

# Effects of Soil Preparation Methods and Spacing on the Growth and Yield of Popcorn on an Alfisol in Southwestern Nigeria

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**ABSTRACT:** Performance of popcorn was investigated under manual tillage and no-tillage soil preparation and three spacing patterns (60cm x20cm, 60cm x 30cm and 60cm x 40cm) in a 2 by 3 factorial experiment fitted into randomized complete-block design and replicated three times. Data on growth and yield characters were obtained and subjected to analysis of variance. The results indicated that some form of reduced tillage is indispensable for optimum grain yield of popcorn; manually tilled treatment out yielded no-tillage treatment. Spacing had significant effects on the growth and yield of popcorn. Popcorn yield in the trials was better at a spacing of 60cm by 20cm than other spacing treatments. It is recommended from the result obtained that popcorn should be planted on manually tilled land and spaced at 60cm by 20cm for optimum grain yield.

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**Keywords:** tillage; spacing pattern; factorial experiment; spacing treatment

## 1. INTRODUCTION

Popcorn is a popular snack, an important part of diet of many people in most region of the world. The rapid increase in the use of popcorn as snacks at amusement parks, motion picture theaters or around family television has greatly increased the demand for popcorn.

The demand has out-run the supply each year, hence, popcorn production has turned out to be a very valuable income earning. The need to increase or boost popcorn production through agronomic research cannot be over emphasized.

One of the problems of popcorn production is poor yield. The poor performance of corn in Nigeria has been attributed to low-input crop production practices, severe crop environmental stresses, and the use of low yielding varieties. There are several crop production practices that could influence growth and performance of crops. These practices include land preparation, spacing, fertilization, plant protection, time of planting, time of harvesting e.t.c. Optimum plant spacing and soil preparation appear to have significant roles in determining yield capacity of corn.

The concept of soil preparation is to create a soil environment favourable to plant growth. The choice of an appropriate method of seedbed preparation depends on soil characteristics, cropping systems and climatic environment (Lal, 1991). There

is scarcity of information on the dominant manual tillage practices and their effect on growth and yield of popcorn on less deep and coarse alfisols located under humid tropical conditions. Few studies carried out on alfisols located in the southwestern Nigeria gave contradictory results. Ojeniyi (1993) compared the effects of manual tillage with hoe and no-tillage on nutrient availability and maize yield and found that tillage with hoe increased maize yield significantly.

In a similar investigation, Osuji (1984), in a five-year study compared the effects of no-tillage, conventional tillage and reported that conventional tillage and ploughing out-yielded no-tillage in the first two years and that no-tillage produced yield that were significantly higher than those for tilled treatments as from the third year of the experiments. Also, in Ghana, Mensah-Bosu and Obang (1979) found that the soil conserving potential for no-tillage exceeded that of ridging and manual hoeing even though the later produced more grain yield of maize.

Plant population is another important factor that determines the yield capacity of crops per unit area of land. Plant population is determined by plant spacing. The current practice among the peasant farmers producing popcorn in the study area is to plant at a spacing of 60cm by 60cm, this spacing might not guarantee optimum yield per unit area. A desire to better understand the effects of tillage and

spacing on popcorn yield prompted the present study which aimed at investigating the relative effects of zero-tillage and manual tillage combined with three different spacing patterns on the growth and yield of popcorn on an alfisol of southwestern Nigeria.

## 2. MATERIALS AND METHODS

Field experiments were conducted in 2007 and 2008 in Ondo (07° 05'N, 04° 55'E) in the rainforest zone of southwestern Nigeria. The treatments included three plant spacing (60cm x20cm, 60cm x30cm, 60cm x40cm) and two soil preparation methods (Manual tillage and no-tillage) in a 2 by 3 factorial experiment fitted into randomized complete-block design and replicated three times. Eighteen (18) plots of 5m by 5m each were maintained in each planting season.

Two seeds of local yellow popcorn were planted per stand. Weeding and other cultural operations were the same for all the treatments and were attended to regularly; three weeding were carried out for the period of the experiments. At three weeks after planting 100 kg/ha of NPK 15-15-15 was applied.

### *Yield Data*

At six (6) weeks after planting, five (5) maize stands per treatment and per replicate were selected for the measurement of vegetative parameters such as leaf number, node number and plant height. The selected maize stands were uprooted and air-dried for eight weeks to determine the leaf, root, stem, total dry weight and shoot-root ratio. At fifteen (15) weeks after planting, the cobs were harvested, air dried and the following grain yield parameters were then measured:- cob number, cob weight, seed number, 100 seed weight, harvest index, shelling percentage and total grain yield. The harvest index was determined by finding the ratio between the economic yield and biological yield while the shelling percentage was determined by multiplying the ratio between grain weights by 100 percent:

### *Data Analysis*

Data on both vegetative and grain yield characters were analyzed following the procedure suggested by Panse and Sukhatme (1978). The mean data of vegetative and grain yield for the different treatment combinations were compared using Least Significant Difference (LSD) at  $P=0.01$ .

## 3 RESULTS AND DISCUSSION

The data on the effect of soil preparation methods on the growth parameters of popcorn (Table

1) indicated that growth of popcorn was significantly influence

Popcorn planted on manually tilled plots grew significantly taller with more leaves and nodes than those planted on untilled plots.

The mean plant height for manually tilled and untilled plots for the two planting seasons was 169.72cm and 158.28cm, respectively. Data in Table 1 also show that other growth characters measured consistently performed better on manually tilled plots than untilled plots. The tallest popcorn height recorded was that from the manually tilled treatment. There was no significant difference in the root-shoot ratio obtained between popcorn planted on manually tilled and untilled plots. The data obtained indicated that a degree of soil tillage appears indispensable for sustained popcorn maize production; this might be due to the fact that tillage enhanced crop root development which promotes water and nutrients uptake by the crops. In addition, reduction in soil compaction in manually tilled plots might have allowed root penetration and improvement of the rhizosphere which might made available nutrient elements for crop growth and development. Poor growth of maize in zero-tillage plots could be attributed to the high compactness of the plots; the high compactness of the zero-tillage plots is expected to reduce root growth resulting in reduced nutrient uptake. This finding corroborates the earlier findings of Adekiya and Ojeniyi (2002) that high soil bulk density reduced root growth, nutrients uptake, crop growth and performance.

The data on the effect of spacing on the growth of popcorn are presented in Table 2 showed that spacing influenced the growth parameters significantly. Popcorn spaced at 60cm by 20cm produced the tallest height, however, those spaced at 60cm by 30cm led to more production of leaves and nodes with heavier stem dry weight and total dry weight. Increased growth characters with increase in spacing is attributable to the plant population that reduces with increase in plant spacing which might have led to a reduction in competition for light, space, soil nutrients and aeration by the plant which made the crop to grow vigorously.

Table 3 shows the interaction effect of soil preparation and spacing on the growth characters of popcorn. Soil preparation and spacing had significant effects on the growth characters measured. At each spacing, popcorn planted on manually tilled plots performed better than those on untilled plots. Popcorn planted on manually tilled plots with a spacing of 60cm by 40cm had the best growth characters in terms of number of leaves, number of nodes, stem dry weight, leaf dry weight, root dry weight and total dry weight. While popcorn planted

on untilled plot with a spacing of 60cm by 30cm performed better than that planted on untilled plots of

other spacing. It was also observed that the narrower the spacing the more the plant height.

Table 1: Effect of Soil Preparation Methods on the Growth Parameters of popcorn

Growth characters	2007			2008		
	MT	NT	LSD(001)	MT	NT	LSD(0.01)
plant height (cm)	173.86	161.38	4.72	165.58	155.18	4.58
No. of leaves/plant	10.06	8.54	0.58	9.58	8.13	0.55
No. of Nodes/plant	13.40	12.30	0.41	12.79	11.71	0.38
Stem dry weight( g)	35.75	25.82	0.57	34.71	24.59	0.54
Leaf dry weight (g)	20.02	15.03	0.40	19.07	14.31	0.38
Root dry weight (g)	14.64	9.50	1.01	14.08	9.05	0.95
Total dry weight (g) Root-	56.47	40.17	1.17	53.78	38.26	1.11
shoot ratio	0.10	0.09	NS	0.09	0.087	NS

MT = Manual tillage, NT = No tillage, N.S = Not significant

Table 2: Effect of Spacing on the Growth Parameters of Popcorn

Growth characters	2007				2008			
	PD <sub>1</sub>	PD <sub>2</sub>	PD <sub>2</sub>	LSD(0.01)	PD <sub>1</sub>	PD <sub>2</sub>	PD <sub>3</sub>	LSD(0.01)
Plant height (cm)	174.51	164.44	164.58	6.17	167.80	156.61	156.74	5.89
No of leaves/plant	8.86	9.71	9.33	0.64	8.44	9.25	8.89	0.61
No of Nodes/plant	12.66	13.06	12.86	N.S	12.06	12.44	12.25	N.S
Stem dry weight (g)	28.55	34.36	30.50	0.69	27.19	32.72	29.05	0.66
Leaf dry weight (g)	15.21	16.32	21.04	0.49	14.49	15.55	20.04	0.47
Root dry weight (g)	10.15	10.98	16.42	12.29	9.67	10.47	15.64	1.17
Total dry weight (g)	43.98	49.44	51.54	1.43	41.89	47.09	49.09	1.36
Root-shoot ratio	0.078	0.076	0.081	0.013	0.075	0.073	0.078	0.012

PD1 = 60cm x 20cm; PD2 = 60cm x 30cm; PD3 = 60cm x 40cm; N.S = Not significant

Table 3: Interaction Effect of Soil Preparation Methods and Spacing on the Growth Parameters of Popcorn

Growth characters	MTPD <sub>1</sub>	NT PD <sub>1</sub>	MT PD <sub>2</sub>	NT PD <sub>2</sub>	MT PD <sub>3</sub>	NT PD <sub>3</sub>	LSD(0.01)
<b>2007</b>							
Plant height (cm)	184.67	166.67	168.15	160.73	168.79	160.98	8.28
No of leaves/plant	9.59	8.14	10.37	9.06	10.23	8.40	0.28
No of Nodes/plant	12.99	12.34	13.65	12.84	13.66	12.08	0.22
Stem dry weight (g)	27.80	18.80	35.24	33.48	46.31	14.70	0.98
Leaf dry weight (g)	15.66	14.76	15.59	17.06	28.82	13.26	0.68
Root dry weight (g)	9.85	10.46	11.67	10.33	25.13	7.72	1.73
Total dry weight (g)	43.45	45.56	50.83	48.06	75.13	27.95	2.0 2
Root-shoot ratio	0.063	0.095	0.066	0.087	0.155	0.092	0.018
<b>2008</b>							
Plant height (cm)	175.88	158.73	160.15	153.08	160.73	153.73	7.89
No of leaves, plant	9.13	7.75	9.88	8.63	9.75	8.00	0.27
No of Nodes/plant	12.38	11.75	13.0	11.89	13.0	11.50	0.21
Stem dry weight (g)	26.48	27.9	33.56	31.89	44.10	14.0	0.93
Leaf dry weight (g)	14.91	14.06	14.85	16.25	27.45	12.63	0.65
Root dry weight (g)	9.38	9.96	11.11	9.84	23.93	7.35	1.65
Total dry weight (g)	41.38	43.39	48.41	45.77	71.55	26.62	1.92
Root-shoot ratio	0.060	0.09	0.063	0.083	0.148	0.88	0.017

MTPD<sub>1</sub> = Manual tillage at 60cm x 20cm, NTPD<sub>1</sub> = No tillage at 60cm x 20cm

MTPD<sub>2</sub> = Manual tillage at 60cm x 30cm, NTPD<sub>2</sub> = No tillage at 60cm x 30cm

MTPD<sub>3</sub> = Manual tillage at 60cm x 40cm, NTPD<sub>3</sub> = No tillage at 60cm x 40cm

Data on the effect of soil preparation methods on the yield component of popcorn are presented in Table 4. Soil preparation method had significant effect on the yield and yield components of popcorn except the shelling percentage.

The cob weight, seed number per cob, seed weight per cob, harvest index and total grain yield of popcorn planted on manually tilled plots performed significantly better than those planted on untilled plots by 39.4% and 38.4% for the first and second planting season respectively. This implies that some form of tillage that mixes the surface soil layer needs to be adopted to maintain soil conditions adequate for sustainable popcorn production. The highest yield observed on manually tilled plots is attributable to the improved soil condition. This observation is in line with the findings of Ojeniyi *et al* (1999) and Alli *et al* (2006) that improved soil macro-porosity and aeration due to tillage enhanced better growth and grain yield of maize in the tilled plots than untilled plots.

Table 4: Effect of Soil Preparation Methods on the Yield Components of Popcorn

Yield characters.	2007			2008		
	MT	NT	LSD(0.01)	MT	NT	LSD (0.01)
Cob No/plant	1.41	1.63	0.11	1.34	1.55	0.10
Cob weight (g)	83.29	66.08	1.73	79.32	62.93	1.65
Seed No/Cob	483.58	340.31	4.20	460.55	341.36	4.0
Seed weight/Cob (g)	54.43	43.45	2.02	51.84	41.38	1.92
100 seed weight (g)	14.31	11.95	0.59	13.63	11.38	0.56
Harvest Index	0.46	0.43	0.15	0.44	0.41	0.014
Shelling %	65.34	65.75	N.S	65.33	65.70	N.S
Total grain yield (t/ha)	4.56	2.76	0.05	4.34	2.63	0.043

MT = Manual tillage, NT = No tillage, NS = Not significant

Effects of spacing on yield and yield components of popcorn are presented in Table 5. The yield and yield components of popcorn were significantly influenced except for cob number per maize plant. The yield was highest for close spacing (60cm x20cm). The wider spacing failed to compensate for the loss incurred due to less plant population. The mean data of the two planting seasons revealed that wider spacing produced relatively more numbers of cob per stand and weight per cob than the closer spacing of 60cm x 20cm, this might be due to the fact that plants grown at wider spacing would have taken advantage of less plant population and produced healthy growth and heavy cobs. The optimum spacing for the best yield components was 60cm x 30cm, at this spacing popcorn had more cob number, cob weight, seed weight, harvest index and shelling percentage. Reduction of 3.8% and 2.3% were obtained in the number of cobs when planted under 60cm x 20cm and 60cm x 40cm, respectively, while reduction of 7.4% and 32.1% were obtained in seed weight per cob under similar spacing in that order.

Table 5: Effect of Spacing on the Yield Components of Popcorn

Yield characters.	2007				2008			
	PD <sub>1</sub>	PD <sub>2</sub>	PD <sub>3</sub>	LSD(0.01)	PD <sub>1</sub>	PD <sub>2</sub>	PD <sub>3</sub>	LSD(0.001)
Cob No/plant	1.24	1.29	1.26	N.S	1.18	1.23	1.20	N.S
Cob weight (g)	78.47	84.01	61.57	2.1	74.73	80.01	58.64	2.00
Seed No/Cob	371.43	312.30	316.79	5.13	353.74	297.43	301.71	4.89
Seed weight/Cob (g)	52.16	56.34	38.25	2.47	49.69	53.66	36.43	2.35
100 seed weight (g)	13.68	13.47	12.23	0.71	13.03	12.83	11.65	0.68
Harvest Index	0.47	0.48	0.39	0.02	0.45	0.46	0.38	0.02
Shelling %	66.47	67.06	62.15	2.47	66.46	67.06	62.05	2.36
Total Grain Yield (t/ha)	5.17	3.89	1.94	0.06	4.92	3.70	1.85	0.06

Table 6 shows that interaction effects of soil preparation and spacing on the yield components of popcorn are significant. Popcorn had the highest grain yield when planted on manually tilled land at a spacing of 60cm by 20cm. At this spacing, the grain yields were 6.38 t/ha and 6.08 t/ha for the first and second planting respectively. This was closely followed by those planted on manually tilled plots at plant spacing of 60cm by 30cm. At every

spacing treatment, popcorn planted on untilled plots had poor yield. The highest yield obtained on manually tilled plots at plant spacing of 60cm by 20cm might be due to the improved soil physical conditions combined with maximum plant population.

Table 6: Interaction Effect of Soil Preparation Methods and Spacing on the Yield Components of Popcorn

Yield characters.	MTPD <sub>1</sub>	NTPD <sub>1</sub>	MTPD <sub>2</sub>	NTPD <sub>2</sub>	MTPD <sub>3</sub>	NTPD <sub>3</sub>	LSD(0.01)
<b>2007</b>							
Cob No/plant	1.37	1.10	1.52	1.05	1.43	1.10	0.18
Cob weight (g)	88.46	69.52	90.23	77.78	71.16	51.99	3.00
Seed No/Cob	380.94	361.91	419.21	415.38	335.58	403.01	7.29
Seed weight/Cob (g)	59.41	44.85	60.12	52.55	43.75	32.75	3.49
100 seed weight (g)	14.89	12.47	14.96	11.97	13.07	11.39	0.98
Harvest Index	0.51	0.43	0.50	0.44	0.36	0.44	N.S
Shelling %	67.16	64.51	66.62	67.56	61.48	62.99	3.51
Total grain yield (t/ha)	6.38	3.95	4.85	2.92	2.46	1.43	0.079
<b>2008</b>							
Cob No/plant	1.3	1.05	1.45	1.00	1.36	1.05	0.17
Cob weight (g)	84.25	66.21	85.95	74.07	67.77	49.51	2.86
Seed No/Cob	362.80	344.68	399.25	395.6	319.60	383.82	6.94
Seed weight/Cob (g)	56.58	42.71	57.26	50.05	41.67	31.19	3.32
100 seed weight (g)	14.18	11.88	14.25	11.40	12.45	10.85	0.95
Harvest Index	0.49	0.41	0.48	0.42	0.34	0.42	N.S
Shelling %	67.29	64.91	66.57	68.65	61.02	63.09	3.34
Total grain yield (t/ha)	6.08	3.76	4.62	2.78	2.34	1.36	0.075

Generally, this study shows that spacing is inversely proportional to the popcorn height but directly proportional to the number of nodes, stem dry weight, leaf dry weight, root dry weight and total dry weight. The yield of popcorn on manually tilled plots were 4.56 t/ha, and 4.34 t/ha, while 2.77 t/ha and 2.63 t/ha were obtained for the two planting seasons for untilled plots. This shows that tillage improves yield of popcorn. However, this finding was not in agreement with the findings of Maurya (1988); Hulugalle and Lal (1986) and IITA

(1981). They obtained highest maize yield on zero-tillage plots compared with tilled treatments. On the other hand, the current finding was in agreement with the findings of Ojeniyi (1999), Alli *et al* (2006) and Ojeniyi (1986). Hence, the results obtained in the trials indicated that popcorn should be planted on tilled land and that spacing of 60cm by 20cm should be adopted for optimum grain yield.

#### 4. CONCLUSION

It could therefore be concluded from the results of this study that spacing has considerable effect on the growth and yield of popcorn spacing greater than 60cm by 30cm will greatly reduce the grain yield. Also, some form of soil loosening is required for optimum yield of popcorn

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