasons ($p \leq 0.05$). The variety for SB19 recorded the higher value of 35.3% more than 23.3% for GAZELLE and TGX1990-5 recorded the lowest value of 2.7% in sole crop. TGX1990-5F variety showed higher value of 58% followed by SB19 (35.7%) and the last was GAZELLE with 6.3% in intercrop in the first season. The percentage obtained in short rain was the same in the first season (Figures 6 and 8). Soybean grain size with 7 mm showed significant difference between sites and seasons ($p \leq 0.05$). GAZELLE showed 16% more than 6.7% for TGX1990-5F and the last was SB19 with 1.7% in sole crop at Embu. GAZELLE presented 35.7% more than 10.7% for TGX1990-5F and SB19 showed the lowest value of 0.3% in intercrop at Embu. The variety GAZELLE showed 32% bigger than 8.3% for SB19 and TGX1990-5F showed the lowest value of 6% in sole crop at Mwea. GAZELLE presented 23% bigger than 8.7% for TGX1990-5F and SB19 showed the lowest value of 0.7% in intercrop at Mwea. However, soybean with 4 mm, 5.6 mm, 6.5 mm and 8 mm did not give significant difference ($p \leq 0.05$). Intercropping affected negatively the soybean grain size according to the results found in both rainy seasons and sites. However, Mwea site produced better grain in size compared to Embu. GAZELLE gave big grain size of (7 mm) compared to other varieties. The variety which had smallest grain size (6 mm) was SB19 where the higher value of grain size was 96% at Mwea in intercropping compared to GAZELLE with 1% in intercropping too (Figures 6 and 8).



Figure 5. Grain of soybean varieties after harvesting: (a) GAZELLE, (b) TGX1990-5F, (c) SB19

Grain size for maize in intercropping and in sole crop did not give significant difference between sites and seasons ($p \leq 0.05$). Nevertheless, the biggest percentage of grain size was found at Embu site compared to Mwea (9.5 mm) against (7 mm) respectively (Figures 7 and 9). So, Embu produced better maize grains than Mwea in both rains seasons. Intercropping did not affect negatively the maize grain size at both sites and both rains seasons. Maize

grain size was not generated for the long rain 2016 at Mwea because plants were attacked by MLN and they didn't produce grains but they produced biomass (Figure 7).

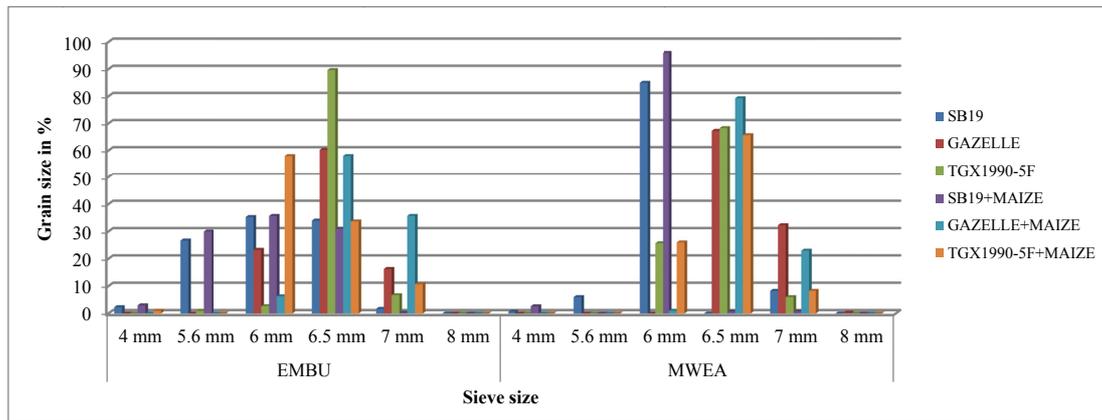


Figure 6. Mean of grain size of different varieties of soybean in sole crop and in intercropping in% (Long rain 2016)

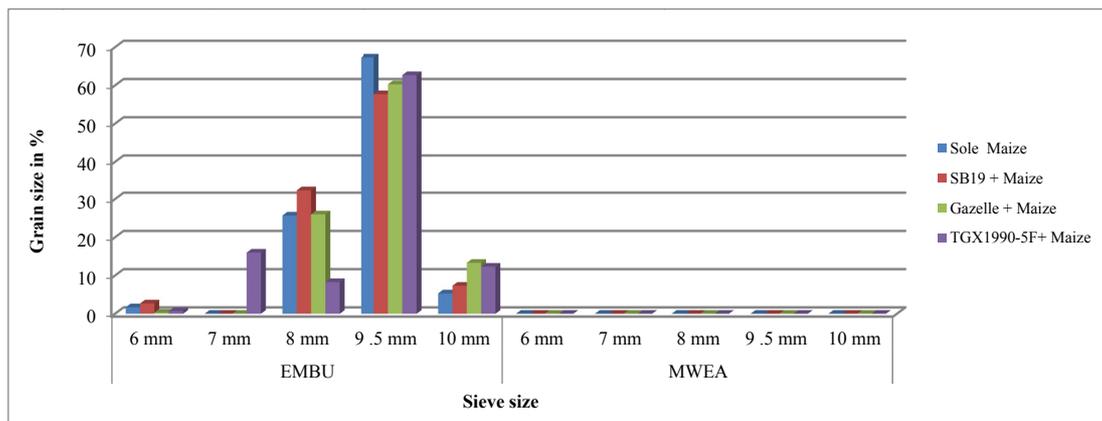


Figure 7. Mean of grain size for Maize (Duma 43) in sole crop and in intercropping in% (Long rain 2016)

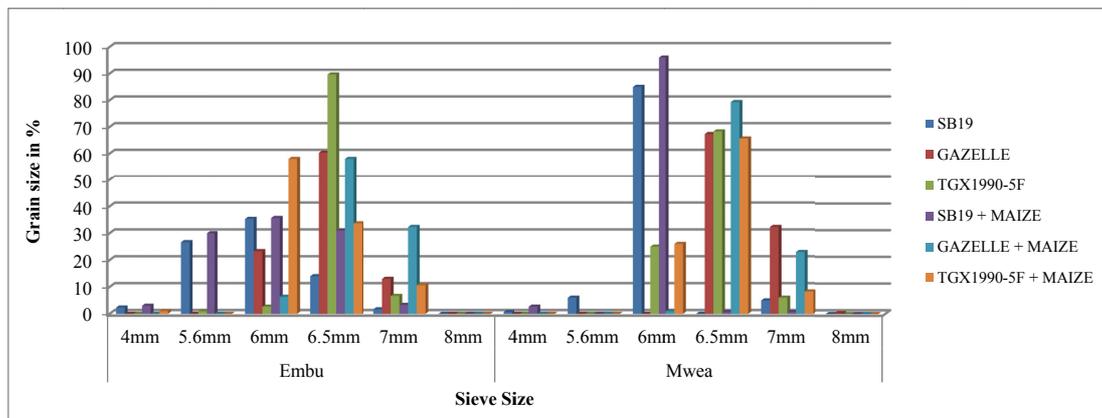


Figure 8. Mean of grain size of different varieties of soybean in sole crop and in intercropping in% (short rains 2016-2017)

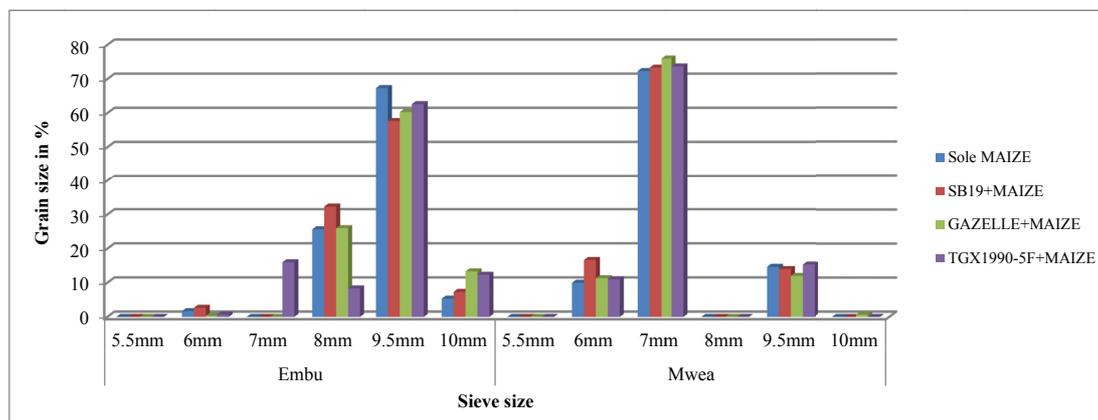


Figure 9. Mean of grain size for Maize (Duma 43) in sole crop and in intercropping in% (short rains 2016-2017)

3.2.2 Effect of Intercropping on Protein, Oil Content and Dry Matter

Soybean protein did not show significant difference between sites for the long rains 2016, but different treatments gave significant difference ($p \leq 0.05$). Soybean protein content was slightly higher in the long rain season (39.34%) compared to the short rain season (35.85%). Protein content ranged from 36% to 43% at Mwea while it ranged from 36% to 42% at Embu for the long rain season. However, during the short rains, it ranged from 31% to 40% at Mwea while it ranged from 36% to 41% at Embu. It means that during the long rains soybean from Mwea increased slightly the value of protein content than soybean from Embu while it was the contrary in the short rains. TGX1990-5F showed higher value of 42.89% of protein followed by GAZELLE (39.18%) in sole crop compared to SB19 with 36.64% of protein content. However, SB19 produced more protein content (40.43%) followed by TGX1990-5F (38.43%) compared to GAZELLE with 37.99% at Embu. From Mwea site, TGX1990-5F showed higher protein content of 43.02% than GAZELLE with 39.36% in sole crop compared to SB19 with 36.64%. Intercropping reduced soybean protein content considering the higher value of protein content for each variety produced in sole crop than in intercropping *i.e.* GAZELLE showed the highest protein content for 40.39% than TGX1990-5F and SB19 which gave similar value of protein content of 38%. Depending to the short rains, protein content gave significant difference between sites ($p \leq 0.05$), *i.e.*, TGX1990-5F protein content was 40.14% more than 36.15% compared to 34.53% mean for SB19 in intercrop. The same situation happened at Mwea site, where TGX1990-5F was first in intercropping followed by SB19 compared to GAZELLE. TGX1990-5F is considered as a variety with high value of protein content because for the long rains and the short rains, it showed high protein values in sole crop and in intercrop (Table 1). However, oil content for the long rains of 2016 gave significant difference between sites and seasons, and GAZELLE gave high values of 21.08% in sole crop followed by TGX1990-5F with 18.63% compared to SB19 with 16.46% at Embu. Variety GAZELLE recorded higher value of oil content of 16.68% than TGX1990-5F with 12.77% compared to SB19 with lower value of 9.37% in intercrop. GAZELLE variety had higher values of oil content at Mwea with 22.98% than SB19 with 15.29% compared to TGX1990-5F in sole crop with 12.78%. GAZELLE variety gave high value of oil content followed by SB19 and TGX1990-5F showed the lowest oil content in intercrop. During the short rain, variety SB19 had lowest value of oil content and TGX1990-5F was in the middle while GAZELLE ranked the first. However, intercropping reduced the value of oil content for both sites and both rainy seasons (Table 1). Dry matter gave significant difference between sites and seasons ($p \leq 0.05$). Embu site did not give significant difference for both rainy seasons. Dry matter ranged from 14% to 16% for the first season while it ranged from 15% to 16% in the short rains in sole crop and in intercrop. The significant difference was shown at Mwea both rains seasons, and TGX1990-5F had higher value of dry matter of 18.82% than SB19 with 16.77% compared to 15.74% for GAZELLE sole crop. TGX1990-5F variety showed the same results in intercrop compared to GAZELLE and SB19 which had the same value of dry matter of 15%. For the short rains, TGX1990-5F presented good performance giving higher dry matter of 17.19% than 16.77% for SB19 compared to GAZELLE with 15.74% in sole crop. TGX1990-5F showed bigger dry matter of 18.82% followed by GAZELLE with 18.19% and SB19 gave the lowest value of 15.11% in intercrop. Thus during the long rains and short rain season TGX1990-5F gave higher values of dry matter than other varieties in intercropping and in sole crop. However, intercropping did not affect negatively the value of dry matter in percentage (Table 1).

Table 1. Soybean protein content, oil content and dry matter at Embu and Mwea 2016-2017

Treatment	Long rains 2016								
	%Protein content			%Oil content			%Dry matter		
	Embu	Mwea	Mean	Embu	Mwea	Mean	Embu	Mwea	Mean
SB19	36.51d	36.64c	36.57a	16.46c	15.29d	15.88d	16.68a	16.77ab	16.73ab
GAZELLE	39.18bc	39.36b	39.27a	21.08a	22.98a	22.03a	15.82a	15.74ab	15.78ab
TGX1990-5F	42.89a	43.02a	42.96a	18.63b	12.78e	15.71d	16.84a	18.21ab	17.53a
SB19+MAIZE	40.43b	40.39b	40.41a	9.37e	18.58c	13.98e	14.87a	15.11b	14.99b
GAZELLE+MAIZE	37.99cd	38.11bc	38.05a	16.68c	19.58b	18.13b	16.79a	15.86ab	16.33ab
TGX1990-5F+MAIZE	38.43bcd	38.54bc	38.49a	12.77d	15.20d	13.98e	16.15a	18.82a	17.48a
Mean	39.24	39.34	39.29	15.83	17.40	16.62c	16.19	16.75	16.47
LSD0.05	2.165	2.183	7.224	0.916	0.5763	2.46	2.501	2.875	1.979
CV%	3.0	3.1	11.7	3.2	1.8	9.0	8.5	9.4	7.3
Treatment	Short rains 2016-2017								
	Protein content			Oil content			Dry matter		
	Embu	Mwea	Mean	Embu	Mwea	Mean	Embu	Mwea	Mean
SB19	34.53ab	31.29b	32.91b	17.47c	15.93b	16.70b	16.01a	16.77cd	16.39ab
GAZELLE	36.15ab	31.10b	33.62b	20.74a	22.27a	21.51a	15.15a	15.74de	15.45ab
TGX1990-5F	40.14ab	34.94ab	37.54ab	19.03b	14.98b	17.00b	16.84a	17.55bc	17.19ab
SB19+MAIZE	38.90ab	37.51a	38.20ab	9.58e	15.61b	12.59c	15.53a	15.11e	15.32b
GAZELLE+MAIZE	33.79b	30.16b	31.98b	17.26c	18.66ab	17.96b	16.46a	18.19ab	17.33a
TGX1990-5F+MAIZE	41.17a	40.50a	40.84a	12.77d	15.20b	13.46c	16.81a	18.82a	17.82a
Mean	37.45	34.25	35.85	16.20	16.87	16.54b	16.13	17.03	16.58
LSD0.05	6.253	5.895	7.224	0.7205	5.456	2.46	2.049	1.217	1.979
CV%	9.2	9.5	11.7	2.4	17.8	9.0	7.0	3.9	7.3

Note. LSD: Least significant difference; CV: Coefficient of variation.

4. Discussion

4.1 Effects of Intercropping Maize-Soybean on Grain Size

The higher values of soybean grain size had 6.5 mm in both sites, where GAZELLE recorded 79.33% compared to SB19 with 0.67%. Intercropping affected negatively soybean grain size according to the results found in both rainy seasons. This could be due to not only the competition of maize against soybean on nutrient, light and air but also the results of shading of maize on soybean. From this results, William (2012) reported that variety with early maturity are the most to give poor grain quality especially for those variety which their maturity are not uniform. Wet conditions, shading, pressures of some diseases, poor conditions between physiological maturity and harvest can enhance decreasing of grain quality. SB19 variety known for early maturity produced poor grain quality because of critical conditions which revealed during the two rainy seasons. Ranking soybean size, GAZELLE had better grain size followed by TGX1990-5F and the last is SB19 (Figure 5). From results, Foundation (2011) reported that GAZELLE is a variety largely cultivated in Kenya and was released in 2009 by KARI Njoro and is high yielding, large grain size, and attractive color. Whan et al. (2014), reported that, grain size is an important trait of both basic plant research, since grain formation and development is a fundamental aspect of reproduction, and breeding, as a component of yield and vigour. Thus, each control methods determining grain size tend to either know if grain size did increase or decrease depending of growing conditions. The high value of soybean good grain size ranged from 5.6 mm to 8 mm. These results have been confirmed by Shahin and Symons (2005) who reported that, depending on the varieties of soybean, grain size can range between 5.56 mm to 7.54 mm.

4.2 Effects of Intercropping Maize-Soybean on Protein, Oil Content and Dry Matter

According to the results found, TGX1990-5F showed significant difference producing high value of protein ranged between (34.94% to 43.02%) at both sites and during two rains seasons. The second variety to produce high value of protein is the local variety which is GAZELLE and the last is SB19. Intercropping affected slightly the protein content considering the higher value of protein content for each variety produced in sole crop than in intercropping. GAZELLE variety produced highest value of oil content (21.08%) compared to SB19 (16.46%) at

Embu in long rains of 2016. The variety which had the lowest value of oil content was SB19. GAZELLE produced high value of oil content both sites and both rain seasons. Intercropping affected slightly the value of oil content than sole crop. This could be attributed on the shading of the maize on soybean which could not allow good penetration of light, air, and the competition of nutrient, hence, low protein and oil production. Depending on the results obtained Lithourgidis et al. (2011) found that grain quality traits, protein content and oil content can be affected positively or negatively by growth conditions of crops. In contrary, Erik (2005) reported that, intercropping can have series of quality factors, such as physical grain quality, ratio of nitrogen and sulphur concentrations, protein quality for wheat and fababean. The spacing of soybean between plant was 40 cm while it was 15 cm within plant which allowed good oil production in maize-soybean intercropping. That was not the case for Abdel et al. (2016) who revealed that intercropping soybean-sunflower spaced at 20 cm (soybean) had the highest grain oil yields per ha compared to others spacing. Ayu et al. (2004) recorded maximum protein yield of sorghum under soybean plus sorghum system than sole sorghum. In many cereal-legume intercropping systems there is emanation of favourable exudates from the component legume to the associated cereal and this is suspected to have effects on the quality of the cereal in terms of protein yield. Moreover, Staniak et al. (2014) found that, intercropping of cereals-legumes enhances protein content in the grain cereals, increasing also the yield of crude protein in the biomass of the component crops. Šarūnaitė et al. (2010) said that, the increases of crude protein was higher in wheat grain yield when wheat had been grown in intercrop with bean. However, depending on dry matter, TGX1990-5F gave significant difference of dry matter (18.82% compared to 15.11%) for SB19 at Mwea for long rains of 2016. Embu site did not give significant difference during long rain of 2016 and short rains of 2016-2017. Furthermore, Musa et al. (2011) reported that intercropping increased chemical composition as dry matter, ash, protein, fiber content and tannin content of cowpea in maize-cowpea intercropping. In addition, Rusdy (2014) showed that intercropping of *Panicum maximum* and *Centrosema pubescens* gave dry matter which was significantly different ($p < 0.05$) than their monocrops.

5. Conclusion

Intercropping maize-soybean showed that TGX1990-5F variety presented high value of protein content in sole crops and in intercrops followed by GAZELLE compared to SB19. For the oil content, GAZELLE came first showing high value of oil content while TGX1990-5F was second. TGX1990-5F can be recommended to smallscale farmers for intercropping with maize because it can produce high protein content and fight against mal nutrition, and increase maize yields. GAZELLE had higher grain size compared to other varieties.

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