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# COMPARATIVE ADVANTAGE OF INTERCROPPING MAIZE, COWPEA AND TOMATO TO SOLE AND MIXED CULTURE

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**ABSTRACT**
*This study investigated the advantage of intercropping maize, cowpea and tomato to the sole culture. This was with a view to provide information on the appropriate intercropping system that will enhance increased yield of the crops under study. The experiment was carried out under a screenhouse to minimize extraneous factors such as pests and rodents using a randomized complete block design (RCBD). The treatments where T1 = sole maize (SM); T2 = Maize intercrop with cowpea (MC); T3 = Maize intercrop with tomato (MT); T4 = Sole tomato (ST); T5 = Tomato intercrop with Cowpea (TC); T6 = Sole cowpea (SC); T7 = Maize intercrop with cowpea and tomato (MCT). Seeds of cowpea, maize and tomato were collected from the Department of Crop Production and Protection, Faculty of Agriculture, Obafemi Awolowo University, Ile Ife, Osun state. These seeds were planted at a depth of about 3 mm below the soil. The seeds were sown at the rate of six seeds per pot in the monoculture, while in the pots designed for the mixed culture of maize and cowpea, maize and tomato, cowpea and tomato, three seeds of each plant were sown. Two seeds of each plant were sown in the pots with the three crops. The bowls were then supplied with 500 ml of tap water in the morning and in the evening respectively until the seedlings become fully established. Statistical analysis was performed using statistical analytical software SAS version 9.13. The result showed that all the competition indices (land equivalent ratio, relative crowding coefficients, relative neighbor effect and relative reproductive rate) of the intercrops, analyzed in this study were greater than 1. This showed that the yield of maize, cowpea and tomato were enhanced in the intercropped than the sole crops. The study concluded that maize, tomato and cowpea plants can perform and produce better when grown with together than when in sole culture.*

**KEY WORDS:** *Competition, Indices, Intercropping, Sole cropping, Growth*

## INTRODUCTION

Various cropping systems are used worldwide to increase food production. One example is intercropping which is the simultaneous planting of two or more crops in the same field. (Ofori & Stern, 1987; Nassef & Abd El-Gaid, 2012). Intercropping is also an agricultural practice of cultivating two or more crops in the same space at the same time. It is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labor.

The advantages of intercropping to competition of plants of the same or different species is the production of greater yield on a given space by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height, and nutrient requirements based on the complementary utilization of growth resources by the component crops in a limited space (Lammerts van Bueren *et al.,* 2002; Ianovici, 2011). Intercropping improves soil fertility when competition is set in through biological nitrogen fixation with the use of legumes, increases soil conservation through greater ground cover than sole cropping, and provides better lodging resistance for crops susceptible to lodging than when grown in monoculture to the mixed culture. Intercrops often reduce pest incidence and improve forage quality by increasing crude protein of forage or cereals (Lithourgids, 2011). Intercropping provides insurance against crop failure and provides good growth, yield and allows plants to accumulate more photosynthetic pigments even when there is competition especially in areas subject to extreme weather conditions such as frost, drought, and flood (Giller, 2001).

Studies which have demonstrated advantages of intercropping with legumes include, cabbage with bean (Poniedzialek *et al*., 1989), watermelon with soybean (Sharaiha & Hattar, 1993) and chilli with bean (Costa & Perera, 1998). Intercopping practice could modify the microclimate by reducing light intensity, air temperature, desiccating wind and other climatic components. For example, tomato intercropped with grain sorghum as the shade crop yielded more than pure stand tomato with little loss of sorghum yield and Land Equivalent Ratio of the tomato + sorghum intercrop ranged from 2.58 to 2.99 (Kamel *et al*., 2004). The shade crop (sorghum) reduced air temperatures surrounding intercropped tomato canopy to as less 5-7 degree Celsius as compared with the pure stand tomato. Poor foliage development, dropping of blossom, poor fruit set, breakage of leaves and branches, fall over of plants in irrigation furrow and high dust coverage on the leaves cause poor plant development and reduce fruit yield in the Rift Valley (Lemma, 2002). However, in a study at Melkassa (in Ethiopia), wind protected tomato plants with strip intercropping of maize and sorghum plants gave higher yield (7.4 t/ha) (Lemma, 2002).

Agricultural research originally focused on sole cropping and ignored the potential of intercropping. There has been a gradual recognition of the value of intercropping system. The essential features of intercropping systems are that there is competition between and among the system components for light, water and nutrients. The growth and yield advantage of intercropping has not been so marked. The goal of this study was to compare the advantage of intercropping maize, cowpea and tomato to the sole culture.

## MATERIALS AND METHODS

The Seeds of cowpea (IT07K-38-33), maize (2008 DTMA-YSTR) and tomato (ROMA VF) were utilized in this experiment. These seeds were collected from the Department of Crop Production and Protection, Faculty of Agriculture, Obafemi Awolowo University, Ile Ife, Osun state. A screenhouse was constructed to minimize extraneous factors such as pests and rodents, supply of water other than the amount specifically applied. The mean daily temperature under the screenhouse was taken with the aid of a thermometer. The intensity of light was also determined using a digital luxmeter LX 1000. Relative humidity was measured using a hygrometer.

Forty two bowls were obtained (of 38cm in diameter and 5.5 cm in height). Holes of about 3mm each were bored at the bottom of the bowls. This is to allow for proper drainage and prevent water logging during the course of the experiment. The bowls were filled near brim with 10 kg of the analyzed soil. The seeds of cowpea, maize and tomato were then planted at a depth of about 3 mm below the soil. The seeds were sown at the rate of six seeds per pot in the monoculture, while in the pots designed for the mixed culture of maize and cowpea, maize and tomato, cowpea and tomato, three seeds of each plant were sown. Two seeds of each plant were sown in the pots with the three crops. The bowls were then supplied with 500 ml of tap water in the morning and 500 ml of tap water in the evening until the seedlings become fully established.

The seedlings were divided into seven regimes which include the following: T1 = sole maize (SM); T2 = Maize intercrop with cowpea (MC); T3 = Maize intercrop with tomato (MT); T4 = Sole tomato (ST); T5 = Tomato intercrop with cowpea (TC); T6 = Sole cowpea (SC); T7 = Maize intercrop with cowpea and tomato (MCT). All the groups of plants were made to receive 500 ml of water every morning and evening throughout the experimental period. An experiment laid out in a Randomized Complete Block Design (RCBD) will be used with six replicates.

The benefit of planting pattern and the effect of competition between three plants that were in this experiment were calculated using Land Equivalent Ratio (LER), Relative Crowding Coefficients (RCC), Relative Neighbor Effect (RNE) and Relative Reproductive Rate (RRR). These were determined as follows:

LER= (Yamix/Yamono) + (Ybmix/Ybmono) Willey & Osiru (1972)

RRR = Oa/Ob de Wit (1960)

RYM = (Yamix+ Ybmix)/ [(Yamono+ Ybmono)/2] Wilson (1988)

RNE = (Pcontrol−Pmix)/x Markham & Chanway (1996)

Where Y is performance per unit area (with $Y = P \times d$; (Biomass) where P is performance per plant, d is planting density), O is number of seeds produced per plant, a and b for species a and b, ), x for the number of species used in the experiment, control for a plant growing alone; mix for plants in the mixed culture.

## RESULTS AND DISCUSSIONS

### Competition Indices of Maize under Competition Stress

The higher LER for T2-plants (1.71) and the lowest for T1-plant was recorded in these findings compare to other treatments. From table 1, the LER for T2-plants, T3-plants and T7-plants were greater than 1, while the LER of T1-plants is equal to 1. The LER of T1-plants which is designated as unity (=1) was significantly different from other treatments at $P>0.05$. There was no significant different in the LER of all the intercrops. The result of the ANOVA shows that the RCC of T2-plants had the highest value while the RCC of T7-plants was the lowest (Table 1). The result shows no significant difference in the RCC of all the treatments. The RNE of T3-plants was the highest and the RNE of T1-plants was the lowest (Table 1). The RNE of T2-plants, T3-plants and T7-plants in all the treatments is greater than 1 and the RNE of T1-plants is less than 1. There was significant difference in the RNE of T1-plants to other treatments and T2-plants to T3-plants and T7-plants. No significant difference in RNE of T3-plants and T7-plants.The RRR ofT2-plants were the highest and the RRR of T7-plants was the lowest (Table 1). Only the RRR of T2-plants and T3-plants were greater than 1, RRR of T1-plants equals 1 and the RRR of T7-plants was less than 1, RRR of T1-plants equals 1 and the RRR of T7-plants was less than 1. There was significant difference in the RRR of T2-plants to RRR of T1-plants and T7-plants. No significant difference in RRR of T3-plants to other treatments.

**Competition Indices of Tomato under Competition Stress**

From the table, LER of all the treatments were greater 1. The LER of T1-plants which is designated as unity (=1) was significantly different from other treatments at P>0.05. There was no significant different in the LER of the monocrop (T4-plants) to the intercrops (T3-plants, T5-plants and T7-plants) (Table 2). The result of the ANOVA shows that the RCC of T3-plants had the highest value while the RCC of T7-plants was the lowest (Table 2). The result shows a significant difference in the RCC of all the treatments. The RNE of T3-plants was the highest and the RNE ofT7-plants were the lowest (Table 2). The RNE in all the treatments was the less than1. There was no significant difference in the RNE of all the treatments. The RRR of T5-plants was the highest and the RRR of T7-plants was the lowest (Table 2). Only the RRR of T3-plants and T5-plantswere greater than 1, RRR of T4-plants equals 1 and the RRR of T7-plants was less than 1. There was significant difference in the RRR of T7-plants to other treatments. No significant difference in the RRR of T3-plants, T5-plants to other treatments and T7-plants.

**Competition Indices of Cowpea under Competition Stress**

The result of the ANOVA shows that LER for T7-plants was the highest and T6-plants were the lowest. From table 3, LER of all the treatments were greater than 1 except T6-plants which equals 1. The LER of T6-plants which is designated as unity (= 1) was significantly different from other treatments at P>0.05. There was significant difference in the LER of the monocrop (T6-plants) to the intercrops (T2-plants, T5-plants and T7-plants). The result of the ANOVA shows that the RCC of T2-plants had the highest value while the RCC of T5-plants was the lowest (Table 3). Only the RCC of T2-plnts was greater than 1 and the remaining treatments (T5-plants, T6-plants and T7-plants) were grater less than 1. There was significant difference in the RCC of T2-plants to T5-plants. The RNE of T2-plants was the highest and the RNE of T6-plants was the lowest (Table 3). The RNE in all the treatments was less than 1. There was no significant difference in the RNE of T2-plants, T5-plants and T7-plants. These treatments were statistically different from T6-plants. The RRR of T7-plants was the highest and the RRR of T6-plants was the lowest (Table 3). The RRR of T2-plants, T5-plants and T7-plants were greater than 1 and RRR of T6-plnats equals 1. There was no significant difference in the RRR of all the treatments.

**TABLE 1. Competition indices of maize under competition stress**

| Treatments | Land Equivalent Ratio | Relative Crowding Coefficient | Relative Neighbor Effect | Relative Reproductive Rate |
|---|---|---|---|---|
| T1 | 1.00[b] | 0.00[a] | 0.00[c] | 1.00[b] |
| T2 | 2.35[a] | 8.23[a] | 16.67[a] | 1.68[a] |
| T3 | 2.26[a] | 0.03[a] | 58.65[a] | 1.05[ab] |
| T7 | 2.23[a] | -4.27[a] | 29.03[a] | 0.74[b] |
| SE | 0.32 | 2.61 | 12.37 | 0.19 |
| CV% | 32.75 | 54.08 | 94.88 | 35.73 |

Means with the same letter along the same column are significantly different at P>0.05
T1: sole maize (SM);
T2: Maize intercrop with cowpea (MC);
T3: Maize intercrop with tomato (MT);
T7: Maize intercrop with cowpea and tomato (MCT)
SE: Standard Error
CV: Coefficient of Variance

**TABLE 2. Competition indices of tomato under competition stress**

| Treatments | Land Equivalent Ratio | Relative Crowding Coefficient | Relative Neighbor Effect | Relative Reproductive Rate |
|---|---|---|---|---|
| T3 | 1.64[a] | 2.52[a] | 0.45[a] | 1.23[a] |
| T4 | 2.00[a] | 0.00[b] | 0.00[a] | 1.00[a] |
| T5 | 2.43[a] | 0.33[c] | 0.28[a] | 3.20[a] |
| T7 | 1.38[a] | -0.35[d] | -0.13[a] | 1.00[b] |
| SE | 0.13 | 0.64 | 0.13 | 0.13 |
| CV% | 24.47 | 206.95 | 175.45 | 24.47 |

Means with the same letter along the same column are significantly different at P>0.05
T3: Maize intercrop with tomato (MT);
T4: Sole tomato (ST);
T5: Tomato intercrop with cowpea (TC);
T7: Maize intercrop with cowpea and tomato (MCT)
SE: Standard Error
CV: Coefficient of Variance

**TABLE 3. Competition indices of cowpea under competition stress**

| Treatments | Land Equivalent Ratio | Relative Crowding Coefficient | Relative Neighbor Effect | Relative Reproductive Rate |
|---|---|---|---|---|
| T2 | 2.02[a] | 7.63[a] | 0.75[a] | 1.13[a] |
| T5 | 2.03[a] | -1.93[b] | 0.13[a] | 1.065[a] |
| T6 | 1.00[a] | 0.00[ab] | 0.00[b] | 1.00[a] |
| T7 | 2.08[a] | 0.88[ab] | 0.58[a] | 1.22[a] |
| SE | 0.26 | 2.08 | 0.18 | 0.05 |
| CV% | 29.30 | 252.83 | 97.88 | 8.51 |

Means with the same letter along the same column are significantly different at P>0.05
T2: Maize intercrop with cowpea (MC);
T5: Tomato intercrop with cowpea (TC);
T6: Sole cowpea (SC);
T7: Maize intercrop with cowpea and tomato (MCT)
SE: Standard Error
CV: Coefficient of Variance

**Competition Indices of Maize under Competition Stress**

The LER for maize-cowpea intercrops (1.71) and for the sole which was 1.00 (Abraha, 2013) was in agreement with this study in which LER for the T2-plantsis 1.71 and for the sole is 1.00. All the LER for the intercrops (T2, T3 and T7) were greater than 1. This indicates the advantage of intercrops over sole intercrop. Similar results for (LER) greater than one were reported for mix proportion of pea-barley (Chen *et al*., 2004). The insignificant difference in the RCC of all the treatments shows that the interaction among the treatments is density independent. The significant difference in the RNE of T1-plants shows that the interaction of maize plants when grown in the sole differs when in the mixed. This indicates the effect of associates i.e. when in intercrop to when in the sole on the growth and yield of maize plants. The RRR of T2-plants and T3-plants which were greater than 1 shows that maize plants can perform and produce better when grown with cowpea plants (T2-plants) and tomato plants (T3-plants) than when grown alone (TI-plants). This may be due to competition of shared resource used in the mixed culture and the same resource incurred in the sole culture

**Competition Indices of Tomato under Competition Stress**

As compare with this research, in a study that was conducted in the field at Kenya Agriculture Research Institute Njoro, Kenya, in both years (2004 and 2006) of the study, land equivalent ratio was greater than 1 in all the intercropping systems (Ramkat *et al*., 2008). This corroborate with this study in which the LER of tomato in the intercrop is greater than 1. This shows yield advantage of the mixed culture of tomato over the sole culture. The results which shows no significant difference in the RCC of all the treatments indicates the yield of tomato both in the sole culture and in the mixed culture is density independent. The RNE of T3-plants which was higher than the RNE of other treatments shows that the tomato plants may not be able to compete well with maize plants due to height-to-crown and size asymmetric of maize plants to tomato plants (Schmitt & Wulff, 1993). The RNE of T7-plants which was lowest with a negative value indicate the better performance of tomato when in the mixed culture with maize and cowpea plants (T7). The RRR of T3-plantsand T5-plants which were greater than 1 shows efficiency of tomato plants relative to T4-plants and T7-plants. Therefore, tomato plants can perform and produce better when grown with cowpea plants (T5-plants) or maize plants (T3-plants) than when grown alone (T4-plants) or in the mixed culture with maize and cowpea (T7-plants).

**Competition Indices of Cowpea under Competition Stress**

Similar results of this study for LER greater than one were reported for mix proportion of pea-barley Chen *et a*l. (2004), bean-wheat and maize-fava bean (Li *et al*., 2003). This also indicates the advantage of intercropping over sole stands. RCC of T2-plantswhich was greater than 1 indicates the advantage of intercropping maize with cowpea over other treatments (T5-plants, T6-plants and T7-plants). The significant difference in the RCC of T2-plants to T5-plants shows that cowpea plants when intercropped with tomato plants. The RRR of T2-plants, T5-plants and T7-plants which were greater than 1 shows the advantage of intercropping cowpea to other crops when in the sole.

**CONCLUSIONS**

The competition indices evaluated in this study that were greater than one implies that for that particular crop combination, intercropping yielded more than growing the same number of stands of each crop as sole crops. This also shows the advantage of the mixed cultures over the sole culture. Therefore, because of reduced yields of maize, cowpea and tomato in sole culture compared to the mixed culture it can be recommended that maize, cowpea and tomato can be grown together for their optimum yield. Depending on the producers objectives for good land management and/or available land, intercropping maize, tomato with cowpea can be practiced to produce more yields.

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