American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Relative Planting Dates Effect on the Agronomic Performance of Maize (Zea Mays L.) and Groundnut (Arachis Hypogea L) in an Intercrop System

Mustapha Mas-ud[a*], James Seutra Kaba[b], Kwadwo Ofori[c], Gumah Salifu[d]

[a,d]*Department of Agriculture Engineering, Tamale Polytechnic, Ghana*
[b]*Faculty of Science and Technology, Free University of Bolzano, Italy*
[c]*University of Ghana, Legon, Crop Science Department Ghana*
[a] *Email: mustaphamansoda@yahoo.com*
[b]*Email: seutra@yahoo.com*

Abstract

A Field experiment was conducted to evaluate the effect of different planting dates on the yield and yield components of maize and groundnut in an intercropping system. The experiment was laid in a Randomized complete block design with four replications. The Experimental treatments were: Sole maize; Sole groundnut; Maize, one row groundnut, 0 WAP maize; Maize, one row groundnut, 1 WAP maize; and Maize, one row groundnut, 2 WAP maize. Data collected during the experiment were: Plant height, growth rate, Chlorophyll content, leaf area index, Days to 50% tasseling (maize), Days to silking (maize), Days to 50% flowering (groundnut), Plant height, Pod number (groundnut), Maize grain yield, total Stover biomass yield, total haulm biomass yield and harvest Index. Dry matter yield was significantly different ($P<0.05$) among treatments at all the stages of growth in both groundnut and maize. Grain yield showed significant differences ($P<0.05$) among all treatments except for the one row of groundnut intercropped two weeks after sowing maize and the sole maize. The study showed that where groundnut is considered the major crop then the one row of groundnut sown at the same time with the maize should be adopted. Also, were maize is the interest crop, then the one row of maize with two rows of groundnut at 2WAP maize would be ideal. Finally, where the farmer wants to maximize the use of the land for both crops equally, then the one row of groundnut intercropped at the same time with maize is the best system.

Keywords: Groundnut; inter-cropping; Maize; Planting dates.

---

* Corresponding author.

1. Introduction

Good timing of planting date is one of the key factors that strongly affect production in rain fed agriculture [1]. This is especially true as in many parts of Africa, the rainy season starts with some light showers followed by dry spells, which can cause poor crop emergence or desiccate a young crop [2]. Differences in time of planting may relate to different climatic conditions (rainfall, temperature and photoperiod). In Ghana, the main cultivated areas are in the Guinea savanna, the transition and the coastal savanna zones. There is only one cropping season in the Savannas. These planting periods correspond to different rainfall and temperature [3]. In the Savanna zones, planting of legumes with cereals is the most predominant cropping system [4], this is usually done to avoid complete crop failure due to unpredictable rainfall patterns. In terms of legumes cultivation, groundnut (Arachis hypogaea *L*) is a major grain legume and it is an important component of sustainable cropping systems in Ghana. Planting commences when temperatures and moisture levels are optimums [5]. Groundnut is a dual-purpose grain legume that is available for human food and for the improvement of soil fertility. It is the only legume eaten in any form such as roasted, fresh, dry, boiled or cooked with soup. It derive a large proportion of its N needs from biological N-fixation and produce a substantial amount of both grain and biomass, making them attractive to smallholder farmers [6; 7]. Due to the beneficial effect of groundnut to soil fertility improvement and farmers desire to avoid complete yield loss during natural disasters, coupled with the desire to maximize land use, farmers usually intercrop groundnut with cereals especially maize in Northern Ghana. [8] reported that maize is a major cereal crop in Ghana and an important staple food, and hence has been a subject of much research.

According to [9] intercropping is the practice of growing more than one crop simultaneously in alternating rows on the same field. Intercropping is a popular cropping system among small-scale farmers in the tropics [10] and has for long been practiced in many countries of Africa, India and China [11] in order to maximize yield per unit of land. A general assumption in intercropping cereals with legume crops is that the legume, when associated with the specific Rhizobium, may have most of its N need supplied through fixation of atmospheric N, leaving the soil available N for the companion cereal. [12] observed that Intercropping of maize and cowpeas (Vigna unguiculata) is especially beneficial on nitrogen poor soils. In addition, [13] observed that intercropping alleviate Fe deficiency stress and contributes to better nutrition of plants with Zn, P and K. Increased leaf cover in intercropping systems helps to reduce weed populations once the crops are established [14; 15; 9]. In areas where there is water scarcity, intercropping is a more suitable method [16] According to [17] intercropping groundnut with maize would be advantageous to the small-scale farmer in terms of increased maize yields, higher combined crop yields/ha. [18] reported intercropping advantages in yield (28–30% for wheat intercropped with soybean). According to [19] intercropping maize with French beans (phaseolus aureus), Cowpea (Vigna unguculata) and Mucuna (Mucuna pruens) increased its mean grain yield by 0.5 tonnes/ha over the control. In a mix maize and beans intercrop, yields of the mixtures were up to 38% higher than could be achieved by growing the crops separately. This reemphasizes the possible importance of growing more than one crop in the same land. Although there are numerous merits of intercropping, there are also associated demerits. [20] reported that roots of crops in association compete for nutrients and other resources, which may affect the associated crops negatively. [21] indicated that Intercropping reduced soybean yields by 87% compared with sole cropping, principally because of reduced plant growth and pod set. Therefore, determining the appropriate

time to intercrop a legume or cereal plant in any intercropping system is essential in maximizing the yield components of both plants. Different research findings have suggested varied times to intercrop legumes in cereals to ensure maximum yield of both component crops. [22] found that cowpeas planted three weeks after maize had significantly reduced yields, and therefore recommends planting cowpeas simultaneously with maize. [23] and [24] indicated that Simultaneous planting could also reduce labour and operational costs, in contrast, delayed bean planting favored maize grain yield. [25] also reported highest intercrop peanut yield when maize and groundnuts were simultaneously planted compared to other planting dates. Small-scale farmers in Ghana do not have specific dates to sow a component crop (groundnut or maize) in an inter-crop system. Even though groundnut and maize intercropping is a common practice in Ghana, quantitative information is lacking on the productivity of the system, especially when farmers should plant the component. In addition, the effects of relative planting dates of groundnut and maize on yield has not been extensively investigated and as such, legumes are intercrop with cereal at the convenient time of the farmer resulting in low yield and low income. Hence, the objective of this research was to evaluate the effect of different planting dates on the yield and yield components of maize and groundnut in an intercropping system.

2. Materials and Methods

2.1 Study Area

Field experiments was conducted on the University of Ghana farm, Legon. The experimental site is within the coastal Savannah zone, with annual mean rainfall of 750 mm and temperature of 26 ° C. The soil belongs to the Adenta series, ferric Acrisol. [26] During the period of study (April-August), maximum mean rainfall was recorded in June (259.7 mm) whilst the minimum was recorded in August (42.1mm). Maximum temperature was 34.4 ^{o}C in April whilst the mean minimum temperature of 23.3 ^{o}C was for both July and August.

2.2 Experimental Design and Treatment

The Experiment was laid in a randomized complete block design (RCBD) with four replications. The planting material of the intercrop components were maize (Obaatampa) and groundnut (*Chinese*) [27]. The treatments consisted of sole maize; sole groundnut; Maize, one row groundnut, 0 WAP maize; Maize, one row groundnut, 0 WAP maize; Maize, one row groundnut, 1 WAP maize; and Maize, one row groundnut, 2 WAP maize.

2.3 Agronomic practices and Data collection

Inorganic compound fertilizer (15-15-15, NPK) was applied at 100kg/ha two weeks after planting and sulphate of ammonia fertilizer was applied at 50kg/ha six weeks after planting as side-dressing. The following data were collected on both maize and groundnut. Bi-weekly Plant height, growth rate, Chlorophyll content, Total leaf area and Leaf area index, Days to 50% tasseling (maize), Days to silking (maize), Days to 50% flowering (groundnut), Plant height at maturity, Pod number (groundnut), Maize grain yield (economic yield), Total Stover biomass yield (Biological yield-maize), Total haulm biomass yield (Biological yield-groundnut) and harvest Index.

3. Results

3.1 Plant height and Growth rate of component crops in maize-groundnut intercrop

At 2 weeks after planting, plant height showed significant differences (P<0.05) among the treatments for groundnut plants (Table 2a). At 4 weeks after planting, one row groundnut intercropped two weeks after sowing maize and one row groundnut intercropped one week after sowing maize were significantly different (P<0.05) from the other treatments. The maize plants height showed significant differences (P<0.05) among the treatments (Table 2b).

Table 2a: Mean plant height (cm) of groundnut in maize-groundnut intercrop

	Weeks after planting (WAP)			
	2	**4**	**6**	**8**
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	3.85	16.48	30.99	42.13
Maize, one row groundnut, 1 WAP maize	9.19	24.00	38.50	57.88
Maize, one row groundnut, 2 WAP maize	15.00	31.44	48.94	54.50
Sole groundnut	5.17	21.46	34.26	38.70
LSD(P=0.05)	1.85	2.35	5.19	4.89

Table 2b: Mean plant height (cm) of maize in maize-groundnut intercrop

	Weeks after planting (WAP)			
	2	**4**	**6**	**8**
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	13.95	37.75	90.90	153.45
Maize,one row groundnut, 1 WAP maize	15.20	37.15	86.80	154.00
Maize, one row groundnut, 2 WAP maize	20.08	55.05	148.50	176.20
Sole maize	18.23	56.20	148.90	183.10
LSD(P=0.05)	2.28	3.94	22.12	6.75

There was significant differences (P<0.05) among the treatments for growth rate for both groundnut and maize.

Except groundnut growth rate of one row groundnut intercropped one weeks after sowing maize, all other treatments were significantly different (P<0.05) at two to four weeks of growth (Table 3a). In addition, the maize plants showed significant difference for all growth rate stages (Table 3b).

Table 3a: Growth rate of groundnut in maize-groundnut intercrop

	Growth rate (cm per week)		
	2 – 4 weeks	4 – 6 weeks	6 – 8 weeks
Crop arrangement-time of planting			
Maize, one row groundnut, 0 WAP maize	15.48	29.99	41.13
Maize, one row groundnut, 1 WAP maize	23.00	37.50	56.88
Maize, one row groundnut, 2 WAP maize	30.44	47.94	53.50
Sole groundnut	20.46	33.26	37.70
LSD(P=0.05)	2.35	5.19	4.89

Table 3b: Growth rate maize in maize-groundnut intercrop

	Growth rate(cm per week)		
	2 – 4 weeks	4 – 6 weeks	6 – 8 weeks
Crop arrangement-planting time			
Maize, one row groundnut, 0 WAP maize	36.75	89.90	152.45
Maize, one row groundnut, 1 WAP maize	36.15	85.80	153.00
Maize, one row groundnut, 2 WAP maize	54.05	147.50	175.20
Sole maize	55.20	147.90	182.10
LSD(P=0.05)	3.94	22.12	6.75

3.2 Leaf area index of groundnut and maize

Except at 2 weeks, Leaf area index showed no significant different among the treatments (Table 4a).The maize leave area index (LAI) was significantly different (P<0.05) among the treatments at all the stages of growth. At Six weeks after planting, sole maize was significantly different (P<0.05) from maize with one row groundnut intercropped at the same time with maize, maize with one row groundnut intercropped one weeks after sowing maize, maize with one row groundnut intercropped two weeks after sowing maize(Table 4b).

Table 4a: Leaf area index of groundnut in maize-groundnut intercrop

	Weeks after planting (WAP)			
	2	**4**	**6**	**8**
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	0.29	0.93	2.78	4.50
Maize, one row groundnut, 1 WAP maize	0.26	0.84	2.61	5.20
Maize, one row groundnut, 2 WAP maize	0.48	1.40	2.14	3.00
Sole groundnut	0.51	1.11	3.70	4.80
LSD(P=0.05)	0.17	NS	NS	NS

Table 4b: Leaf area index of maize in maize-groundnut intercrop

	Weeks after planting (WAP)			
	2	4	6	8
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	0.17	0.54	0.82	1.20
Maize, one row groundnut, 1 WAP maize	0.17	0.33	0.47	2.32
Maize, one row groundnut, 2 WAP maize	0.25	0.60	1.32	1.27
Sole maize	0.20	1.40	3.07	3.84
LSD(P=0.05)	0.13	0.55	1.33	1.64

3.4 Dry matter yield of groundnut and maize

Dry matter yield was significantly different ($P<0.05$) among treatments at all the stages of growth. At 2 weeks, treatments one row groundnut intercropped at the same time with maize, one row groundnut intercropped two weeks after sowing maize were significantly different ($P<0.05$) from the other treatments (Table 5a). Treatments one row groundnut intercropped one weeks after planting maize and sole groundnut, and one row groundnut intercropped one weeks after planting maize are significantly different ($P<0.05$) from each other (Table 5a).

3.5 Number of days to flowering (groundnut), tasselling (maize) and Yields of component crops

Sole groundnut recorded the earliest flowering days of 24. The longer days to flowering was recorded by one row groundnut intercropped two weeks after sowing maize (Table 6a). The grain yield per hectare for groundnut and maize showed significant differences among all treatments (Table 6a). On the harvest index for groundnut, sole groundnut was significantly different ($P<0.05$) from all other treatments. For the maize, the grain yield had sole maize recording the highest of 2966.0 kg/ha followed by maize with one row groundnut intercropped two weeks after sowing maize (Table 6b).

Table 5a: Shoot dry weight (kg/ha) of groundnut in maize-groundnut intercrop.

	Weeks after planting (WAP)			
	2	4	6	8
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	3.36	9.35	24.1	25.93
Maize, one row groundnut, 1 WAP maize	4.21	7.30	11.2	13.78
Maize, one row groundnut, 2 WAP maize	3.11	8.30	19.6	21.35
Sole groundnut	3.38	11.67	29.4	32.20
LSD(P=0.05)	0.92	2.77	9.25	2.01

Table 5b: Shoot dry weight (kg/ha) of maize in maize-groundnut intercrop

	Weeks after planting (WAP)			
	2	4	6	8
Crop arrangement-planting time				
Maize, one row groundnut, 0 WAP maize	2.44	20.90	32.70	47.60
Maize, one row groundnut, 1 WAP maize	3.00	10.50	31.20	56.00
Maize, one row groundnut, 2 WAP maize	5.01	40.50	51.00	76.50
Sole maize	3.70	23.50	52.10	70.90
LSD(P=0.05)	NS	NS	22.72	NS

3.6 Land equivalent ratios of maize-groundnut intercrop

The land equivalent ratio (LER) values of the intercrops were more than 1.0.Maize with one row groundnut intercropped at the same time with the maize had the highest LER of 1.48, followed by one row of groundnut

intercropped two week after maize with 1.39 and one row groundnut intercropped one week after sowing maize recording the smallest value of 1.10.

Table 6a: Days to 50% flowering, height at maturity, grain yield and harvest index of groundnut

Crop arrangement-planting time	Days to 50% flowering	Height at maturity (cm)	Grain yield (kg/ha)	Harvest index
Maize, one row groundnut, 0 WAP maize	26.00	44.33	1374.00	31.05
Maize, one row groundnut, 1 WAP maize	29.00	60.08	976.00	16.46
Maize, one row groundnut, 2 WAP maize	32.00	56.70	865.00	15.25
Sole groundnut	24.00	40.90	1438.00	35.20
LSD (P=0.05)	3.12	4.89	120.40	3.74

Table 6b: Days to 50% tasseling, height at maturity, grain yield and harvest index of maize

Crop arrangement-planting time	Days to 50% tasselling	Height at maturity (cm)	Grain yield (kg/ha)	Harvest index
Maize, one row groundnut, 0 WAP maize	52.00	155.65	1553.00	9.98
Maize, one row groundnut, 1 WAP maize	56.00	156.20	1253.00	8.02
Maize, one row groundnut, 2 WAP maize	53.00	178.40	2921.00	16.40
Sole maize	54.00	185.30	2966.00	15.99
LSD (P=0.05)	NS	6.75	255.80	1.23

4. Discussion

4.1 Growth of component crops in relative planting dates of maize-groundnut intercrop

Plant height of groundnut and maize increased regularly at all developmental stages under all the treatments. The results showed that the groundnut-intercropped plants produced much more heights than the sole groundnut and this might be due to competition for sunlight between the maize and groundnut. The maize plants were tall in stature than the groundnut casting some shadow on the groundnut. Since plants need sunlight for

photosynthesis, the intercropped groundnut then tends to grow in such a manner to enable it grow out of the shadow to obtain light and this causes it to grow a little much taller than their sole counterparts. This result is in agreement with [17], who observed that intercropped legume crops grew taller than their sole counterparts did. In addition, [28] earlier reported that shade effects on legume crops increase their height. The maize intercropped plants had plants whose heights are a little shorter than their sole counterparts are. The sole maize recorded 5-19% in height than the intercrops. The maize plants normally grow taller than the groundnut plants and the decrease in height with reference to the sole crop might be due to competition for soil nutrients. The plant obtains enough sunlight for photosynthesis but seems to have fewer nutrients from the soil for active growth due to competition for nutrients with the groundnut plants. This result is in agreement with [20] who reported that crops in association compete for nutrients resources, which may affect the associated crop negatively.

The growth rate of a crop determines the rate at which the crop increases in height per period. The groundnut crop usually does not grow tall and thereby its increases in height are minimal and may explain why its growth rates were not as high as that of maize plant. There were however significant differences among the treatments as compared to the sole groundnut, meaning that intercropping had effect on the growth rate of the groundnut. The growth rate for maize was much higher than that of groundnut ranging from 20-90cm weekly where as that of the groundnut was 9-29cm. The maize plant is a much taller plant than the groundnut and grows much faster than groundnut, which causes it to have a higher growth rate than the groundnut. According to [29] and [30] the leaf area index (LAI) of groundnut varies with environmental conditions, cultural practices and stages of crop growth. From this study, intercropped groundnut produced higher LAI than the sole groundnut. However, LAI increased with delayed intercropping. The groundnut, though intercropped and sowed solely did not show any significance among them except for the first two weeks where the above inference was made. For the maize, the sole maize crop recorded higher Leaf area index (LAI) than the other treatments. This is in agreement with the report that maize is more sensitive to variations in plant density than other members of the grass family [31]. Higher plant densities of maize affect leaf area index (LAI) negatively [32] which might be due to the fact that when maize is intercropped with groundnut, because of the increased density of the intercrop, there is an increase in competition for soil nutrients. It also reveals that the intercrop ability to intercept sunlight for photosynthesis is reduced with reference to the sole crop. The plants accumulated dry matter differently at the different stages of growth as indicated by the treatments. In general, the sole groundnut field showed higher dry matter accumulation at all sampling stages consistently than the other treatments. Furthermore, it was observed from the results that delayed intercropping coupled with increased density significantly reduced dry matter accumulation for the groundnut. This is in agreement that shade effects on growth and yield of legume crops decrease dry matter accumulation [28]. This as well means that the sole groundnut accumulated much dry matter, because of the absence of competition from the maize for nutrient, and benefited from the wider spacing as compared with those in competition whose spacing was narrower and so only grew taller and thinner. This reasoning conforms [33] who reported higher stem and root biomass in tilled plots as compared to zero tillage explained that increase in biological yield at higher plant population might be due to increase in number of plants as well as in plant height of individual plants at denser populations. At an individual plant level, dry matter decreased significantly because of the greater intraspecific competition produced by the shortening of

distances between rows. [34] and [35] working on cereal/legume intercropping noted that higher density of maize in intercropping shaded the cowpea, caused by higher maize height, and reduced cowpea growth. [13] revealed that shoot yields of peanut and maize plants were decreased by intercropping the plants, as compared to monoculture plants. The results for maize obtained in this study showed that dry matter accumulations were not significantly different among the treatments except on the sixth week. The sole maize gave the highest in the sixth week. [13] revealed that shoot yields of peanut and maize plants were decreased by intercropping the plants, as compared to monoculture plants. Contrary however, results had been reported by many investigators [36; 37; 38] that dry matter production increases when maize is intercropped relative to sole maize. The dry matter accumulation of maize is larger than that of groundnut, and this might be because the maize plant is bigger in stature than that of groundnut.

The days to flowering of groundnut depends on whether it is planted solely or intercropped. This study revealed that, groundnut plant flowers early when planted solely and a little late when intercropped with maize. [39] reported that increasing planting densities could delay flower formation in legumes. The period of intercropping also affected days to flowering. When one row of groundnut are intercropped into maize between one to two weeks after planting maize, the days of flowering of groundnut were prolonged as compared to sole planting of groundnut. The results showed that the shading effects caused by taller maize plants delay flowering and maturity of groundnut. The result however contradicts findings with cowpea where [40] observed that days to flowering and maturity of all cowpea cultivars did not differ between the sole and intercrops with maize. The days to tasselling of the maize plants was not significantly affected by intercropping.

4.2 Yield and components of yield of component crops in relative planting dates of maize-groundnut intercrop

The harvest index refers to the portion of the crop that is used for economic purpose with reference to the whole crop. The sole groundnut produced the highest harvest index of 35.20, which shows that this treatment produced the highest number or weight of grains of groundnut among the other treatments. The results indicated that delayed intercropping of groundnut by either a week or two after planting maize could produce a highly significant effect on yield and reduce harvest index. However, this is not in agreement with [23] and [24] indicated bean and maize yield reduction when plant population density is lowered in intercropping. The maize field intercropped with one row of groundnut two weeks after sowing the maize had the highest harvest index of16.40 even more than the sole maize. This reveals that such treatments produced the highest number or weight of grains as compared to other treatments and even the sole maize. Reference [41] reported that **f**or reproductive yields, all intercropping systems showed some increase in relative advantages with increase in stress because of higher harvest indices in intercropping than in sole cropping. The grain yield is the weight of grains harvested from the crops on the field per plot or treatments as used in the experiment. There was a relationship between the grain yield and the harvest index of the crop, which was the higher the harvests index of a crop the greater the yield. The grain yield of the legume decreased with delayed intercropping whilst the grain yield of the maize increased with delayed intercropping of the legume. The field where the groundnut was solely cropped significantly produced higher harvest index for groundnut and eventually produced the highest grain yield of groundnut. The above findings conform to [42] Plants in wider rows compensated for yield by producing more

branches and seed pods per plant. Most importantly, it was observed that grain yield of the groundnut decreased with delay intercropping hence the one row groundnut intercropped at the same time with maize was significantly higher (1374kg /ha) than groundnut intercropped a week after maize which was also higher than intercropping two weeks after planting maize. This agrees with the findings of [25] who reported highest intercrop groundnut yield when maize and groundnuts were simultaneously planted compared to other planting dates. In addition, [22] found that cowpeas planted 3 weeks after maize had significantly reduced yields and therefore recommends planting cowpeas simultaneously with maize. The increased grain yield in this study could be attributed to early competition for growth factors. This may be because the groundnut did not suffer early shading from the maize because they both started growing around the same time.

The groundnut also had a fair beginning with the maize hence nutrient uptake from the soil was fairly competed for by both component crops. The higher intercrop yield appeared to be achieved by an increased efficiency in converting light energy into dry matter and not by any increase in the amount of light energy intercepted. It is suggested that this increased efficiency may have been because the combined intercrop canopy resulted in light being more efficiently spread over a greater surface of leaf [43]. However, the same cannot be said for the maize. The maize fields that had one rows groundnuts intercropped two weeks after planting maize significantly gave the highest grain yield than both the one row intercropped one week and one row intercropped at the same time with the maize. However, there was no significant yield difference between the sole maize and the one row intercropped two weeks after planting maize. This finding was in concord with report that delayed bean intercropping favored maize grain yield by [44] and [45] working with bean/maize and maize/cowpea intercropping systems, respectively. The two weeks period gave the maize plant monopoly over sunlight and soil nutrients enabling the maize to establish good stand in growth. In such a case, since the maize plant already has a tall stature than the groundnut there is no way the groundnut will catch up with the maize again to compete for sunlight. Concerning the soil nutrients, once the maize establishes a good roothold on the soil before the groundnut begins to root, the maize root will have advantage on nutrient uptake than the groundnut.

The land equivalent ratio (LER) gives an accurate assessment of the greater biological efficiency of the intercropping situation. The greater than one (1) LER means that in this study intercropping maize and groundnut was beneficial. LER values indicated that groundnut recorded yield advantage in all intercropping systems due to crop complementarities, which corroborates the findings of several researchers [46; 43]. This study also confirms earlier reports by [47] that total yield per hectare in mixtures are often higher than sole crop yield even when yields of individual components are reduced. Furthermore, [50] reported that, mixtures involving groundnut and cereal produce a greater total yield per hectare/season than one sole crop. [41] observed that on the basis of a Land Equivalent Ratio (LER) intercropping gave 26% more reproductive yield (LER = 1.26) than growing the two crops separately. It is suggested that this increased efficiency may have been because the combined intercrop canopy resulted in light being more efficiently spread over a greater surface of leaf [43]. The findings from this study shows that: where groundnut is considered the major crop then the one row of groundnut sown at the same time with the maize should be adopted for maximum harvest. However, if the farmer considers maize to be the major interest for the faming then the one row of maize followed by two rows of groundnut intercropped two weeks after sowing maize would be ideal. Finally, where the farmer wants to maximize the use of the land for both crops equally, then the one row of groundnut intercropped at the same

time with maize is the best system**.**

References

[1] Ati, O.F. Stigter, C.J. Oladipo, E.O. (2002). "A comparism of methods to determine the o9nset of the growing season in northern Nigerai" Int. J. Climatol., 22:731-742.

[2] Makarau, A. (1995), intra-seasonal Oscillatory mode of the southern Africa circulation: PhD thesis, University of Cape Town, South Africa.

[3] Kumaga, F.K. Ofori, K. and Coblavi, C.S.F. (2002). Effect of time of planting on growth, flowering and seed yield of bambara groundnut (Vigna subterranean (L) Verdc.). in Begemann F., I. Mukema and E. Obed – Lawson, (eds) 2002. Pp 60 – 65.

[4] Fisher, M.N. (1979) Studies in mixed cropping (3). Further results with maize/ bean mixtures. Expl. Agric. 15: 112 – 114.

[5] Frimpong, A. (2002). Production guide on groundnut and bambara groundnut. (eds: Clottey, V.A. Alhassan, A.Y. Asante, S.K. and Owusu, R.K.) SARI, Ghana. Pp 1-11

[6] Giller, K. E. (2001). Nitrogen Fixation in Tropical Cropping Systems, 2nd edn. Wallingford, UK

[7] Sanginga, N. Okogun, J. A., Vanlauwe, B., Diels, J., Carsky, R. J. and Dashiell, K. (2001). Nitrogen contribution of promiscuous soybeans in maize-based cropping systems. In Sustaining Soil Fertility in West Africa.157–178.

[8] Tweneboah, C.K. (2000). Modern agriculture in the tropics. Food Crops. Co. wood publishers. Pp 37-191.

[9] Beats, W.C. (1990). Raising and Sustaining Productivity of Smallholder Systems in the Tropics: A Handbook of Sustainable Agricultural Development. Netherlands.

[10] Snaydon, R.W. and Harris, P.M. (1979). Interactions below ground-the use of nutrients and water. Proceedings of the International Work Shop on Intercropping, ICRISAT, pp: 181-201.

[11] Fawusi, (1985). Influence of spatial arrangements on the growth, fruit and grain yields and yield components of intercropped maize and okra (Abelmoschus esculentus). Fld Crops Res., 11: 345-352

[12] Vesterager, J.M.,. Nielsen N.E and Hogh-Jensen, H. (2008). Effects of cropping history and phosphorus source on yield and nitrogen fixation in sole and intercropped cowpea-maize systems. Nutrient Cycling Agro-ecosystems, 80: 61-73.

[13] Inal, A. Gunes, A. Zhang, F. Cakmak I (2007) Peanut/maize intercropping induced changes in rhizosphere and nutrient concentrations in shoots. Plant Physiol Biochem Department of Soil Science and Plant

Nutrition, 06110 Ankara, Turkey. 45(5):350-6

[14] Dimitrios, B., P. Panayiota, K. Aristidis, P. Sotiria, K. Anestis, and E. Aspasia, (2010). Weed-suppressive effects of maize-legume intercropping in organic farming. Int. J. Pest Manage., 56: 173-181.

[15] Makindea, E.A. Ayoolab, O.T and. Makindec, E.A (2009). Intercropping leafy greens and maize on weed infestation, crop development and yield. Int. J. Vegetable Sci., 15: 402-411.

[16] Lynam, J.K. Sanders, J.H. and Mason, S.C. (1986). Economics and Risk in Multiple Cropping. In: Multiple Cropping Systems, Francis, C.A. (Ed.). Macmillan, pp: 250-266.

[17] Thwala M.G. and. Ossom E.M. (2004). Legume-maize association influences crop characteristics and yields. Proceedings of the 4th International Crop Science Congress. Faculty of Agriculture, University of Swaziland.

[18] Li, L. Sun, J. Zhang, F. Li, X. Yang, S. and Rengel, Z. (2001).Wheat/maize or wheat/soybean strip intercropping: I. Yield advantage and interspecific interactions on nutrients Field Crops Research. Vol71, Pages 123-137

[19] Agboola, A.A. and Fayemi, A.A. (1972). Effects of soil management on corn yield. Agronomy Journal 64: Pp 641 – 644.

[20] Wahua, T.A.T. (1983) Nutrient uptake by intercropped maize, cowpea, and a concept of nutrient supplementation index. Experimental Agric. 19: Pp 263-275

[21] Ahmad, S. and M.R. Rao, (1981). Performance of maize-soybean intercrop combination in the tropics: Field Crops Res., 5: 147-161.

[22] Mongi, H.O. Uriyo, A.P. Sudi, Y.A. and. Singh, B.R. (1976). An Appraisal of Some Intercropping Methods in Terms of Grain Yield, Response to Applied Phosphorus and Monetary Return from Maize and Cowpeas. East African Agricultural and Forestry Journal. 42(1): 66-70.

[23] Willey R. W. and Osiru D. S. O. (1972). Studies on mixtures of maize and beans (Phaseolus vulgaris) with particular reference to plant population Cambridge University Press The Journal of Agricultural Science, 79:517-529

[24] Dagnew, G. (1981). Effect of Intercropping on Yield, Yield Components and Relative Yield Totals of the Associated Maize and Bean, Phaseolus vulgaris. M.Sc Thesis, Addis Ababa University, Ethiopia.

[25] Misbahulmunir, M.Y., Sammons, D.J. and Weil, P.R. (1989). Corn-peanut intercrop performance in relation to component crop relative planting dates. Agronomy Journal 81:184-189.

[26] Food and Agriculture Organization Report (1990). UNESCO: Rome.

[28] Stirling, C.M. Williams, J.H. Black, C.R. Ong, C.K. (1990). The effect of timing of shade on development, dry matter production and light use efficiency in groundnut (Arachis hypogaea L.) under field conditions, J. Agric. Res. (Australian) 41: 633-644.

[29] Williams, J.H. (2000). The implications and applications of resource capture concepts to crop improvement by plant breeding. Agric. For. Meteorol. 104: 49-58.

[30] Saxena, N.P. Natarajan,M. and Reddy, M.S. (1983) Chickpea, Pigeon pea and groundnut. In: IRRI(ed) Potential productivity of field crops under different environments IRRI, Los Banos, Phillippines. Pp 281-305.

[31] Almeida, M.L., De, Sangoi, L.(1996). Aumento da densidade de plantas de milhopararegiões de curtaestaçãoestival de crescimento.PesquisaAgropecuáriaGaúcha, Porto Alegre, v.2, n.2, p.179-183.

[32] Wiyo,K.A. Kasmekera, Z.M. and Fe yen, J. (1999). Variability in ridge and furrow size and shape and maize population density on small subsistence farms in Malawi. Soil and Tillage, 51(1-2): 113-119

[33] Karunatilake, U. van Es, H.M. and Schindelbeck, R.R. (2000). Soil and maize response to plow and no-tillage after alfalfa-to-maize conversion on a clay loam soil in New York. Soil and Tillage Res. 55(1-2): 31-42.

[34] Ofori, F. and Stern, W.R. (1987).Cereal-legume intercropping advantages. Agronomy Journal 64: Pp 41-90.

[35] Russell, J. T. Caldwell, R. M. (1989). Effect of component densities and nitrogen fertilization on efficiency and yield of maize/soybean intercrop. Experimental Agriculture, v. 25, p. 529-540.

[36] Searle, PG, Comudon, E.Y, Shedden, D.C, Nance, R.A (1981). Effects of maize and legume intercropping systems and fertilizer nitrogen on crop yields and residual nitrogen. Field Crops Res., 4: 133-145.

[37] Clement A, Chalifour FP, Bharati, M.P. Gendron G (1992). Effects of nitrogen supply and spatial arrangement on the grain yield of a maize / soybean intercrop in a humid subtropical climate. Journal of Plant Science (Canadian) 72: 57 – 67.

[38] Rerkasem, K. and Rerkasem, B., (1998). Yields and nitrogen nutrition of intercropped maize (Zea mays L.) and rice bean (Vigna umbellta (Thumb.) Ohwi and Onashi). Plant Soil **108**, pp. 151–162.

[39] Rhoda, E.I. (1989). Growth, yield and yield components of soybean as influenced by sowing dates and plant populations. MSc. Thesis. Ahmadu Bello University, Zaria, Nigeria, 65 pp.

[40] Kowal, J.M. and Kassam, A.H. (1970). Agricultural Zoology of the Savanna. A Study of West Africa Oxford England, Clarendon Press pp. 282.

[42] Forcella, F. Westgate, M. E. Warnes, D. D. (1992).Effect of row width on herbicide and cultivation requirements in row crops. American Journal of Alternative Agriculture, p. 161-167,

[43] Reddy, M.S. and Willey, R.W. (1980).Growth and resource use studies in an intercrop of pearl millet/groundnut. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

[44] Francis, C.A. (1990). Biological sciences in multiple-cropping systems. Adv Agon. 42: 1-15.

[45] Francis, O. and Stern, W.R. (1987). Relative sowing time and density of component crops in a maize/cowpea intercrop system. Experimental Agriculture 23:41-52

[46] Willey, R.W. (1979). Intercropping, its importance and research needs. Part I competition and yield advantages. Field Crop Research Abstracts 32: Pp 1 – 10.

[47] Altieri, M.A. and Liebman, M. (1986). Insect Weed and Plant Disease Management in Multiple Cropping systems. In: Multiple cropping systems, France CA (Ed).