Asian Journal of Research in Crop Science

1(2): 1-8, 2018; Article no.AJRCS.40975

The Effect of Population of Maize on the Performance of Component Crop in Cowpea – Maize Intercrop

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BA and MO were the supervisors of the work. Author BK performed the field experiments and wrote the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRCS/2018/40975
Editor(s):
(1) Deligios Paola Antonia, Professor, Department of Agriculture, Università degli Studi di Sassari, Italy.
Reviewers:
(1) Hakan Geren, University of EGE, Turkey.
(2) Leyla Idikut, Sutcu Imam Universty, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history/24336

Original Research Article

Received 8th February 2018
Accepted 15th April 2018
Published 25th April 2018

ABSTRACT

The effects of plant population density of maize on performance of component crop on cowpea-maize intercrop, were studied in field experiments at the Teaching and Research Farm, University of Agriculture Makurdi in 2005 and 2006 cropping season, the experiment was set as a 2x3 factorial in split plot design and was replicate three times. Cowpea varieties that are Ife-brown and Kano-white constituted the main plots whereas maize population density occupied the subplots. The main crop had a constant population density of 40,000 plants/ha while maize in sub plot crop had varying population densities of 10,000, 20,000, and 40,000 plants/ha. Sole crop of maize and cowpea were also included in the experiment. Cowpea and maize planted at the same time. The results indicate that population density of maize at 40,000 plants/ha have significant effects on yield of cowpea varieties. Grain yield of maize was highest when maize planted at population density of 40,000 plants/ha. Population interaction effect and varieties was not significant on grain yield of maize in 2005. Interaction effect showed that yield was highest (765.3 kg/ha) when Kano-white variety of

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cowpea was planted with maize population density of 10,000 plant/ha while the least grain yield 613.3 kg/ha was obtained when Kano-white was planted with maize population density of 40,000 plants/ha . Land Equivalent ratio (LER) was greater than 1, indicating efficiency of resource use.

Keywords: Maize; cowpea; intercrop; population density.

1. INTRODUCTION

Intercropping is the growing of two or more crops on the same piece of land within the same year to promote their interaction and it also maximizes chances of productivity by avoiding dependence on only one crop [1]. Intercropping is a principal means of intensifying crop production and to improve returns from limited land holdings [2] and in the tropics maize and cowpea are often intercropped [3]. Suitable land area for agricultural production remains fixed or is diminishing, yet farmers are faced with the task of increasing production demands. The traditional farmers have adopted mixed cropping for various reasons which include increased monetary returns, insurance against crop failure and reduction of pests and diseases due to biological diversity within the system, among others [4]. In recognition of the economic and nutritional importance of cowpea as grain legume and maize as important cereal crop, resource poor farmers prefer the cultivation of cowpea and maize in mixture as against sole cropping system. In the guinea savannah agro- ecological zones, mixtures involving maize include maize/yam, maize/cowpea, maize/rice and maize/melon systems [5].

Maize (*Zea mays* L.) is one of the most important grain cereal crops grown in Africa and ranks as the third most cultivated crop in Nigeria [6] features prominently in inter-cropping systems involving legume and non-legume crops such as soybean, cowpea, cassava, yam, etc. Maize is used for human food, livestock feed and as a source of industrial raw material for the production of oil, alcohol and starch. Grain legume/cereal crop mixtures are very popular among small scale farmers in West Africa.

In Africa, Nigeria produces about 5.1 metric tonnes out of the 26 million tonnes of maize produced annually (Food and Agriculture Organization [7]. About 50% of the green maize produced in Nigeria comes from the southwestern Nigeria [8].

Cowpea is the most economically important grain legume adapted to savanna ecologies where it matures its grain on residual moisture. Cowpea variety selection is the key to the modification of cropping systems and is exceptionally suitable for intercropping [9]. The climbing cowpea types with long growth duration have higher nutrient and water uptake than the short bush type cowpea cultivars [10] Subsistence farmers require varieties, which produce acceptable grain and fodder yields under a wide range of environments.

Nigeria and Niger account for 87% of the world cowpea production [11,7]. It contributes majorly to the food security, income generation and soil amelioration for under small-scale farming conditions. The grain contains about 25% protein and 64% carbohydrate and thus has high potential to reduce malnutrition [12]. The average grain yield of cowpea generally ranges from 0.132 to 0.500 t/ha in the dry savanna [7], where it is widely cultivated in intercrop with sorghum, millet, and maize in northern Nigeria. Growth and development of crops are highly dependent on genetic composition and environmental factors [13] which enable the crops to optimize the use of natural resources [14]. Growth analysis is one approach to determine factors that influence yield and plant development [15] it helps to monitor the independent and interactive effects of various factors affecting yield and opens the way to managing these factors in integrated systems [15]. The main disadvantages of intercropping systems may comprise of planting, managing fertilization, weed control, pest control and harvesting for both crops as it is normally done manually by small-scale farmers [1]. The main advantages of intercropping are the reduction in risk for total crop failure, and in product diversification- food crops are often mixed with cash crops to help ensure both subsistence and disposable income [16,17]. Yield advantages from intercropping as compared to sole cropping are often attributed to mutual complementary effects of component crops, such as better total use of available resources. Generally, monoculture legumes have higher yields compared to an intercropping system. However, in most cases, land productivity, measured by Land Equivalent Ratio (LER), clearly shows the advantage of mixed cropping of cereals and

legumes [18] and [19]. Many vegetative and yield variables of crops are potentially influenced by the competition of the plant with the second crop in an intercropping system and by competition with other plants of the same species. This influence may be affected by changes in plant population density. Crop arrangement in time and space dimensions is known to contribute to the performance of the component crops when grown as intercrops. A major problem associated with these is often reported as low grain yield of the legume component when grown in association with a cereal component. This problem is also often implicated by the spatial arrangement and relative plant population densities time of introduction of each component in the mixture.

The objective of this study was to determine optimum plant density of maize in cowpea/maize inter-crop with a view to identify cowpea cultivars suitable for inter- cropping with maize in the environment.

2. MATERIALS AND METHODS

The study was conducted for two years (2005 to 2006) at the experimental farm of University of Agriculture Makurdi, Nigeria. Geographically, is situated within the Southern Guinea Savannah agro-ecological zone of Nigeria, on latitude 7º44'N and longitude 8º35'E. It experiences in six months (May to October) of bimodal rainfall. It has about four months (November – April) of dry season each year with slight irregularity in the rainfall distribution pattern. The experiment design used was a factorial combination of two cowpea varieties and three maize population density in a split-plot arrangement, two varieties maintain a constant population of 40,000 plant /ha in intercrop with maize at three population densities varied at 10,000, 20,000 and 40,000 plants/ha.

The two varieties of cowpea (Ife brown and kano white) were assigned to the main plot while the three population densities of maize were assigned to subplots. The sole crop of each component was maintained at respective plant population densities.

The experiment consisted of 5 treatments replicated 3 times. The treatments were; cowpea varieties was designated as V, V1 (Ife brown) and V2 (Kano white), while maize population density was designated as P. P1 (10,000 plant /ha of maize 1 m x1 m), P2 (20,000 plant/ha of maize 1m x 0.5 m) and P3 (40,000 plant /ha of maize 1 m x 0.25 m). There were plots of cowpea at 40,000 and sole maize at three levels of the population (10,000, 20,000 40,000). These were used as a check for the determination of land equivalent ratio.

The seeds of cowpea and maize were treated with Aldrex T dust shortly before planting to control soil borne pest and pathogens. Three seeds of the crops were sown per hole manually at the same time but latter thinned to one per stand two week after planting. Cowpea were planted at the crest of the ridge with 1 m space (40,000 plant/ha) in both the sole and intercrop systems. For maize, it was planted at the side of the ridge with 1m space (10,000 plant/ha), 0.5m (20,000 plant/ha) and 0.25 m (40,000 plant/ha) in both the sole and intercrop systems. Data were collected at 6 and 9 weeks after planting (WAP) on the following growth parameters which were determined on maize: Plant height (cm), number of leaves per plant, and leaf area. Plant height was measured from ground level to the tip of the main stem of five randomly tagged plants in the four middle rows, of each sub- plot [20]. The leaf area was determined non destructive by length method quoted by [21] using linear equation. Leaf are -0.75(L x W). Where L is the length and W is the maximum width of leaf. Data collected on growth parameters of cowpea are number of leaves per plant, number of branches per plant, number of days to 50% flowering and number of days to 50% podding. Yield and yield component of maize taken included number of cobs/plant, number of cobs/plot, cob length, number of grain per cob and total grain yield. Yield and yield component of cowpea taken included number of pods per plant, total grain yield, pod length, number of pods per plot and number of seeds per pod. The land equivalent ratio was calculated using the equation developed by [22].

Data were subjected to analysis of variance (ANOVA) to determine the effects of the treatments on the parameters. Duncan's Multiple Range Test (DMRT) was used to separate means where F values were significant at $p \leq 0.05$. [23,24]. All analyses were done with the Statistical Analysis System (SAS) software version 8.1 (SAS, 1985).

3. RESULTS AND DISCUSSION

Intercropped cowpea declined in number of leaves and branches per plant (Table 1) than sole crop except for, the number of leaves in 2005 and the number of branches in 2006 for 20 000, this is likely due to competition between

component species for growth factors and spacing, since inter-specific competition do not exist in sole cropping systems. Intercropped cowpea and maize was significantly affected the number of leaves and branches produced by cowpea. Ife brown cowpea variety was much reduced in leaves and branches than Kano white. This could have resulted from the erect growth habit of Ife brown. [25] Explained this suppression of branches to have resulted from the lack of adequate light, which happen when crop are intercrop. Intercropped Ife brown cowpea with maize population density of 10,000 plants/ha first reached 50% flowering. (Table 1). Good lighting enhance early flowering for cowpea. Grains per pod in Ife brown in 2006 declined than Kano white intercropped and sole cropping in both year (Table 2). This could be as a result of proper development of source in sole crop to support the sink compare to inadequate source development for intercropping. The intercropped of cowpea and maize were significant in number of grains/pod, number of pods/plant and yield. In both years Ife brown produce less pod compared to Kano white, this was as a result of the differences in the varieties (Table 2).

Table 1. Effect of maize population density on growth of two varieties of cowpea

Treatments intercropping	Number of leaves 6 Wap		Number of branches 6 Wap		Number of days to 50% flowering	
	2005	2006	2005	2006	2005	2006
Ife brown						
10,000	4.53	3.90	31.30	29,15	46.00	47.02
20,000	3.89	3.70	28.24	28.20	28.00	48.67
40,000	4.12	3.83	30.15	27.10	47.33	46.33
Kano white						
10,000	6.31	7.04	53.30	55.20	75.67	77.00
20,000	7.23	6.30	56.60	58.15	76.67	76.33
40,000	6.03	6.85	46.33	56.20	75.67	77.67
Sole cropping						
Ife brown	4.87	4.81	33.65	30.20	46.33	46.67
Kano white	7.18	7.38	64.50	56.30	76.67	74.67
Cv (%)	5.70	10.6	7.60	5.10	5.70	3.90
SE(±)	0.32	0.58	3.19	2.10	3.52	2.41
Interaction(V x P)	X	X	X	X	X	X

X-Significant effect at 5% level of probability; V-Cowpea varieties, P-Maize population density Ha^{-1}, WAP- Week after planting

Table 2. Effect of population density of maize in two varieties of cowpea in the yield and yield component of cowpea 2005 and 2006

Treatments	Number of grains/pod		Number of pods/plant		Yield (kg/ha)	
	2005	2006	2005	2006	2005	2006
Intercropping Ife brown						
10,000	11.09abc	10.80b	11.82a	11.92a	710.0b	548.7a
20,000	10.89ab	10.76a	12.24a	10.96a	713.3b	556.0a
40,000	10.67a	10.00a	11.57a	12.12a	683.3b	545.3a
Kano white						
10,000	12.41c	13.22d	14.61bc	14.20c	630.0a	763.3d
20,000	11.55bc	12.33c	14.61bc	13.03bc	640.0a	726.7b
40,000	11.75cd	12.55cd	15.32c	17.70bc	613.3a	738.3c
Sole cropping						
Ife brown	11.31abc	10.69ab	11.86a	12.80ab	706.7b	546.7a
Kano white	12.40bc	12.82cd	16.45c	18.09b	626.7a	765.3d
Cv (%)	3.3	3.7	8.6	3.3	13.2	7.1
SE(±)	0.3857	0.42	0.17	0.48	21.7	14.11
Interaction(V x P)	X	X	X	X	X	X

X-Significant effect at 5% level of probability, V-Cowpea varieties, P-Maize population density Ha^{-1}

Maize plant height was highest when planted with Ife brown at 10,000 plants/ha of maize population density, this was because maize was more competitive in mixtures when planted with higher plant population density. At higher population density reported by [26] plant height was expected to decline due to intense interplant competition for growth factors such as nutrients, water and light within the crop stands as population increase number of leaves of maize (Table 3).

Increase in plant density affect maize plant height due to over-crowding interplant competition for growth factor The number of leaves of maize was not affected by the population density, this was because maize which was more competitive in the mixture when planted with another crop. The leaf area index increased with time, this shown that vegetative growth was progressing steadily. The result in Table 4 shown that, there was no significant difference on leaf area index of the maize crop.

Table 3. Effect of population density and two varieties of cowpea on maize plant height (cm) in a cowpea – maize intercrop

Treatments	Sampling weeks 6 Wap		Sampling weeks 8 WAP	
	2005	2006	2005	2006
Intercropping Ife brown				
10,000	75.1	61.8	130.3	121.1
20,000	67.7	52.2	124.5	109.0
40,000	57.4	62.4	105.7	113.5
Kano white				
10,000	62.0	59.8	113.5	115.3
20,000	65.7	66.7	107.4	114.5
40,000	61.1	71.2	103.6	128.0
Sole cropping				
10,000	79.2	74.9	138.6	120.4
20,000	71.7	73.4	130.5	117.9
40,000	68.3	73.0	124.8	119.0
Cv(%)	8.2	10.0	10.1	11.8
SE(±)	5.5	6.6	12.18	13.8
Interaction(V x P)	NS		NS	

NS- Non-Significant effect at 5% level of probability, V-Cowpea varieties, P-Maize population density Ha^{-1}, WAP-Week after planting

Table 4. Effect of population density and two varieties of cowpea intercropped on the number of leaves of maize and leaf area of maize

Treatments	Number of leaves/plant		Leaf area/plant	
	2005	2006	2005	2006
Intercropping Ife brown				
10,000	11.0	9.62	1.65	1.53
20,000	10.5	9.57	1.51	1.47
40,000	10.9	10.15	1.63	1.47
Kano white				
10,000	9.9	10.25	1.78	1.54
20,000	10.8	9.87	1.53	1.47
40,000	11.2	10.00	1.66	1.50
Sole cropping				
10,000	10.9	10.06	1.65	1.53
20,000	10.2	10.06	1,63	1.47
40,000	31.1	10.58	1.66	1.53
Cv(%)	88.4	3.8	6.4	2.3
SE(±)	11.45	0.38	2.79	0.03
F-LSD(0.05)	NS	NS	NS	NS

NS- Non-Significant effect at 5% level of probability

Table 5. Effect of population density of maize on two varieties of cowpea on the yield and yield component of maize in a cowpea-maize intercrop

Treatments	Number of cobs/plot		Number of grains/cob		Grain yield kg/ha	
	2005	2006	2005	2006	2005	2006
Intercropping Ife brown						
10,000	20.6	17.9	466.9	275.5	430.0	386.67
20,000	39.5	33.9	422.1	287.0	448.3	405.00
40,000	49.1	40.4	405.5	270.8	466.7	426.67
Kano white						
10,000	20.4	19.8	406.4	283.5	421.7	430.33
20,000	38.6	38.7	315.1	282.2	445.0	421.67
40,000	38.6	44.4	315.1	285.4	445.0	446.67
Sole maize						
10,000	22.2	20.2	468.5	282.8	430.0	410.00
20,000	40.3	38.1	406.6	292.4	458.3	423.33
40,000	46.9	43.6	422.3	281.8	453.3	438.33
Cv(%)	5.8	8.4	5.1	13.5	10.9	4.1
SE(±)	2.09	4.6	20.02	38.97	25.96	15.85
Interaction(V x P)	NS	NS	NS	NS	NS	X

X – Significant, NS- Non Significant effect at 5% level of probability, V-Cowpea varieties, P-Maize population density Ha^{-1}

The population density of maize two varieties of cowpea intercropped had no significant difference on the number of cobs per plot, maize planted at 40,000 plants/ha had the highest number of cobs per plot. The population density of maize was a significant difference on a number of grains per cob of maize. 10,000 population density had highest grains per cob while the least was obtained from 40,000 population density of maize/ha. The grains per cob in 2006 were recorded low value this may be due to the rainfall pattern of that year. Population density was significant difference on grain yield of maize. The land equivalent ratio total values were greater than 1, meaning ler values increased from 10,000 to 40,000 plants/ha.

4. SUMMARY AND CONCLUSIONS

The paper investigated the effect of population density of on performance of component crops in cowpea –maize intercrop at a southern guinea savanna location (Makurdi) in middle belt Nigeria. The result showed that maize population density on growth of two varieties of cowpea was significant difference in number of leaves, number of branches and number of 50% to flowering. Population density of maize in two varieties of cowpea in the yield and yield component of cowpea for both 2005 and 2006 were significantly difference. The highest number of plant height of maize was obtained in 10,000 population density of sole cropping in 6WAP and 8WAP in both years. The cultivation of cowpea in intercrop with another crop, especially maize had come to stay in Southern Guinea Savannah location of Nigeria. The local cowpea variety Kano-white is preferred for grain production in this agro ecological zone of Nigeria. For higher grain yield in intercrop with 10,000 maize plants/ha should be used.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/24336