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Full Length Research Paper

Grain yield and yield components of maize (*Zea mays* L.) as affected by crude oil in soil

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A field experiment on the effect of crude oil levels: 0.0 (control), 5.2, 10.4, 20.8 and 41.6 ml applied at different stages of growth on maize yield and yield attributes, with a view to making appropriate recommendation to maize growers in the oil producing areas of the Niger Delta, was conducted in Ozoro, Delta State during the 2003 and 2004 cropping seasons. Seven maize varieties: Composite (suwan 1), Hybrid 3x-yx, AMATZER w, TZBRSYN w, AMATZBR y, TZBRSYN y and Ozoro local were evaluated. The current study has objective of evaluating the yield and yield components of seven varieties of maize grown in soil contaminated with crude oil with a view to identifying and selecting the tolerant ones and recommending the same to farmers in the Niger Delta region where oil industrial activities are predominant. The experiment was laid out in a randomized complete block design with five treatments replicated four times. Crude oil application (ring application) was carried out at three weeks after planting (3 WAP), 5 WAP and 7 WAP. Plants were harvested at 112 days after planting and assessed for grain yield, 1000-grain weight, cob girth and shelling percentage. The results showed that crude oil treatment significantly reduced ($P > 0.05$) grain yield, grain weight and cob girth but increased shelling percentage at $P < 0.05$. Significant differences at the 5% probably level in the responses of maize varieties to crude oils were also recorded at 5 and 7 WAP with Hybrid 3x-yx recording highest grain yield and weight whereas Ozoro local produced the highest cob girth and shelling percentage. Based on the results obtained from this investigation, Hybrid 3x-yx appeared to be susceptible to soils affected with crude oil as death was eminent at higher oil doses. The open pollinated varieties (AMATZER w, TZBRSYN w, AMATZBR y, TZBRSYN y) are better in terms of relative tolerance hence should be recommended to farmers and maize growers in the oil producing areas of Nigeria. There is therefore the need to test the open pollinated varieties on farmers' field to determine their adaptability to oil pollution. Furthermore, the need for further studies to determine the level of pollution at which maize growth and yield are adversely affected cannot be overemphasized. The study established varietal differences with respect to maize response to crude oil level and this provides a basis for future breeding work by plant breeders.

Key words: Crude oil, grain yield, yield components, *Zea mays*.

INTRODUCTION

Maize is the third most important cereal crop following wheat and rice in the world production of cereal crops (FAO, 2002). Maize is one of the major staples consumed in Nigeria (Obi, 1991). It has a lot of industrial uses including its use as feed for domestic animals (Watson, 1977; Ronanet, 1992). Maize is grown in most agro ecological areas especially in the Niger Delta region where oil industrial activities are predominant (Agbogidi et al., 2005a, 2006a, 2007). Oil pollution effects on the growth and yield of crop plant species have been variously reported by several workers, to include poor growth, yield reduction and sometimes death (Anoliefo, 1991; Anoliefo and Vwioko, 1994; Agbogidi et al., 2005b; 2006a, b; 2007).

There is however, paucity of information on the effect of crude oil levels on grain yield and yield attributes of maize. A crop yield is a function of a number of factors and processes such as light intercepted by the canopy, metabolic efficiency of the plant, translocation efficiency of photosynthesis from the source (leaves) to economic parts and sink capacity or sink strength (Agbogidi et al., 2006b). The photosynthetic capacity of the plant determines overall productivity and the extent of development

Table 1. Effect of crude oil levels applied at 5 WAP on grain yields (t /ha) and yields components of seven maize varieties in Ozoro, Delta State.

Yield attributes	Maize variety	Crude oil level (ml/plant)					
		0.0	5.2	10.4	20.8	41.6	Means
Grain yield (kg/plant)	Composite (Suwan 1)	0.64b	0.58c	0.52b	0.00c	0.00a	0.35
	Hybrid 3x-yx	1.21a	1.02a	0.90a	0.00c	0.00a	0.63
	AMATZBR w	0.72ab	0.70ab	0.62b	0.59a	0.00a	0.53
	TZBRSYN w	0. 70b	0.60b	0.51b	0.43b	0.00a	0.49
	AMATZBR y	0.68ab	0.63b	0.54b	0.51ab	0.00a	0.47
	TZBRSYN y	0.64b	0.60b	0.51b	0.43b	0.00a	0.44
	Ozoro Local	0.60b	0.54c	0.50b	0.00c	0.00a	0.33
	Means	0.74	0.67	0.60	0.31	0.00	
1000 Grain weight (gm)	Composite (Suwan 1)	160.94c	167.46b	164.57ab	0.00c	0.00a	98.59
	Hybrid 3x-yx	178.46a	174.69a	170.73a	000c	0.00a	104.78
	AMATZBR w	176.74b	164.71c	160.94b	154.91a	0.00a	131.46
	TZBRSYN w	175.96b	171.82ab	162.42ab	151.14b	0.00a	132.27
	AMATZBR y	177.90ab	170.97ab	161.61ab	153.44a	0.00a	132.78
	TZBRSYN y	176.87b	171.08ab	163.42ab	152.18b	0.00a	132.71
	Ozoro Local	156.42b	150.25d	143.34c	0.00c	0.00a	90.00
	Means	171.90	167.28	161.00	87.38	0.00	
Cob girth (cm)	Composite (Suwan 1)	12.00c	11.86b	11.53b	0.00c	0.00a	7.08
	Hybrid 3x-yx	12.68ab	12.26ab	12.22ab	0.00c	0.00a	7.43
	AMATZBR w	12.63AB	12.0AB	12.00B	11.64B	0.00a	9.67
	TZBRSYN w	12.80ab	12.45ab	12.04b	11.66b	0.00a	9.79
	AMATZBR y	13.80a	13.40b	13.21a	13.10a	0.00a	10.70
	TZBRSYN y	12.39b	12.09b	11.92b	11.60b	0.00a	9.60
	Ozoro Local	13.97a	13.63a	13.30a	0.00c	0.00a	8.18
	Means	12.90	12.54	12.34	6.86	0.00	
Shelling percentage	Composite (Suwan 1)	69.64d	69.81c	69.94c	0.00c	0.00a	41.88
	Hybrid 3x-yx	72.45b	72.94b	72.84b	0.00c	0.00a	43.65
	AMATZBR w	71.94c	72.32b	72.65b	73.72b	0.00a	58.13
	TZBRSYN w	72.44b	72.94b	72.98b	73.42b	0.00a	58.36
	AMATZBR y	72.48b	73.84b	74.88b	75.67ab	0.00a	59.37
	TZBRSYN y	74.40ab	75.61ab	76.72a	77.48a	0.00a	60.84
	Ozoro Local	76.39a	76.42a	77.68a	0.00c	0.00a	46.10
	Means	72.82	73.41	73.94	42.90	0.00	

Means with the same letter (s) for each parameter are not significantly different at ($P \geq 0.05$) by Duncan's multiple range test (DMRT)

mines overall productivity and the extent of development of each yield character and is dependent on the inter-relationship between the various yield components. The study was conducted to evaluate the effect of various levels of crude oil applied at different stages of growth on maize grain yield and yield components with a view to making appropriate recommendation to maize growers in the oil producing areas of the Niger Delta including Delta State.

MATERIALS AND METHODS

Field experiment using randomized complete block design was carried out during the 2003 and 2004 cropping seasons using seven maize varieties: Composite (suwan 1), Hybrid 3x-yx, AMATZER w, TZBRSYN w, AMATZBR y, TZBRSYN y and Ozoro local and five crude oil levels 0.0 (control), 5.2, 10.4 20.8 and 40.6 ml/ plant at Ozoro, Delta State. NPK (20: 10: 10) fertilizer was incorporated into the soil during the land preparation stage while the crude oil was applied at 3, 5 and 7 WAP on separate sets of maize plants (ring application). The experiment was laid out in three factorial in a randomized complete block design with five treatments replicated four times. Plants were harvested at 112 days after planting and assessed for grain yield, 1000-grain weight, cob grain and shelling percentage. Means were pooled over the years. Data collected were subjected to analysis of variance while the significant means were separated with the Duncan's multiple range tests (DMRT) using SAS (2005).

RESULTS AND DISCUSSION

The results showed that crude oil treatment significantly reduced ($P \leq 0.05$) grain yield, grain weight and cob girth. Shelling percentage was however, significantly increased ($P \leq 0.05$) as a result of crude oil application to soil (Tables 1 and 2). All the maize seedlings that had crude

Table 2. Grain yield (t/ha) and yields components of seven maize varieties as affected by various levels of crude oil application to soil at 7 WAP.

Yield components	Maize variety	Crude oil level (ml/plant)					
		0.0	5.2	10.4	20.8	41.6	Mean
Grain yield (kg/plant)	Composite (Suwan 1)	0.71d	0.62b	0.60b	0.54ab	0.32b	0.56
	Hybrid 3x-yx	1.42a	1.12a	0.94a	0.90a	0.66a	1.01
	AMATZBR w	0.95b	0.90a	0.84ab	0.82a	0.51ab	0.80
	TZBRSYN w	0.94b	0.84ab	0.64c	0.54ab	0.49ab	0.69
	AMATZBR y	0.97b	0.86ab	0.72b	0.75ab	0.63a	0.77
	TZBRSYN y	0.89c	0.82ab	0.70b	0.62ab	0.68ab	0.74
	Ozoro Local	o.69d	0.60b	0.56c	0.50ab	0.30b	0.53
	Means	0.94	0.82	0.71	0.65	0.51	
1000 Grain weight (gm)	Composite (Suwan 1)	168.56b	166.0b	162.41b	159.32b	155.81b	162.42
	Hybrid 3x-yx	179.40a	177.85a	174.61a	174.32a	172.08a	175.65
	AMATZBR w	177.64a	174.32a	171.46a	164.24a	162.13a	169.96
	TZBRSYN w	176.81a	175.16a	170.82a	165.82a	163.40a	170.36
	AMATZBR y	177.92a	174.81a	170.86a	168.01a	164.32a	171.18
	TZBRSYN y	177.41a	175.62a	172.00a	170.21a	164.62a	171.97
	Ozoro Local	156.43c	154.62c	151.52c	148.41c	145.40c	151.28
	Means	173.45	171.20	167.69	164.30	161.11	
Cob girth (cm)	Composite (Suwan 1)	12.09b	12.02b	11.68c	11.47b	11.20a	11.69
	Hybrid 3x-yx	12.89ab	12.41ab	12.22b	12.01b	11.64b	12.23
	AMATZBR w	12.69ab	12.46ab	12.21b	12.01b	11.44c	12.16
	TZBRSYN w	12.82ab	12.70ab	12.42b	12.13b	12.02b	12.42
	AMATZBR y	13.71a	13.62a	13.36a	13.14a	12.64a	13.29
	TZBRSYN y	12.46ab	12.31b	12.01b	11.94b	11.54b	10.05
	Ozoro Local	13.96a	13.74a	13.52a	13.26a	12.82a	13.46
	Means	12.95	12.75	12.49	12.28	11.90	
Shelling percentage	Composite (Suwan 1)	69.66d	69.84d	70.04d	70.42d	71.64c	70.32
	Hybrid 3x-yx	72.50b	72.96c	73.50c	73.86c	74.38b	73.44
	AMATZBR w	71.61c	72.41c	74.00b	75.08b	75.82ab	73.78
	TZBRSYN w	72.41b	73.50b	74.61b	75.32b	75.45ab	73.93
	AMATZBR y	73.70ab	73.95b	74.08b	74.80b	74.86b	74.28
	TZBRSYN y	74.46ab	75.60ab	75.89ab	76.41ab	76.64ab	75.80
	Ozoro Local	78.41a	76.81a	76.96a	77.81a	78.04a	77.61
	Means	73.25	73.58	74.15	74.81	75.26	

Mean with the same letter (s) for each parameter are not significantly different at ($P \geq 0.05$) by Duncan's multiple test (DMRT).

oil treatment at 3 WAP died within 24 h when compared with the control seedlings which grew and developed normally. At 5 WAP, all the maize seedlings from the seven varieties subjected to 41.6 ml crude oil treatment died within 48 h of oil application while only composite (suwan 1), Hybrid 3x-yx and Ozoro local died on exposure to 20.8 ml of the crude oil. The open pollinated varieties (AMATZER w, TZBRSYN w, AMATZBR y, TZBRSYN y) survived at 20.8 ml of the oil treatments. No death was recorded in the four varieties studied (Tables 1 and 2).

The observed significant reduction in the grain yield, grain weight and cob girth with increasing crude oil level could be attributed to the toxic effect of oil. This finding is consistent with the reports of De Jong (1980) and Agbogidi et al. (2006a, 2006c) that crude oil application to soil has a significant effect of reducing the yield characters of plants. The increased shelling percentage of the seven maize varieties as observed in this study may be attributed to the reduction in the other yield parameters as these could have enhanced shelling percentage.

Significant differences ($P \leq 0.05$) in the responses of maize varieties to crude oil level were also recorded at 5 and 7 WAP with the Hybrid 3x-yx generally recording highest grain yield and grain weight whereas Ozoro local recorded the highest cob girth and shelling percentage.

Composite (suwan 1) produced the lowest level of yield responses in terms of cob girth and shelling percentage while Ozoro local had the lowest grain yield and grain weight among the varieties evaluated.

These differences in the yield characters of maize varieties to crude oil levels support the reports of Baker (1970) and Naegele (1974) that the effect of crude oil on plants is dependent on the variety amongst other factors. As reported by Naegele (1974) and Anoliefo (1998), differences in plants reaction to pollution are due to an innate genetic response of the plant system as modified by environmental influences. Based on the results obtained from this investigation, Hybrid 3x-yx appeared to be susceptible to soils affected with crude oil as death was eminent at higher oil doses. The open pollinated varieties (AMATZER w, TZBRSYN w, AMATZBR y, TZBRSYN y) are better in terms of relative tolerance hence should be recommended to farmers in Delta State and maize growers in the oil producing areas of Nigeria. There is therefore the need to test the open pollinated varieties on farmers' field to determine their adaptability to oil pollution. Furthermore, the need for further studies to determine the level of pollution at which maize growth and yield are adversely affected cannot be overemphasized.

The study established varietal differences with respect to maize response to crude oil level and this provides a basis for future breeding work by plant breeders.

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