Environtropica, Augusty 2013, Vols 9&10, 84-89 ISSN 1597-815X

Physiological Maturity of Maize as Influenced by Cultivars and Rates of NPK (15-15-15) Fertilizer

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Accepted on July 10, 2013

Abstract
A field trial to determine the effects of cultivars and rates of NPK (15-15-15) fertilizer on the physiological maturity of maize (Zea mays L.) was conducted for a duration of 2 years at the Research Farm of the University of Ado-Ekiti in the rain forest zone of the South-western Nigeria. Commercial NPK (15-15-15) fertilizer was applied to DMRESR-Y, SUWAN-Y and DMRLSR-Y maize cultivars at 0, 250, 500 and 750 kg/ha. Results revealed that physiological maturity differed significantly among the three varieties of maize with DMRLSR-Y having the longer days to tasseling, silking, leaf browning and black layer formation than those of SUWAN-Y and DMRESR-Y while the periods to all the maturity factors were statistically similar in SUWAN-Y and DMRESR-Y. Period of physiological maturity (black layer formation) and the processes leading to it also decreased with the increasing rates of NPK (15-15-15) fertilizer up to 500kg/ha and thereafter stabilized or formed a plateau.

Key words: *Tasseling, silking, physiological maturity, black layer formation*

Introduction

Physiological maturity in corn is the time when dry matter accumulation in the maize grain or kernel has ceased, (Rench and Shaw, 1971; Eastin *et al.*, 1976). Since timely harvest is very important to minimize field losses due to incidence of pests and diseases following maturity, the use of physiological maturity as an accurate prediction tool to identify the most appropriate maturity period for timely harvest of maize is of considerable significance. Even though other methods such as growing degree days (GDD) or heat units (Cross and Zuber, 1972; Wolf *et al.*, 1974; IAH, 1975) and moisture content of the grain (Hallauer and Russel *et al.*, 1962; Hillson and Penny, 1965) have been used, physiological maturity has been described as the best method for determining the maturity of corn (Daynard and Duncan, 1969; Eastin *et al.*, 1976). It is indicated by the formation of a black layer at the tip of the kernel where it is attached to the cob.

Maize field can be harvested immediately after physiological maturity has been attained in maize grains irrespective of the physical appearance of maize plant. The grains can thereafter be dried to a moisture content of 12-15.5% depending on what the farmer intends to do with the maize grains (Adeyemi, 1979). Consequently, field losses due to pests and diseases are prevented, and higher yield of maize than harvesting at 'physical maturity' can be obtained as a result of which full yield potentials of maize can be explored. This is because black layer formation in maize can also be used to determine when seeds have completed development. It also helps farmers to time harvest preparations relative to other labour requirements. With all these comparative advantages derivable from the harvesting of maize at physiological maturity, a way of accentuating this phenomenon through fertilizer application may therefore further result in higher yield of maize than hitherto obtained. Irrespective of the invigoration of maize with fertilizer application, black layer development in maize may still vary from cultivar to cultivar. Consequently, there is the need to investigate the effect of maize cultivars and rates of NPK (15-15-15) fertilizer on the physiological maturity of maize. This study is therefore an attempt to determine the influence of cultivars and rate of NPK (15-15-15) fertilizer on the physiological maturity of three maize varieties.

Materials and Method

The physiological maturity of three maize varieties – DMRESR-Y, SUWAN-Y and DMRLSR-Y were investigated under four rates of NPK (15-15-15) fertilizer in the early planting season of 2004 and 2005 at the Research Farm of the University of Ado-Ekiti, Ado-Ekiti in the rain forest zone of the South-western Nigeria. DMRESR-Y, SUWAN-Y and DMRLSR-Y are short (early), medium and long (late) maturity-period maize varieties respectively while the three cultivars are downey mildew and streak resistant, and yellow seeded in colour. Pre-cropping soil samples from 0-15cm depth representing top soil were taken from the experimental site at the beginning in the 2004 to determine the physico-chemical properties of the soil using standard laboratory methods (IITA, 1982). Commercial NPK (15-15-15) fertilizer was applied at the rate of 0, 250, 500, and 750kg/ha.Twelve treatments combinations from the combination of three maize cultivars and four fertilizers levels were distributed into the different plots using randomized complete block design (RCBD) with four replications. Plot size was 2.0 x 3.0 with maize plants spaced at 0.50 x 0.75 cm at 2 plants per stand to give plant population of 53,000 per hectare. Planting was done in June, 2004 and May, 2005. Experimental site was maintained by hand weeding the plot thrice through hoeing. Fertilizer application was carried out at three WAP using spot application after thinning operation had been effected. Periods (days) of tasseling, silking, leave browning and black layer formation which are the signs of maturity in corn were observed from 7 WAP and progressed to 16 WAP. Dates of incidence of the various factors of maturity were recorded in each plot until 50% formation was attained and from where the periods were calculated. Black layer formation was detected in the maize kernel by removing the grains from the cobs and observing the tips of the grains for black layer formation. Where it was not clearly discernible, the tip of the kernel was removed to permit a thorough observation of the tissue that formed the black layer. Data were subjected to analysis of variance and means separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results

The pre-cropping physicochemical properties of the soil from the experimental site range from low to medium (Table 1).

Table1: Physico-chemical properties of the soil in the experimental site at Ado- Ekiti

Soil properties	Mean values
Soil pH (H_2O)	6.50
% Organic Carbon	0.97
% Total N	0.11
Available P (Bray 1) (mg/kg)	9.50
Exchangeable K (cmol/kg)	0.37
Exchangeable Ca (cmol/kg)	2.42
Exchangeable Mg (cmol/kg)	0.90
% Sand	71.21
% Silt	20.20
% Clay	8.59

Days to maize tasseling and silking as influenced by different maize cultivars and NPK (15-15-15) fertilizer rates are presented in Table 2.

Table 2: Days to maize tasseling and silking as influenced by different maize cultivars and NPK (15-15-15) fertilizer rates.

Physiological index	Maize cultivar	NPK (15-15-15) fertilizer rate (Kg/ha)									
		2004					2005				
		0	250	500	750	Mean	0	250	500	750	Mean
	DMRESR-Y	57.00	55.00	53.00	53.00	54.50b	57.50	55.50	55.00	55.00	55.75b
	SUWAN-Y	58.00	56.00	53.00	53.00	55.00b	58.00	56.00	54.00	54.00	55.63b
Tasseling	DMRLSR-Y	60.00	58.00	56.00	56.00	57.50b	60.00	57.00	57.00	57.00	57.75a
	Mean	58.33a	56.33b	54.00c	54.00c		58.50a	56.17b	55.33c	55.33c	
	S.E					0.42					0.25
	C.V (%)					1.69					1.11
	DMRESR-Y	62.00	60.00	58.00	57.00	59.25b	62.22	60.44	57.72	58.00	59.60b
	SUWAN-Y	63.00	61.00	58.00	58.00	60.00b	62.00	60.50	58.50	59.00	60.00b
Silking	DMRLSR-Y	65.00	63.00	61.00	62.50	65.00a	65.00	62.00	62.00	61.50	62.63a
	Mean	63.33a	61.33b	59.00c	58.67c		62.07a	60.98b	59.41c	59.50c	
	S.E					0.42					0.34
	C.V (%)					3.07					1.49

Means followed by the same letter(s) within a row or column are not significantly different at p=0.05 (DMRT).

Periods of tasseling and silking in maize in the trial follows the same pattern in both years of study. Periods of tasseling and silking were significantly longer in DMRLSR-Y than those of SUWAN-Y and DMRESR-Y while the phenomenons were similar in SUWAN-Y and DMRESR-Y. Days of tasseling and silking in the maize cultivars decrease with increasing rate of NPK (15-15-15) fertilizer up to 500kg/ha and thereafter leveled out. Leaf and husk browning in maize also follows the same pattern in the two experimental years except leaf browning in DMRESR-Y in 2005 that varied from that of SUWAN-Y (Table 3).

Table 3: Days to leaf and husk browning in the different maize cultivars as affected by NPK (15-15-15) fertilizer rates.

Physiological index	Maize cultivar	NPK (15-15-15) fertilizer rate (Kg/ha)									
		2004					2005				
		0	250	500	750	Mean	0	250	500	750	Mean
	DMRESR-Y	105.00	103.00	101.00	101.00	102.50b	111.00	105.00	100.00	100.50	104.13c
	SUWAN-Y	104.00	102.00	101.00	103.25	102.56b	110.00	108.00	108.00	109.38	108.85b
Tasseling	DMRLSR-Y	110.00	107.00	103.00	102.00	105.50a	117.00	112.00	108.00	108.00	111.25a
	Mean	106.33a	104.00b	101.67c	102.08c		112.67a	108.33b	105.50c	105.96c	
	S.E					0.44					0.70
	C.V (%)					1.46					1.47
	DMRESR-Y	101.00	89.00	95.00	94.00	94.75b	98.00	98.00	91.00	91.00	94.50b
	SUWAN-Y	90.00	90.00	96.00	97.25	93.31b	94.00	91.00	91.00	94.63b	92.66b
Silking	DMRLSR-Y	101.00	98.00	98.00	98.00	98.75a	101.00	98.00	98.00	91.00	98.63a
	Mean	97.33a	92.33b	96.33c	96.42c		97.67a	95.67b	93.33c	92.21c	
	S.E					0.38					0.55
	C.V (%)					1.50					1.67

Means followed by the same letter(s) within a row or column are not significantly different at p=0.05 (DMRT).

Consequently, periods of leaf browning and husk browning were longer in DMRLSR-Y than those of SUWAN-Y and DMRESR-Y while they were similar in SUWAN-Y and DMRESR-Y except in 2005 when these parameters were shorter in DMRESR-Y than those of SUWAN-Y. Days to leaf and husk browning also decreased with increasing rate of NPK (15-15-15) fertilizer up to 500kg/ha beyond which they stabilized.

Effects of cultivars and NPK (15-15-15) fertilizer rate on the periods (days) of black layer formation in maize are shown in Table 4.

Table 4: Effects of NPK (15-15-15) fertilizer rates on the period (days) of black layer formation in the different maize cultivars.

Experimental Year	Maize cultivar	NPK (15-15-15) fertilizer rate (Kg/ha)				
		0	250	500	750	mean
	DMRESR-Y	106.00	104.00	99.00	96.00	101.25b
	SUWAN-Y	105.00	103.00	97.00	95.00	100.00c
2004	DMRLSR-Y	108.00	105.00	101.00	100.00	103.50a
	Mean	106.33a	104.00b	99.00c	97.00c	
	S.E					0.64
	C.V (%)					0.79
	DMRESR-Y	112.00	107.50	105.00	105.00	107.38b
	SUWAN-Y	108.00	105.00	105.00	105.00	105.75b
2005	DMRLSR-Y	119.00	116.00	113.00	113.00	115.25a
	Mean	113.00a	109.50b	107.67c	107.67d	
	S.E					0.77
	C.V (%)					2.06

Means followed by the same letter(s) within a row or column are not significantly different at p=0.05 (DMRT).

Black layer formation like other signs of maturity in corn was longer in DMRLSR-Y than the SUWAN-Y and DMRESR-Y that were similar to each other except in 2004 when periods of black layer formation was unexpectedly shorter in SUWAN-Y than that of DMRESR-Y. Periods of black layer formation in maize decreased linearly with increasing rate of NPK fertilizer in 2004 while the decreases due to higher rate of NPK fertilizer leveled out or formed a plateau beyond the rate of 500kg/ha in 2005. Table 5 shows the maize grain yield as affected by the different cultivars and NPK (15-15-15) fertilizer rate in both years of study. Maize grain yield was higher in DMRLSR-Y followed in that order by SUWAN-Y and DMRESR-Y. Maize grain yield in the three cultivars increased significantly with increasing rate of NPK (15-15-15) fertilizer up to 500kg/ha and thereafter stabilized.

Table 5: Maize grain yield (t/ha) as affected by the different cultivars and NPK (15-15-15) fertilizer rates.

Experimental Year	Maize cultivar	NPK (15-15-15) fertilizer rate (Kg/ha)				
		0	250	500	750	mean
2004	DMRESR-Y	2.40	3.46	4.53	4.79	3.80c
	SUWAN-Y	2.93	4.24	5.07	5.33	4.39b
	DMRLSR-Y	3.50	4.85	5.60	5.60	4.89a
	Mean	2.94c	4.18b	5.06a	5.24a	
	S.E					0.15
	C.V (%)					6.17
2005	DMRESR-Y	2.68	3.67	4.90	5.40	4.16c
	SUWAN-Y	3.04	4.02	5.40	5.70	4.54b
	DMRLSR-Y	3.31	4.45	5.90	6.15	4.95a
	Mean	3.01c	4.04b	5.40a	5.75a	
	S.E					0.18
	C.V (%)					5.98

Means followed by the same letter(s) within a row or column are not significantly different at p=0.05 (DMRT).

Discussion

Maize cultivars of DMRLSR-Y had larger period to complete the processes of maturity in maize than SUWAN-Y and DMRESR-Y varieties as indicated by tasseling, silking, leaf and husk browning and black layer formation because it is a naturally late maturing variety while SUWAN-Y and DMRESR-Y are early maturing variety. Naturally, it takes late maturing maize longer period to complete its onthogenic and anthesis growth stages than the early maturing varieties. Irrespective of the natural periods of maturity in the various cultivars of maize in this study, application of NPK (15-15-15) fertilizers was able to accentuate the growth of maize faster than usual and this accounted for the marked reduction in the duration or periods of physiological processes of maize at higher rate of NPK fertilizer in this study

The results of this study which generally follow the same trend with the cultivars as well as the rates of NPK fertilizer in both years of study, are confirmation that the maturity parameters used in this study especially tasseling, silking and black layer formation are true factors of physiological maturity in maize. These are in line with the findings of many workers who have observed that tasseling and silking are important factors for maturity ratings in corn because they are the physiological processes that lead to physiological maturity in maize (Daynard and Duncan, 1969; Cross and Zuber, 1972; Eastin *et al.*, 1976; Adeyemi, 1979). Adeyemi (1979) in addition to the use of tasseling and silking for maturity rating in maize varieties has also found that they can provide a rough estimate of when to observe for the subsequent physiological processes such as kernel denting and black layer formation that follows silking. Similarly Hilson and Penny (1965) have also shown that formation of silk in maize provides an indication of when to test for some physiological indicators. Physiological maturity in maize which has been defined by many workers as a time when maximum dry matter accumulation in maize kernels has been reached was determined in this study using 50% black layer formation which is in consonance with results of Daynard (1972) and IAH (1975) who used 50-75% black layer formation to determine physiological maturity in maize.

Conclusion

This study has revealed that maize cultivars and rate of NPK (15-15-15) fertilizers can considerably influence the various periods/times of incidences of the various factors of physiological maturity in maize especially tasseling and silking which are the processes that lead to physiological maturity. Consequently, physiological maturity (black layer formation) in maize can be accentuated with the application of higher rate of NPK (15-15-15) fertilizer by reducing significantly the period of physiological maturity by 5.9% irrespective of the variation in the phenomenon among cultivars. Using the phenomenon/process, therefore, to determine the time of harvesting of maize will further result in higher yield of maize since a lot of field losses due to weather hazards and incidences of pests and diseases following maturity can be prevented by so doing.

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