Intercropping Maize + Sorghum in the Guinea Savanna Zone of Ghana

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ABSTRACT

Field experiments were conducted from 1989 to 1992 to investigate the effect of spatial arrangement and time of planting on the performance of a maize + sorghum intercrop in an attempt to provide grower recommendations for the resource poor farmers. Maize and sorghum grain yield or plant height were not significantly affected by growing them in alternate-row or within-row arrangements. However, delaying interplanting of sorghum in maize by 15 days increased maize grain yield by 19% - 77% compared to simultaneous planting of the two crops. The corresponding value for a 30 day delay was 25% - 73%. Conversely, sorghum grain yield was depressed by 29% - 95% and 39 -98% when interplanting of sorghum was delayed by 15 and 30 days, respectively.

Keywords: spatial arrangement; time of planting; maize+ sorghum intercrop; grower recommendations; resource poor farmer.

AGRICULTURE

INTRODUCTION

Intercropping is defined as the growing of more than one crop simultaneously on the same area of land. The crops are not necessarily planted or harvested at the same time but exist together for a significant part of their growing period[1].

The success of crop mixtures, relative to pure stands might be influenced by various agronomic practices which affect the nature of the interaction between species and so affect their use of limiting resources [2]. Such practices include manipulating overall plant density, the relative density of component crops, the intimacy with which the crops are mixed and the relative time of planting. This paper deals with the latter two in a maize+ sorghum intercrop. In an attempt to optimize labour and moisture use, and to ensure that they do not experience total crop failure, farmers in the guinea savannah zone of Ghana grow many crops together, without giving due consideration to the spatial arrangement of the mixtures. Spatial arrangement of crops in the field is very important since it enhances the efficiency with which available and intercepted radiant energy is utilized to produce economic yield [3]. It has been suggested that the best crop yields are correlated with the planting pattern that results in the highest per plant vegetative dry matter [3,4]

Previous studies of the effect of planting pattern on the performance of crop mixtures have not given consistent results. Using sorghum and groundnuts, [5] found that intimate single alternate rows mixtures gave greater yields but [6,7] working with maize and pigeon pea found that alternate row mixtures yielded most. Other researchers [8, 9] working with sorghum and pigeon pea also found that less intimate mixtures (triple rows/strip intercropping) yield most whilst [10] and [11] did not find any significant differences between different planting patterns.

In the guinea savannah zone of Ghana, sorghum and maize are important staples to the farmer. The sorghum acts as an insurance crop in case of failure of the maize crop due to drought or the inability of the farmer to acquire and apply the required amounts of fertilizer. The maize matures earlier than the sorghum and help to bridge the hunger gap which, in most years, extend from May to July.

This paper investigated 4 types of spatial arrangement and 3 times of planting sorghum relative to time of planting maize on farmers' fields in the guinea savannah zone of Ghana with the objective of producing grower recommendations for intercropping maize and sorghum by resource poor farmers.

MATERIALS AND METHODS

Field experiments were conducted at Babile (2.8°W, 10.6°N), Wa (2.5° W, 10° N) and Tumu (2° W, 10.8° N), all in the Upper West Region of Ghana from 1989 to 1992 on Verempere soil series (Plinthaquox) as part of the on-farm research programme of the Ghana Grains Development Project. Some of the soil characteristics at the experimental sites are shown in Table 1. The experiments were 4x3 factorial in randomized complete block design with three replications. Okomasa, a 120-day white dent, streak resistant maize variety and a local late maturing sorghum were planted in plots 5m long and 3.6m wide. In all years maize was planted between June 10 - 20. The planting of sorghum relative to maize was staggered to give three times of planting, namely, simultaneous with maize, 15 and 30 days after planting (DAP) maize. The spatial arrangements used were

1. maize + sorghum planted in the same row but on separate hills (A_1)
2. maize + sorghum planted in the same row on the same hill (A_2).
3. maize + sorghum planted in alternate rows, (A_3).
4. maize +sorghum planted in alternate rows, with sorghum drilled (A_4) .

Both crops were planted at 90x40 cm spacing and thinned to 2 plants per hill 2 weeks after planting (WAP) except the drilled sorghum (in treatment A_4) where 4 plants per linear metre were left.

Starter fertilizer was applied to maize 10 DAP at 50:50:0 kg N:P_2 0_5: K_20/ha and side dressed with sulphate of ammonia at 40 kg N/ha 6 weeks after planting (WAP). Weeds were controlled by handweeding at 3 and 6 WAP.

Data recorded include maize and sorghum densities, height (at 50 DAP and at final harvest) and grain yield. All data were taken on bordered plants within each plot. Maize grain yield was calculated at 15% moisture content. Sorghum grain yield was recorded as the sun dried yield.

In 1990, sorghum could not be planted at the scheduled time as a result of severe drought. The trial was therefore analysed as 4x2 instead of 4x3 factorial.

RESULTS

1989 Experiment

The yield of maize and sorghum averaged over two sites as affected by spatial arrangement and time of planting is presented in Table 2.

Maize grain yield was not significantly affected by spatial arrangement. However maize yield from the alternate row spacing (A_3 + A_4) was 25% higher than that of the within row spacing (A_1 + A_2). Sorghum grain yield was also not affected by spatial arrangement except that A_2 outyielded A_1 by 48%.

Delaying interplanting of sorghum in maize by 15 and 30 days increased maize yield by 36% and 59%, respectively compared to simultaneous planting. Conversely, sorghum yield was depressed by 79% and 89% at 15 and 30 days delayed planting, respectively.

Maize and sorghum plant heights were not affected by spatial arrangements (Table 2). While maize plant height was not affected by the relative planting time of sorghum, plant height of the latter crop was significantly ($P = 0.05$) depressed by 58% and 92% at 15 and 30 days delayed planting of sorghum respectively. No significant effect of spatial arrangement and time of planting was detected.

1990 Experiment

Spatial arrangement significantly affected the grain yield of maize and sorghum averaged over two sites (Table 3). Maize grain yield followed the trend of $A_4 > A_3 > A_2 = > A_1$. Planting maize and sorghum in the same row and on the same hill (A_2) increased maize grain yield by 53% compared to the yield of maize and sorghum in the same row but on separate hills (A_1). Mean grain yield for alternate row spacing (A_3 + A_4) was about 33%

Table 1: Some physical and chemical properties of soils at the experimental sites for the maize + sorghum intercrop in the Guinea Savannah Zone of Ghana.

	Wa		Tumu	
	Soil Depth (cm)			
	0-15	15-30	0-15	15-30
Sand (%)	80.5	62.5	70.5	65.5
Silt (%)	10.5	16.0	25.5	23.5
Clay (%)	9.0	21.5	4.0	11.0
pH (H_20)	5.8	5.8	5.1	5.2
C (%)	0.53	0.53	0.35	0.23
N (%)	0.04	0.03	0.06	0.03
P (mg kg^{-1})	14.3	4.1	6.6	2.9
K (cmol kg^{-1})	0.55	0.27	0.21	0.21

Table 2: Effect of spatial arrangement and time of planting on plant height and grain yield of maize + sorghum intercrop in the Guinea Savannah Zone of Ghana in 1989.

	Grain yield		Plant height	
	Maize	Sorghum	Maize	Sorghum
A. Spatial Arrangement	----------kg/ha----------		----------cm----------	
In row, separate hill (A1)	1162	481	153	153
In row same hill (A2)	1549	927	153	128
Between rows, hill (A3)	1673	691	156	152
Between rows, drilled (A4)	1962	568	152	193
SE	486	168	8.2	39
B. Planting Time				
Simultaneous	1203	509	151	313
15 DAP	1638	361	154	132
30 DAP	1918	56	156	24
SE	421	145	6.7	33.7
CV %	67.5	7.8	11.5	54.7

DAP - Days after planting.

Table 3: Effect of spatial arrangement and time of planting on plant population, height and grain yield of maize + sorghum intercrop in the Guinea Savannah Zone of Ghana in 1990.

	Grain Yield		Plant Height		Plant/m²	
	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
A. Spatial Arrangement	---------kg/ha---------		----------cm--------			
In row, separate hill (A_1)	1474	288	123	258	1.70	1.46
In row, same hill (A_2)	2251	529	143	207	3.54	2.38
Between rows, hills (A_3)	2427	529	137	239	3.66	2.82
Between rows, drilled (A_4)	3201	242	133	238	3.42	1.35
SE	496.5	94.7	0.07	0.16	0.34	0.26
B. Planting Time						
Simultaneous	1602	738	130	300	3.53	3.31
*15 DAP	-	-	-	-	-	-
30 DAP	3024	56	138	171	3.18	0.18
SE	351.1	66.9	0.05	0.11	0.24	0.18

** Sorghum could not be planted due to severe moisture stress.*
DAP - Days after planting

higher than that of the within row spacing ($A_1 + A_2$). The highest sorghum grain yield was recorded for A_2 and A_4. This was followed by A_1 with A_4 recording the lowest yield. Sorghum grain yield for A_1 and A_4 was depressed by 45% and 54% respectively compared with either A_2 or A_3.

Maize planted simultaneously with sorghum recorded 48% lower grain yield than those planted 30 days before sorghum. However, sorghum planted 30 days after maize gave a 92% lower grain yield than those planted simultaneously with maize.

Maize and sorghum plant heights were both affected by spatial arrangement and time of planting. While delaying planting of sorghum till 30 days resulted in taller maize plants, the height of sorghum plants was depressed. There was however no significant interaction effect of the two factors on the parameters measured

1991 Experiment

Spatial arrangement had no significant effect on plant height and grain yield of either maize or sorghum averaged over two site (Table 4). However, time of planting significantly (P=0.05) influenced grain yield. A 15 day delay in the interplanting of sorghum in maize gave a 39% increase in maize grain yield over that of the simultaneous planting of the two crops. The corresponding value for the 30 day delay was 27%. Conversely, sorghum grain yield was drastically reduced by 66% when interplanting of sorghum was delayed by 15 days. Sorghum planted 30 days after maize did not germinate in most cases due to inadequate soil moisture at planting.

Those that germinated could not produce any grain due to attack by shoot flies and drought. Maize plant height was not significantly affected by the time of interplanting sorghum. Sorghum plant height was however depressed by 17% and 12%, respectively at 50 DAP and final harvest when interplanting of sorghum in maize was delayed by 15 days (Table 4). The analyses did not detect any significant interaction of the two factors on grain yield and plant height of both crops.

1992 Experiment

Only grain yield of maize and sorghum are presented since the effect of spatial arrangement and planting time on plant height were similar for the other year.

Spatial arrangement had no significant effect on grain yield of either maize or sorghum (Table 5). The time of planting, however significantly (P=0.05) influenced grain yield. Delaying interplanting of sorghum in maize by 15 days increased maize yield by 25%, 19% and 77% at Ping, Tumu and Babile, respectively. Similarly, a 30 day delay resulted in increased maize yield of 27%, 25% and 73% at Ping, Tumu and Babil, respectively, compared to simultaneous planting. Conversely, sorghum yield was depressed by 95%, 59% and 42% at 15 day delayed planting at Ping, Tumu and Babile, respectively. The corresponding values for the 30 day

Table 4: Effect of spatial arrangement and time of planting on plant height and grain yield of maize + sorghum intercrop in the Guinea Savannah Zone of Ghana in 1991.

	Grain Yield		Plant Height			
	Maize	Sorghum	Maize 50 DAP	Maize Har.	Sorghum 50 DAP	Sorghum Har.
	----------kg/ha----------		----------cm----------			
A. Spatial Arrangement						
In row, separate hill (A_1)	2576	499	86	161	7	157
In row, same hill (A_2)	2023	646	82	146	78	155
Between rows, hills (A_3)	2499	587	85	155	70	159
Between rows, drilled (A_4)	2479	529	89	150	75	151
SE	411	152	4.4	4.7	10.3	10.8
B. Planting Time						
Simultaneous	1790	1267	86	151	123	246
15 DAP	2932	429	87	158	102	217
30 DAP	2460	0	83	151	0	0

Table 5: Effect of spatial arrangement and time of planting on grain yield of maize + sorghum intercrop in the Guinea Savannah Zone of Ghana in 1992.

	Ping		Tumu		Babile	
	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum
	kg/ha					
A. **Spatial Arrangement**						
In row, separate hill (A_1)	3043	1278	1640	881	1768	1834
In row, same hill (A_2)	2585	1161	1698	968	1545	1893
Between rows, hills (A_3)	2618	1134	1629	827	1775	1790
Between rows, drilled (A_4)	2785	1193	2057	781	1652	2145
SE	233	104.4	205.8	104.5	138.1	202.6
B. **Planting Time**						
Simultaneous	2233	3196	1480	1280	1105	2987
15 DAP	2784	154	1768	521	1959	1730
30 DAP	2841	0	1845	782	1917	55
SE	201.8	90.4	178.3	90.5	119.5	175.4
CV (%)	25.4	28.0	25.7	37.4	24.0	38.2

DAP - Days after planting.

delay were 39% and 98% for Tumu and Babile respectively. Sorghum interplanted in maize at 30 day delay at Ping did not produce any grain.

As reported for the other years, no significant interaction of spatial arrangement and time of planting was observed for the parameters measured.

DISCUSSION

The results of the four year experimentation indicated that planting maize and sorghum in alternate rows or within rows had no significant effect on grain yield and plant height of either maize or sorghum.

While this observation is consistent with the findings of [10], [11] it is at variance with the results obtained by [8], [9] that less intimate mixtures (triple rows/strip intercropping) yielded most.

This study however did not investigate the less intimate mixtures reported by [8], [9]. The only exception was in 1990 when within row spacing resulted in higher maize grain yield than the alternate row spacing. This may be attributed to the removal of maize seed and seedlings by pests resulting in lower plant population recorded for that spatial arrangement. Paul [12] observed that when sorghum is planted within the same row as maize, it competes more than when it is planted in the inter row and leads to a lowering of the maize yield. However, the relative planting times of both crops, unlike the spatial arrangement significantly affected the grain yield of both crops. Delaying the planting of sorghum into maize beyond 2 weeks enhanced maize grain yield at the expense of sorghum. This may be due to increased inter-species competition with the already established maize having a greater advantage over the newly planted sorghum. In situations where maize and sorghum are planted simultaneously, inter-species competition becomes very high and maize yield is significantly depressed. This accounts for the lower maize grain yield recorded for simultaneous planting than the 15 and 30 day delay in interplanting sorghum in maize. On the contrary, simultaneous planting recorded the highest sorghum grain yield. Therefore the decision of the farmer to plant maize + sorghum simultaneously would have to be made on individual family preference. This is important because different intercropping combinations may have to satisfy different socio-economic requirements. For a family that needs both maize + sorghum there is no justification based on these results, to delay the planting of sorghum till 30 days after maize. This is because they stand the risk of poor sorghum grain yield.

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