ISSN - 2277 - 2755

Journal of Agricultural Science and Environment

EFFECTS OF INCREASING MAIZE PLANTING DENSITY IN A CASSAVA/MAIZE MIXTURE AND WEEDING FREQUENCY ON THE PERFORMANCE OF CASSAVA (*Manihot esculenta* Crantz) IN ADO – EKITI, SOUTH-WESTERN NIGERIA

B. OSUNDARE

Department of Crop, Soil, and Environmental Sciences, University of Ado - Ekiti, Nigeria.
E-mail: biodunosundare@yahoo.com **Tel:** +2348057212838

ABSTRACT

A two – year field experiment was conducted at the Teaching and Research Farm of the University of Ado-Ekiti, Nigeria, during 2005 and 2006 cropping seasons to determine the effects of increasing maize planting density in a cassava/maize mixture and weeding frequency on the performance of cassava (*Manihot esculenta* Crantz). The design was a split–plot, laid out in a randomized complete block, with three replications. Varying maize planting densities constituted the main – plot treatment, namely: sole cropped cassava (10,000 plants ha^{-1}) as the control, and cassava + maize mixture at four maize planting densities of 20,000, 40,000, 60,000, and 80,000 plants ha^{-1}. Weeding frequency was the sub – plot factor, which included: the control (i.e. no weeding, W_0), weeding once (W_1), at four weeks after planting (WAP), weeding twice (W_2) at 4 and 8 WAP, and weeding thrice (W_3) at 8, 12 and 16 WAP. The results obtained indicated that there were significant differences ($p \leq 0.05$) between the treatments in respect of growth and yield parameters of cassava. The two-year average values indicated that increase in maize planting density resulted in a significant decrease in cassava leaf area from 2.74 m^2/plant for sole cropped cassava (control) to 2.43, 2.20, 2.02 and 1.74 m^2/plant for cassava + maize mixture at 20,000 maize plants ha^{-1} , 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Similarly, increase in maize planting density resulted in a significant decrease in cassava tuber weight from 9.71 t ha^{-1} for sole cropped cassava (control) to 9.24, 8.78, 8.27 and 7.80 t ha^{-1} for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Weeding significantly increased cassava leaf area from 1.68 m^2/plant for W_0 to 1.95, 2.01, and 1.80 m^2/plant for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. Similarly, weeding significantly increased cassava tuber yield from 4.96 t ha^{-1} for W_0 to 6.35, 8.75 and 5.90 t ha^{-1} for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. The interactions between maize planting density and weeding had significant effects on growth and yield of cassava. The treatment combination of sole cropped cassava (10,000 plants ha^{-1}) and W_2 (4 and 8 WAP) resulted in the highest values of growth and yield indices of cassava in both years.

Keywords: Cassava, planting density, frequency, mixture, weeding.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a long duration crop, suitable for intercropping with crops that mature within 2 – 3 months before cassava canopies close (Olsa, 2006; Ereze, 2007). Thus, about 50% of the

cassava grown in tropical Africa is intercropped with maize and other leaf vegetables (Ogungbe, 2004; Ereze, 2007). Ogungbe (2004) ascribed the popularity of cassava/ maize association to the high productivity and compatibility of the mixture, as the faster growing maize exploits the micro – environmental resources earlier in the growing season than does the slow – growing cassava. Furthermore, cassava/maize intercrop has been reported to give the highest amount of calories per hectare, which is why it is one of the most wide spread mixed cropping systems in the derived savanna and forest zones of Southwestern Nigeria (Ereze, 2007). Significant effects of increasing maize planting density in a cassava/ maize mixture on growth and yield of cassava have been demonstrated by many studies (Sas, 2002; Tiffen, 2004; Orallo, 2006; Ait, 2007; Rye, 2007). In all these studies, significant decreases in growth and yield of cassava with increasing maize planting density in cassava/maize mixture were reported.

Weeds constitute one of the most complex pests, which Nigerian farmers, like all farmers in the developing countries do contend with. Yield reductions of crops in Nigeria, due to weed interference may be as high as 40 – 90%, while weeding as a percentage of total farm labour ranges from 22 – 54% (Akobundu and Agyakwa, 1987). Cassava is so sensitive to weed interference that its tuber yield can be reduced by as much as 40 – 55% (Aigh, 2005; Terh, 2007). Thus, to minimize the tuber yield reduction associated with weed interference, weeding regimes should be planned in such a way that they will coincide with the critical stage in the life – cycle of cassava, when it is most sensitive to weed interference (Terh, 2007). Cassava has been reported to benefit immensely from properly timed weeding, as delayed weeding will result in yield reduction (Aigh, 2005; Terh, 2007). Brath *et al.* (2001); Aigh (2005); and Terh (2007) recommended weeding at 3 – 4 weeks after planting, while Freau (2004) recommended 4 weeks after planting, as the time for first weed removal in cassava.

In the Southwestern Nigeria, many aspects of the Agronomy of cassava had been investigated, with a view to raising the present level of cassava yield on farmers' farms. However, very little work has been published on growth and yield of cassava as affected by increasing maize planting density in a cassava/maize mixture and frequency of weeding. To this end, this research was carried out to determine the effects of increasing maize planting density in a cassava/maize mixture, weeding frequency, and the interactions between these two treatments on growth and yield of cassava.

MATERIALS AND METHODS

Study site

The two – year field experiment was conducted at the Teaching and Research Farm of the University of Ado-Ekiti, Nigeria, during 2005 and 2006 cropping seasons. The soil of the study site belongs to the broad group Alfisols (SSS, 2002). The soil is well drained, with an appreciable amount of quartz stones and gravels. The study site had earlier been cultivated to a variety of crops, among which were melon, sweet potato, cocoyam, soybean, before it was left fallow for three years prior to the commencement of this study. The fallow vegetation was manually slashed, residues were burnt, and the land was ploughed and harrowed.

Experimental design and treatments

The design was a split – plot, laid out in a randomized complete block, with three replications. Maize planting density constituted the main–plot treatment, which included: sole cropped cassava (10,000 plants ha^{-1}) as the control, and cassava + maize mixture at four maize planting densities of 20,000, 40,000, 60,000 and 80,000 plants ha^{-1}. Weeding frequency was the sub–plot factor, namely: the control (i.e. no weeding, W_0), weeding once (W_1) at four weeks after planting (WAP), weeding twice (W_2) at 4 and 8 WAP, and weeding thrice (W_3) at 8, 12 and 16 WAP.

Planting, collection and analysis of data

In 2005 and 2006, planting was done on March 20 and March 15, respectively. Stem – cuttings (20 cm long each) of cassava variety TMS 30572 were planted at 1 m x 1 m (10,000 plants ha^{-1}). Seeds of Oba Super 1 maize variety, dressed with Apron Plus were planted at the varying population densities.

Cassava leaf area was determined by the method described by Mantz (2001). At harvest, data were collected on tuber yield and yield components. Analysis of variance was carried out, and treatment means were compared, using the Least Significant Difference (LSD) at 0.05 level of probability.

RESULTS

Cassava leaf area

Leaf area of cassava as affected by increasing maize planting density in cassava / maize mixture and weeding frequency is presented in Table 1. The two – year average values indicated that increase in maize planting density resulted in a significant decrease in cassava leaf area from 2.74 m^2/plant for sole cassava (control) to 2.43, 2.20, 2.02 and 1.74 m^2/plant for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Weeding significantly increased cassava leaf area from 1.68 m^2/plant for W_0 to 1.95, 2.01 and 1.80 m^2/plant for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. The interactions between maize planting density and weeding had significant effects on cassava leaf area.

Cassava tuber yield and number of tubers per plant

Table 2 shows the effects of increasing maize planting density in cassava/maize mixture and weeding frequency on cassava tuber weight and number of tubers per plant. Increase in maize planting density resulted in a significant decrease in cassava tuber yield from 9.71 t ha^{-1} for sole cassava (control) to 9.24, 8.78, 8.27 and 7.80 t ha^{-1} for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Similarly, increase in maize planting density resulted in a significant decrease in number of tubers per plant from 10.8 for sole cassava to 9.5, 8.7, 6.4 and 5.2 for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Weeding significantly increased cassava tuber yield from 4.96 t ha^{-1} for W_0 to 6.35, 8.75 and 5.90 t ha^{-1} for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. Similarly, weeding significantly increased number of tubers per plant from 5.6 for W_0 to 8.3, 10.5 and 7.0 for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. The interactions between planting density and weeding had significant effects on tuber weight and number of tubers per plant.

Table 1: Effects of increasing maize planting density in a cassava / maize mixture and weeding frequency on cassava leaf area

	Cassava leaf area (m^2/plant)						
	4 WAP		8 WAP		12 WAP		
Treatments	2005	2006	2005	2006	2005	2006	**Mean**
Varying maize planting density							
Sole cropped cassava (10,000 plants ha-1)	1.66a	1.71a	2.60a	2.68a	3.88a	3.91a	2.74
Cassava (10,000 plants ha-1) **+ maize (20,000 plants ha-1)**	1.51b	1.59b	2.41b	2.46b	3.28b	3.33b	2.43
Cassava (10,000 plants ha-1) **+ maize (40,000 plants ha-1)**	1.43c	1.48c	2.09c	2.14c	3.01c	3.06c	2.20
Cassava (10,000 plants ha-1) **+ maize (60,000 plants ha-1)**	1.33d	1.37d	1.84d	1.90d	2.80d	2.87d	2.02
Cassava (10,000 plants ha-1) **+ maize (80,000 plants ha-1)**	1.20e	1.25e	1.61e	1.67e	2.37e	2.42e	1.74
Weeding frequency							
No weeding (control)	1.40a	1.36a	1.55b	1.58b	2.08d	2.13d	1.68
Weeding once (4 WAP)	1.37a	1.38a	1.77a	1.80a	2.66b	2.71b	1.95
Weeding twice (4 and 8 WAP)	1.37a	1.37a	1.75a	1.79a	2.88a	2.91a	2.01
Weeding thrice (8, 12 and 16 WAP)	1.40a	1.36a	1.53b	1.57b	2.43c	2.48c	1.80
P x F interactions LSD (0.05)	1.26s	1.21s	1.30s	1.33s	2.21s	2.24s	

Values followed by the same letter in the same column under each treatment are not significantly different at p=0.05 (LSD).
WAP = Weeks After Planting, P = maize planting density, F = frequency of weeding, s = significant.

Table 2: Effects of increasing maize planting density in cassava / maize mixture and weeding frequency on cassava tuber yield and number of tubers per plant at harvest

Treatments	Cassava tuber yield (t ha-1)			Number of tubers per plant		
	2005	2006	Mean	2005	2006	Mean
Varying maize planting density						
Sole cropped cassava (10,000 plants ha-1)	9.68a	9.74a	9.71	10.6a	10.9a	10.8
Cassava (10,000 plants ha-1) + maize (20,000 plants ha-1)	9.20b	9.28b	9.24	9.1b	9.9b	9.5
Cassava (10,000 plants ha-1) **+ maize (40,000 plants ha-1)**	8.75c	8.81c	8.78	8.4b	9.0b	8.7
Cassava (10,000 plants ha-1) **+ maize (60,000 plants ha-1)**	8.24d	8.30d	8.27	6.1c	6.6c	6.4
Cassava (10,000 plants ha-1) **+ maize (80,000 plants ha-1)**	7.77e	7.83e	7.80	5.0d	5.3d	5.2
Weeding frequency						
No weeding (control)	5.00d	4.91d	4.96	5.5d	5.7d	5.6
Weeding once (4 WAP)	6.40b	6.29b	6.35	8.1b	8.4b	8.3
Weeding twice (4 and 8 WAP)	8.80a	8.70a	8.75	10.3a	10.6a	10.5
Weeding thrice (8, 12 and 16 WAP)	5.88c	5.91c	5.90	6.8c	7.1c	7.0
P x F interactions LSD (0.05)	4.11s	4.13s		3.80s	3.83s	

Values followed by the same letter in the same column under each treatment are not significantly different at P = 0.05 (LSD).
WAP = Weeks After Planting, P = maize planting density, F = frequency of weeding, s = significant.

Length and diameter of cassava tuber
The effects of increasing maize planting density in cassava/maize mixture and weeding frequency on length and diameter of cassava tubers are presented in Table 3. Increase in maize planting density resulted in a significant decrease in length of cassava tuber from 15.71 cm for sole cassava (control) to 15.26, 14.75, 14.25 and 13.78 cm for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Similarly, increase in maize planting density resulted in a significant decrease in cassava tuber diameter from 9.44 cm for sole cassava (control) to 9.14, 8.83, 8.56 and 8.27 cm for cassava + maize mixture at 20,000 maize plants ha^{-1}, 40,000 maize plants ha^{-1}, 60,000 maize plants ha^{-1} and 80,000 maize plants ha^{-1}, respectively. Weeding significantly increased length of cassava tuber from 12.04 cm for W_0 to 14.26, 15.74 and 13.07 cm for W_1 (4 WAP), W_2 (4 and 8 WAP) and W_3 (8, 12 and 16 WAP), respectively. Similarly, weeding significantly increased cassava tuber diameter from 6.25 cm for no weeding (control) to 8.31, 9.21 and 9.27 cm for weeding once (4 WAP), weeding twice (4 and 8 WAP) and weeding thrice (4, 8 and 16 WAP), respectively. The interaction between maize planting density and weeding had significant effects on length and diameter of cassava tuber.

DISCUSSION

The significant decrease in leaf area, yield and yield components of cassava associated with increasing maize planting density in cassava/maize mixture agrees with the findings of Sas (2002), Tiffen (2004), Orallo (2006), Ait (2007) and Rye (2007). These authors reported decreased growth and yield of cassava with increasing maize planting density in a cassava/maize mixture. This observation can be ascribed to increased incidence of inter – specific competition among maize and cassava crops for growth resources, such as air, water, light, nutrients with increasing maize planting density. The inter – specific competition, consequently prevented cassava crops from putting forth much vegetative growth, which perhaps, resulted in reduced supply of photosynthates to the sink. So, the poor growth of cassava, characterized by reduced leaf area resulted in the low cassava tuber yield, based on the premise that the growth of crops is positively correlated with their yields (Nyende *et al*; 2001). The production of small – sized cassava tubers that attended increasing maize planting density in cassava/maize mixture suggests that the inter – specific competition between cassava and maize did not only result in a reduction in the overall cassava tuber yield, it also affected certain yield parameters such as length and diameter of tubers. This implies that one major disadvantage of increasing maize planting density in cassava/maize mixture is that of decrease in cassava tuber size, which may consequently lead to a decline in the quantity of commercially acceptable tubers, especially if and when tuber size determines the degree of marketability or acceptability for presentation at Agricultural Shows.

The best performance (in terms of growth and yield) of cassava associated with weeding twice (4 and 8 WAP) agrees with the findings of Aigh (2005) and Terh (2007). This observation points to the superiority of weeding twice (4 and 8 WAP) to other weeding treatments evaluated in this study, with respect to the growth and yield of cassava. The superiority emanates from the fact that weeding

Table 3: Effects of increasing maize planting density in cassava / maize mixture and weeding frequency on length and diameter of cassava tuber

	Length (cm) of cassava tuber			Diameter (cm) of cassava tuber		
Treatments	2005	2006	Mean	2005	2006	Mean
Varying maize planting density						
Sole cropped cassava (10,000 plants ha-1)	15.61a	15.80a	15.71	9.40a	9.47a	9.44
Cassava (10,000 plants ha-1) + maize (20,000 plants ha-1)	15.20b	15.31b	15.26	9.10b	9.18b	9.14
Cassava (10,000 plants ha-1) **+ maize (40,000 plants ha-1)**	14.70c	14.80c	14.75	8.80c	8.86c	8.83
Cassava (10,000 plants ha-1) **+ maize (60,000 plants ha-1)**	14.21d	14.29d	14.25	8.51d	8.60d	8.56
Cassava (10,000 plants ha-1) **+ maize (80,000 plants ha-1)**	13.73e	13.83e	13.78	8.24e	8.30e	8.27
Weeding frequency						
No weeding (control)	12.01d	12.07d	12.04	6.21d	6.28d	6.25
Weeding once (4 WAP)	14.21b	14.30b	14.26	8.28b	8.34b	8.31
Weeding twice (4 and 8 WAP)	15.71a	15.76a	15.74	9.18a	9.23a	9.21
Weeding thrice (8, 12 and 16 WAP)	13.04c	13.10c	13.07	7.24c	7.30c	9.27
P x F interactions LSD (0.05)	9.10s	9.12s		4.21s	4.24s	

Values followed by the same letter in the same column under each treatment are not significantly different at p = 0.05 (LSD).
WAP = Weeks After Planting, P = maize planting density, F = frequency of weeding, s = significant.

twice (4 and 8 WAP) reduced the incidence of cassava – weed competition for growth factors, compared to weeding once (4 WAP) and weeding thrice (8, 12 and 16 WAP) treatments, characterized by cassava – weed competition, especially in the first seven weeks of planting before weeding was done later at 8 weeks after planting. Thus, weeding twice (4 and 8 WAP) provided an initial weed – free environment for proper establishment of cassava crops before the first flush of weeds got established, and this gave cassava a higher competition advantage over the weeds. The poorest growth and lowest tuber yield of cassava associated with weeding thrice (8, 12 and 16 WAP) can be attributed to severe weed interference suffered by cassava through weed – cassava competition for growth resources, as well as the allelopathic effects of weeds on cassava, especially in the first 8 weeks of planting. From the findings of this study, weeding once (4 WAP) and weeding twice (4 and 8 WAP) proved superior to weeding thrice (8, 12 and 16 WAP), implying that, for cassava, a slow – growing crop to really benefit immensely from weeding treatments, not the number of weeding administered that actually matters, but programming weeding operations in such a way that they will coincide with the most critical stage in the life – cycle of cassava when it is most sensitive to weed interference. In view of the immense benefits that cassava derived from early weeding, especially at 4 and 8 weeks after planting, hence, the recommendation of properly timed weeding operations, especially at 4 and 8 weeks after planting for cassava cultivation is imperative to minimize the yield reduction associated with weed interference. The significant interactions between maize planting density and weeding frequency imply that the magnitude of the differences in growth and yield of cassava among maize planting densities was affected by weeding frequency.

CONCLUSION

The results of this study have shown that increasing maize planting density in cassava/maize mixture resulted in a significant reduction in growth and yield of cassava. Weeding once (4 WAP) and weeding twice (4 and 8 WAP) significantly increased growth and yield parameters of cassava far more than weeding thrice (8, 12 and 16 WAP) counterpart.

REFERENCES

Aigh, F.A. 2005. Influence of weed interference on growth and yield of cassava. *Weed Science Research*, 8 (3): 204 – 209.

Ait, S.M.R. 2007. Effects of varying maize planting density in a cassava/maize mixture and NPK fertilization on growth and yield of cassava. *Field Crops Research*, 13: 904 - 909.

Akobundu, I.O., Agyakwa, C.W. 1987. *Handbook of West African Weeds*, IITA Publications. 350 pp.

Brath, F.N., Ezumah, K.L., Black, C.A. 2001. Effects of weed competition on growth and yield of cassava interplanted with melon. *Crop Science Research*, 10 (7): 673 – 678.

Ereze, D.P. 2007. Studies on improving the productivity of cassava – based cropping systems in the Southwestern Nigeria. *Cropping Systems Research,* 6 (4): 212 – 216.

Freau, T.K. 2004. Effects of weeding frequency and nitrogen application on growth and yield of cassava in South Asia. *Agricultural Science Journal,* 18: 1021 – 1026.

Mantz, C.E. 2001. Methods of leaf area determination of root and tuber crops. *Field Crops Research*, 8: 404 – 407.

Nyende, P.J.S., Tenywa, J., Oryokot, M. Kidoido 2001. Weed Profiles and management assessment for increased finger millet production in Uganda. *African Crop Science Journal*, 9 (3): 507 – 516.

Ogungbe, C.A. 2004. Investigation of the traditional mixed cropping systems in the Southwestern Nigeria. *Journal of Sustainable Agriculture,* 2 (1): 77 – 81.

Olsa, P.O. 2006. Evaluation of the productivity of cassava – based intercropping systems. *Crop Science*, 8: 511 – 516.

Orallo, T.F.P. 2006. Evaluation of the productivity of cassava/maize intercropping systems in Europe. *Crop Husbandry Research*, 18: 1117 – 1123.

Rye, A.Y. 2007. Improving the productivity of cassava/maize mixture through the determination of the optimal maize planting density. *Crop Ecology*, 6 (3): 188 – 194.

Sas, I.F. 2002. Studies on cassava/maize intercropping systems in the humid tropics. *Food and Agricultural Research Journal*, 10: 888 – 895.

Soil Survey Staff (SSS) 2002. Keys to soil taxonomy, SMSS Tech. Monograph (8th edition), Natural Resource Conservation.

Terh, L.S.V. 2007. Studies on weed – cassava competition. *Crop Protection*, 14 (11): 803 – 807.

Tiffen, J.S.M. 2004**.** Effects of varying maize planting density in cassava/maize mixture and nitrogen application on yield of cassava. *Root and Tubers*, 6 (4): 528 – 534.

(Manuscript received: 24th March, 2009; accepted: 15th December, 2009).