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Performance of Sweet Potato and Soybeans as Affected by Cropping Sequence in the Northern Guinea Savanna of Nigeria

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Abstract: A field experiment was conducted to study the performance of sweet potato and soybeans under different cropping sequences during the raining seasons of 2007, 2008 and 2009 in Bauchi, Nigeria. The cropping sequences consisted of sweet potato transplanted 1 week after soybeans (+1), sweet potato transplanted 2 weeks after soybeans (+2), sweet potato + soybeans planted simultaneously (0), sweet potato transplanted 1 week before soybeans (-1), sweet potato transplanted 2 weeks before soybeans (-2), Sole sweet potato (Ssp) and Sole soybeans (Ssb). These were arranged in randomized complete block design with four replications. Percent production of tubers and pods as well as tuber and grain yields of component crops were significantly increased ($p = 0.05$) by the cropping treatments in all the three seasons of this study. However, same parameters do not statistically differ from one treatment to another in each season, except in percent tuber production with sole sweet potato in both 2008 and 2009 as well as in tuber yield with sole sweet potato in 2009. Therefore, component crops can be sole-grown or adopt sweet potato transplanted a week or 2 before soybeans-sequence for better tuber and grain yields.

Key words: Performance, sweet potato, soybeans, crop sequence, northern guinea savanna

INTRODUCTION

Sweet potato (*Ipomoea batatas* L. Lam.) is an important crop widely grown in Nigeria. Globally, sweet potato is the seventh most important food crop and second most important tuber crop in the world after irish potato (Horton, 1988; Dantata *et al*., 2010). While, soybeans (*Glycine max* L. Merrill) is an important crop grown for its high quality vegetable oil, about 20% of its fat content and protein, about 40% of the bean (Singh *et al*., 1987; Okpara *et al*., 2005). These workers reported that oil obtained from soybeans is highly digestible, high in unsaturated fatty acids and contains no cholesterol its protein is superior, with substantial levels of most essential amino acids. Soybeans are a cheap substitute for meat and fish when consumed with cereals (Singh *et al*., 1987) or roots and tubers to supply methionine and cystine. Legumes, in a legume-non-legume mixture obtain much of their nitrogen by fixation, whereas the non-legume component(s) exploit the NO_3^- and NH_4^+ in the soil. Although, legumes in mixtures will not usually compete with other species for nitrogen, they will of-course, compete for other growth factors in which case, some loss of yield of the main crop is normal (Enyi, 1972).

Cropping sequence can be defined as a feature of inter-cropping which deals with timing of introduction and/or establishment of intercrops, as well as ascertaining degree of compatibility and incompatibility with other intercrops (Babatunde *et al*., 2000). This phenomenon can also be simply defined as a feature of intercropping which deals with planting date intervals between series of intercrops (Babatunde, 2000). Sequential cropping as a system of farming implies the growing of one crop after the other time, being a very vital factor (Andrew and Kassam, 1975). They noted that for crop mixtures to be successful, the sum of the intercrop competition should be less than the sum of the intra-crop competition of the component crops when grown alone.

Intercropping is the growing of two or more crops in proximity to promote interaction between them. In line with this definition, Wahua (1982), Ikeorgu (1983) and

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Okigbo (1978) explained that intercropping is the growing of two or more crops simultaneously on the same field such that the period of overlap is long enough to include their vegetative stage. Sequential cropping and intercropping are the two basic principles of multiple cropping (Ruthernberg, 1971, Andrew and Kassam, 1975). Specific multiple cropping systems have developed over the centuries in the different regions and they are closely adapted to the prevailing ecological and socio-economic conditions. Lagemann (1977) observed that population pressure has led to an intensification of intercropping in order to increase the production per unit area. In general, there is a high indication in the importance of multiple cropping since it has for some time now become government policy to increase production by improving intercropping systems (Kurt, 1984). Sequel to the foregoing, it become necessary to know at what time to introduce the different intercrops in combination for better crop performances.

MATERIALS AND METHODS

The study was conducted under rainfed conditions in 2007, 2008 and 2009 at Abubakar Tafawa Balewa University, Bauchi, teaching and research farm situated at 10° 17" N, 90° 49" E and 609.3 m above sea level in the Northern Guinea Savanna Ecological zone of Nigeria. The soil of the experimental site was a well drained tropical sandy loam with pH from 6.10 (in 2007), 6.22 (in 2008) and 5.93 (in 2009). The experimental site recorded an annual rainfall of 1136.9, 1133.1 and 1211.6 mm in 2007, 2008 and 2009, respectively and a mean monthly temperature of 27.2°C (2007), 26.8°C (2008) and 28.4°C (2009).

Most popular Bauchi local (Bolobolo) a White- Fleshed Sweet Potato (WFSP) variety was used throughout the period of the study. Longer vines of this crop variety measuring more than 100 cm were employed using farmers' traditional method of planting as reported by Tewe *et al*. (2003). While, soybean seeds of TGX 1448-2E variety were drilled (inside grooves, measuring approximately 5 cm deep made on the well prepared ridges) in alternate with sweet potato rows. The soybeans were later thinned into 10 cm spacing during the first weeding at 4 weeks after sowing (WAS) according to Islam *et al*. (2004).

The treatments consisted of seven different cropping sequences namely sweet potato planted 1 week after soybeans, sweet potato planted 2 weeks after soybeans, sweet potato and soybeans planted simultaneously, sweet potato planted 1 week before soybeans, sweet potato planted 2 weeks before soybeans, sole sweet potato and sole soybeans. These treatments were arranged in a randomized complete block design with four replications.

The gross plot was 461.1 m^2. This was demarcated into plots of 4 m×3.6 m, with 6 ridges per plot. In 2009 raining season, the experimental area was tractor-ploughed incidentally before being demarcated into plots. Planting started in third week of the month of June of each season after rain has established. Weeds were controlled as often as necessary. Fertilizer ($N_{20}P_{10}K_{10}$) was applied at the rate of 50 kg ha^{-1} consistently in two equal splits, first and second dose at 2 and 6 weeks after planting (WAP) on sweet potato rows.

The crops were harvested at physiological maturity. Harvesting which followed the rhythm of the cropping sequence at planting was done at different times. The net plot was harvested for the determination of percent production of tubers and pods (Dantata *et al*., 2010) as well as tuber and grain yields in sweet potato and soybeans respectively. Data collected were subjected to analysis of variance (ANOVA) using SPSS version 13 computer software package to test for the significant effect of the treatments. Comparison of treatment means for significance at 5% probability level was done using the Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Percent tuber production: The percent tuber production in sweet potato in 2007 did not statistically vary among cropping sequences, especially when sweet potato vines were planted alone (sole) and a week before soybeans were introduced. Sweet potato planted a week before soybeans did not vary also with sweet potato planted two weeks before soybeans were introduced. Likewise between the same treatment (sweet potato planted two weeks before soybeans) and simultaneous planting of sweet potato+soybeans. Crops sown simultaneously do not really differ with sweet potato planted a week after soybeans. The same treatment (sweet potato planted a week after soybeans) also was not different with sweet potato planted two weeks after soybeans. This trend was also observed in 2008 and 2009, respectively. However, sole sweet potato in the two preceding years, were significantly different (p = 0.05) when compared with other cropping sequences (Table 1). The observation recorded on percent tuber production in this study resembles the one reported by Egbe and Idoko (2009) who worked on the suitability of sweet potato for cropping with pigeon pea in 2006 and 2007. These authors reported that sole pigeon pea produced significantly higher number of tubers than pigeon pea cropped with sweet potato. All the other combinations gave lower number of tubers than the

Table 1: Effect of cropping sequence of sweet potato and soybeans on percent tuber production of sweet potato during the 2007, 2008 and 2009 raining seasons

	Percent tuber production (%)		
Treatment	2007	2008	2009
Sweet potato 1 week after soybeans	11.5^{de}	11.9^{d}	13.5^{d}
Sweet potato 2 weeks after soybeans	70.8^{e}	90.6^{d}	11.2^{d}
Sweet potato+soybeans simultaneously	15.5^{cd}	15.9^{c}	16.0^{c}
Sweet potato 2 weeks before soybeans	18.5^{bc}	18.6^{c}	16.7^{c}
Sweet potato 1 week before soybeans	21.1^{ab}	20.0^{b}	19.4^{bc}
Sole sweet potato	25.6^{a}	24.0^{a}	23.4^{a}

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT

sole pigeon pea in both 2006 and 2007. Their results further revealed that there was no significant difference among other cropping combinations. The reduction in percent tuber production observed with sequential cropping of sweet potato with soybeans in this study is associated with depressed level of photosynthesis due to shading of sweet potato by the taller soybeans companion crop. This is in conformity with the total number of fresh and saleable tuber yields of sweet potato varieties cropped with pigeon pea in the Southern Guinea savanna of Nigeria (Egbe and Idoko, 2009) and earlier reports of Anders *et al*. (1994) who indicated that when component legume is taller than non-legume, the legume can grow well due to high photosynthetic and high biological nitrogen fixation activities with adequate solar radiation and that the non-legume growth is severely suppressed due to depression of photosynthesis through decreases in irradiance.

Percent pod production: In the 3-year study percent pod production in soybeans, did not differ significantly (p = 0.05) among cropping sequences, particularly in sole soybeans, sweet potato planted both at one week and two weeks before soybeans and when sweet potato+soybeans were planted simultaneously. Sweet potato introduced a week or two weeks after soybeans also do not vary significantly in percent pod production. However in 2009, sweet potato planted at one week after soybeans also do not vary significantly in percent pod production with all of the cropping sequences (Table 2). Njoku *et al*. (2007) in a field experiment conducted in the rainforest zone of Nigeria in 2000 and 2001 cropping seasons to assessed the productivity of sweet potato intercropped with okra, reported that intercropping generally with sweet potato significantly reduced the number of pods per plant in both years (Njoku *et al*., 2007). According to them, number of pods per plant was higher in the sole crop than intercrop by 36% in 2000 and 47% in 2001.

Table 2: Effect of cropping sequence of sweet potato and soybeans on percent pod production of Soybeans during the 2007, 2008 and 2009 raining seasons

	Percent pod production		
Treatment	2007	2008	2009
Sweet potato 1 week after soybeans	14.0^{b}	12.6^{b}	11.9^{ab}
Sweet potato 2 weeks after soybeans	12.3^{b}	11.2^{b}	90.6^{b}
Sweet potato+soybeans simultaneously	17.2^{a}	18.1^{a}	18.2^{ab}
Sweet potato 2 weeks before soybeans	17.7^{a}	18.1^{a}	19.0^{ab}
Sweet potato 1 week before soybeans	18.6^{a}	19.1^{a}	20.1^{a}
Sole soybeans	20.2^{a}	20.9^{a}	21.2^{a}

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT

Table 3: Effect of cropping sequence of sweet potato and soybeans on tuber yield (t ha^{-1}) of sweet potato during the 2007, 2008 and 2009 raining seasons

	Tuber yield (t ha^{-1})		
Treatment	2007	2008	2009
Sweet potato 1 week after soybeans	9.7^{c}	17.0^{d}	51.3^{c}
Sweet potato 2 weeks after soybeans	6.9^{c}	13.9^{d}	41.4^{c}
Sweet potato+soybeans simultaneously	10.8^{c}	22.0^{c}	60.6^{b}
Sweet potato 2 weeks before soybeans	14.7^{bc}	25.1^{bc}	62.8^{b}
Sweet potato 1 week before soybeans	16.5^{ab}	28.3^{ab}	73.5^{b}
Sole sweet potato	19.2^{a}	33.8^{a}	88.7^{a}

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT

Tuber yield: In all cropping seasons, cropping sequences significantly influenced tuber yield (Table 3). Sole sweet potato gave the highest tuber yield in 2007. Within the same season, sweet potato either transplanted a week or two before soybeans, or sweet potato+soybeans planted simultaneously or sweet potato transplanted a week or two after soybeans do not statistically vary in tuber yield. This trend of behavior was recorded in 2008 and 2009 raining seasons, which agree with the better performance of sole crops than in mixtures in separate works of Lizanga (1980), Emuh and Agboola (2000) and Egbe and Idoko (2009). These workers observed better performance in yield of sole crop than in their intercrops. Consequently, tuber yield of sweet potato obtained in 2009 season, was 4-6 times more than that of 2007 and 2-3 times greater than that of 2008. The trend in tuber yield observed in 2009 confirmed the factor of seasonal variation as reported severally in sweet potatoes (Austin and Aung, 1973; Lowe and Wilson, 1975; Onwueme, 1978; Belehu, 2003; Dantata *et al*., 2010). Possibly, the increase in amount of rainfall up to 1215.62 mm in 2009 with optimum growing temperature range of 20-32°C (Belehu, 2003) and soil pH of 6.30 (Onwueme, 1978) coupled with ploughing (Dantata *et al*., 2010) before ridging prompted tuber yield development in this study. Earlier, Sajjapongse and Roan (1982), Belehu (2003) as well as Dantata *et al*. (2010) reported that sweet potato require loose soil in which tubers can grow and enlarge to form yield with little hindrances. As compact soil (soil with high bulk density or poor aeration) hampers tuber formation, therefore, additional tillage such

Table 4: Effect of cropping sequence of sweet potato and soybeans on grain yield of soybeans during the 2007, 2008 and 2009 raining seasons

	Grain yield (kg ha^{-1})		
Treatment	2007	2008	2009
Sweet potato 1 week after soybeans	2290.90^{cd}	3358.81^{b}	4053.78^{ab}
Sweet potato 2 weeks after soybeans	1807.34^{d}	2848.67^{b}	3296.30^{b}
Sweet potato+soybeans simultaneously	2821.19^{b}	4928.10^{a}	6135.77^{ab}
Sweet potato 2 weeks before soybeans	2965.48^{b}	4947.72^{a}	6543.82^{a}
Sweet potato 1 week before soybeans	3092.95^{ab}	5215.11^{a}	6677.40^{a}
Sole soybeans	3431.72^{a}	5635.53^{a}	7106.22^{a}

In a column, means followed by same letter are not significantly different at 5% probability level by DMRT

as the tractor-ploughing in 2009 raining season could be very particular in greatly reducing soil bulk density and increase soil aeration of the experimental area.

Grain yield: Grain yield in soybeans was significantly (p = 0.05) higher with sole soybeans in 2007, however, this do not differ with when sweet potato was transplanted a week before soybeans. Within the same growing season, sweet potato transplanted both at one and two weeks before soybeans with simultaneous planting of sweet potato + soybeans do not really differ statistically, so also, sweet potato transplanted a week or two after soybeans. The trend of observation in grain yield of soybeans was similar in 2008 and 2009. However, in 2008 grain yield was higher in sole soybeans and when sweet potato was transplanted a week or two weeks as well as when both crops were planted simultaneously. Whereas, lower yield within the same cropping season was recorded only when sweet potato was planted a week or two after soybeans were introduced. In 2009 growing season, higher grain yield was obtained in sole soybeans, when sweet potato was transplanted a week or two weeks and when both crops were planted simultaneously as well as when sweet potato was transplanted a week after soybeans. Whereas, lower and similar yield within the same cropping season was realized when sweet potato and soybeans were introduced simultaneously as well as when sweet potato was planted a week or two after soybeans were introduced in the sequence (Table 4). This agrees with Alhassan (1995) who reported that grain yield of soybean was significantly higher under sole crop than as an intercrop in yam. The worker indicated that sole crop soybean produced 1.5 times the grain yield of soybean as an intercrop in yam. All intercropped soybean treatments did not significantly differ in grain yield or pod yield. Differences in grain yield of soybeans in this study seemed to be associated with percent pod production which was influenced too well by seasonal variation and other important factors reported in literature (Austin and Aung, 1973; Lowe and Wilson, 1975; Onwueme, 1978; Lizanga, 1980; Palaniappan, 1985; Olasantan and Lucas, 1992; Alhassan, 1995; Emuh and Agboola, 2000; Belehu, 2003; Njoku *et al*., 2007; Egbe and Idoko, 2009; Dantata *et al*., 2010). For instance, Palaniappan (1985) observed that when one component is taller than the other in an intercropping situation, the taller component intercepts major share of the light such that performance of the two components will be proportional to the quantity of the Photo-synthetically Active Radiation (PAR) they intercepted.

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