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Influence of Weed Control Methods on Viability and Vigour of Maize (*Zea mays* L.) Seeds

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Abstract: Weed control method of choice should achieve the objective of controlling weeds without sacrificing seed quality. The influence of Combination of mechanical method (slashing at 2, and 4 week intervals), and herbicide (pre-emergence and post emergence) for weed control in maize on seed quality (viability and vigour) of maize seeds were evaluated.. Field and laboratory experiments were conducted to investigate the influence of pre-emergence (Diuron 50% SC {N (3, 4-dichlorophenyl) N, N-dimethyl urea} and post-emergence (Atrazine 50FW-{6 chloro-N-methyl-N-(1-methylethyl) 1, 3, 5-triazine, 2, 4 diamine}) herbicides either alone, or in combination with slashing at two and four-week, on seed quality. Combination of pre-emergence herbicide and slashing 2-weeks after planting slashing gave the highest viability (91.37%) and lowest conductivity value (2.79 µS/cm/g), whereas combination of post emergence herbicide and 4 week slashing gave the lowest viability (77.67%) and the highest conductivity value (15.71 µS/cm/g). In accelerated ageing test, combination of pre-emergence herbicide with either 2 week slashing, or 4 week slashing WAP gave the highest viability (84%), whereas combination of post emergence herbicide with 2 week slashing gave the lowest viability (51.33%) and lowest germination rate index (10.37). Combination of pre-emergence herbicide and 2-week slashing is the best complementary option for weed control in maize seed crop.
Keywords; pre-emergence, post-emergence herbicides, seed physiology, maize seed viability
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INTRODUCTION

The use of seeds with low vigour has been implicated in the substantial loss of yield by peasant farmers (Finch-Savage, 1995; Rambakudzibag *et al*., 2002). Performance of seeds is largely influenced by physiological quality, inheritance and environment (Delouche, 2004). Weeds are part of the environment of plant and are stressors that compete with crops for light (thereby reducing photosynthesis activity), nutrients, CO_2, and moisture (Tollenaar *et al*., 1994; Berti *et al*., 1996). Weeds can also interfere with performance of crops by parasitism and can be host of diseases (Paulo, 2005). These interferences negatively affect seed quality as observed by Saayman and Van De Henter (1997) who reported that both germination and vigour of maize seeds decreased with an increase in weed density. Therefore, weeds must be effectively controlled in order to guarantee the production of high quality seed.

Effective weed control is an essential management task for crop establishment under field situations. Several controls options are usually employed to tackle the problem of weeds in farmers' fields. These options range from mechanical, cultural, biological to chemical control methods. However, much of the control strategies employed in the farming systems of resource-limited and peasant farmers is primarily manual (hand weeding), and to a lesser degree herbicides. Complementary applications of these methods as demonstrated by Sharara *et al*. (2005) showed that Atrazine, a pre-emergence herbicides complemented with hoeing was more effective on both narrow and broad-leaf weeds compared with two post emergence herbicides (Bentazone and Fluroxypyr). Given the growing involvement and significance of community seed producers in emerging seed industries like Nigeria's (Ajayi and Fakorede, 2003; Dew and Ajayi, 2010; Odeyemi et al.; 2010), this study was undertaken to compare the effectiveness of weed control options in maize and their effect on seed quality. seed fields.

MATERIALS AND METHODS

Seed Production

Seeds of Oba Supa I maize variety were produced at the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso ((8°10'N, 4°10'E),. The seedbed was prepared following standard agronomic practices- ploughing and harrowing. The crop was sown on 30th May 2006. Plant spacing was 75 cm x 50 cm with three seeds sown to a hill and thinned to 2 plants per hill. A total of 10 treatments (as shown in table 1) consisting of sole and combinations of different weed control methods were used. Diuron 50% SC {N (3, 4-dichlorophenyl) N, N-dimethyl urea},) was used as a pre-emergence herbicide and applied at the rate of 1.25kg a.i/ha^{-1}. (Atrazine 50FW-{6 chloro-N-methyl-N-(1-methylethyl) 1, 3, 5-triazine, 2, 4 diamine} was used as a post-emergence herbicide. It was applied at the rate of 1.5 kg a.i/ha^{-1}.

The experiment was replicated three times and laid out as randomized complete block design. At maturity, cobs seeds were harvested from each treatment separately and dried and processed in the laboratory. Cobs were weighed after air drying for 14 days and carefully shelled for grains and cleaned. Thereafter the resulting maize seeds were subjected to seed quality tests as follow:

Standard germination test

Viability of the seeds was assessed by standard germination test. There were 100 seeds per replicate in three replicates Seeds were sown in moistened riverbed sand substrate in plastic germination bowls. Germination counts were done 4, 5, 6 and 7 days after planting. Germination was assessed as the percentage of seeds producing normal seedlings following the guidelines in the handbook of seedling classification (ISTA, 2003). The proportion of abnormal seedlings was also similarly determined. Germination percentage (GPCT), germination index (GI), and germination rate index (GRI) were calculated from germination data as follows:

$$\text{GPCT} = \frac{\text{Total number of seedlings that emerged on the final count}}{\text{Total number of seeds planted}} \times 100$$

$$\text{GI} = \frac{\sum(\text{Nx})(\text{DAP})}{\text{Total number of seedlings that emerged on the final count}}$$

Where Nx is the number of seedling that emerge on day x after planting,

DAP is day after planting.

$$\text{GRI} = \frac{\text{Germination index}}{\text{Germination percentage (0-1 scale)}}$$

Vigour tests

Seeds were subjected to two vigour tests: accelerated ageing and bulk conductivity.

Accelerated Ageing test: The moisture content of the seeds was determined gravimetrically and thereafter recorded. Fifty seeds from each treatment were artificially aged in three replications by placing a single layer of the seeds from each treatment over a wire mesh screen and suspended over 40 ml of distilled water inside accelerated ageing box. The boxes were held at 43^{0}C and 100% relative humidity for 72 h in an accelerated ageing chamber. After this ageing period, the seeds were tested for germination as previously described for the standard germination test.

Bulk conductivity test: leakage of electrolytes was monitored by placing 50 pre-weighed apparently intact (that is no visible physical damage) seeds in 250 ml of distilled water for 24 h at 20 ℃ in three replicates. Bulk conductivity per gram of seed weight for subsample was measured at after 24 hours with conductivity meter and expressed as μ S cm^{-1} g^{-1} as described by Hampton and Tekrony (1995).

$$\text{Conductivity per gram} = \frac{\text{conductivity (μS) for each flask}}{\text{weight (g) of seed sample}}$$

At the end of the conductivity test, the seeds were carefully blot-dried without applying pressure and the weight of the seeds were taken to determine the amount of water imbibed by the seeds and this was expressed as a percentage of the initial weight of the seeds.

Data analysis: The control plot in which there was with no weed control did not yield any seed and was therefore excluded from the analysis. Analysis of variance was carried out for each of the seed quality tests to detect variations across the treatments. Mean separation and ranking was done using Duncan's Multiple Range Test.

RESULTS

The coefficient of variability (CV) associated with the analysis of variance ranged between 2.25 and 25.29 while the coefficient of determination (R^2) ranged from 50 to 79% (Table 2). Significant mean squares due to method of weed control were detected for standard germination (SG), accelerated aging germination (AAG), accelerated aging germination index (AARI) and bulk conductivity (COND). Mean germination percentage of maize seeds for each weed control method is shown in Table 2. The difference between the lowest and highest mean values for seed viability and vigour traits were wide and significant ($P<0.05$), 77.67 and 91.33% for standard germination percentage, 4.19 and 4.32 days for germination index, 51.33 and 84.00% for accelerated aging germination percentage, 4.15 and 5.32 days for accelerated aging germination index and, 2.97 and 15.71 µS cm^{-1} g^{-1} seed for bulk conductivity. Seeds from plots in which weeds were controlled with both the pre- and post-emergence herbicides had 88.67% standard germination percentage. With combination of pre-emergence application and 2 week slashing standard germination was 91.33% while supplementation with 4 week slashing gave 88.00% germination. The two highest standard germination percentages were from plots in which pre-emergence herbicide was supplemented with slashing. Similarly, for accelerated ageing germination, three of five highest percentages were associated with weed control methods that involved the spraying of the pre-emergence herbicide either singly or in supplementation with slashing.

Mean value for conductivity test revealed that combination of pre-emergence herbicide and 2 week slashing had the lowest value (2.97 µS cm^{-1} g^{-1}) among the treatments. This was followed by 4-weekly slashing. Combination of pre-emergence herbicide and 4 week slashing had the highest value of 15 µS cm^{-1} g^{-1}.

Across the three standard and recommended seed quality tests namely standard germination test for viability (ISTA, 1999) as well as accelerated ageing and conductivity tests for vigour ((Hampton and TeKrony, 1995), plots treated with pre-emergence herbicide supplemented with slashing at two weeks intervals consistently ranked the best for seed quality (Table 4). On the other hand, plots in which weeds were controlled with a contact herbicide supplemented with slashing at four weeks interval ranked the lowest in standard germination and second to the lowest in accelerated aging test.

In this study, weed control treatments and time of application of herbicides influenced the seed quality parameters estimated with standard germination test and vigor tests. Standard Seed germinability was highest in plots treated with post emergence herbicide plus two and four weeks slashing and lowest in plots treated with only two weeks slashing alone. Standard germination rate index did not seem to be significantly affected by weed control treatments.

DISCUSSION

The physiological quality of botanical seeds encompasses viability and vigour and these are the primary determinants of the usefulness of a seed or seedlot. Seed quality in turn is influenced by the environment where it is produced. Weeds are an integral component of the environment of any seed crop in that a failure to effectively control these unwanted plants could mean zero harvest (Muhammad *et al*., 1999) as reported in this study. However the imperative of understanding the impact of weed control method on seed quality arises from the paucity of information on the agronomy of seed production (Ajayi, 2003) more so that seed production efforts are judged on the basis of quality of the produce rather than quantity.

The results of this study establishes a clear influence of weed control method on maize seed quality and that the differential ranking of the weed control methods in different seed quality test is an indication of the differential physiological response of the developing seeds and by inference the mother plants to competing weed situations. Harvesting will also be made easier if the crop is free of weed (MacRobert *et al*., 2007).

Differences in time of seed maturity due to weed infestation is a critical factor to tropical farming. The results of this study reveal that there was a variation in total germination which is a measure of seed viability. When seed that has this trait is introduced into the field for production, it exhibit a wide variation in performance after sowing due to the differences in physiological quality ar reported by Spears, (2004). Meanwhile, since seeds do not ripen at same time at all sites, variation in seed viability due to after ripening is inevitable (Singh, 2008). However, it has been reported that the most critical period of weed competition is during the first four to six weeks after emergence of the crop (MacRobert *et al*., 2007)**.**

It is known that maize seedling is susceptible to weed competition at different stage of development (Muhammad, *et al*., 1999; MacRobert *et al*., 2007) and this has been confirmed in this study by the differential responses of maize seeds harvested from the different weed control treatment plots.,What is not clear in this study and which needs further detailed investigation is at what stage of the growth of the maize seed crop was weed competition so severe as to have caused the observed seed vigour differences. However the fact that the treatments that gave best seed viability and vigour involved pre-emergence herbicides suggest that the likelihood of a significant effect of seedling vigour at the juvenile (pre-flowering) stages of the growth of the maize seed crop. Pre-emergence herbicides inhibits the germination and emergence of weed seeds and leaves the field clean and usually the crop will have been well established and grown to a stage where canopy is well formed and closed to manage weeds below the economic threshold after the action of the pre-emergence herbicides would have worn out. This, given that the fields are normally sown immediately after tillage, as it was done in this study, the seed crop emerge into a no-competition environment. This then permits rapid establishment and subsequently, the allocation as well as utilization of the products of photosynthesis entirely for growth. This scenario will definitely give plants under a pre-emergence herbicide treatment a clear advantage over crops where assimilates will be shared between the concurrent growth and competition requirements. In contrast to pre-emergence herbicides, post emergence herbicides are sprayed directly on emerged weeds and translocated throughout the plant. Thus there is a time lag during which weed competes with the crop seedling both before the application of the herbicide and while the herbicide was still being translocated and the plant is eventually killed. Overall, the differences among the treatments were more distinct for vigour tests than for viability test

In conclusion, weed control methods generally had significant influence on seed quality. Combination of these methods in weed management is more efficient than the single application on maize field in other to enhance optimum acquisition of seed quality during seed development . Since maize seedling are susceptible to weed competition at different stage of development, a single application of either contact herbicide, or 2 week slashing may not be sufficient for optimum acquisition of seed quality.

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Table 1: Different weed control methods applied to maize seed production plots

Treatments		Designation
T_1	No chemical + slashing at 2-week interval	2 wk
T_2	No chemical + slashing at 4-week interval	4 wk
T_3	Pre-emergence + Post emergence herbicide	Pre + Post
T_4	Pre-emergence herbicide alone	Pre only
T_5	Post emergence herbicide alone	Post only
T_6	Pre-emergence herbicide + slashing at 2-week interval	Pre + 2 wk
T_7	Pre-emergence herbicide + slashing at 4-week interval	Pre + 4 wk
T_8	Post emergence herbicide + slashing at 2-week interval	Post + 2 wk
T_9	Post emergence herbicide + slashing at 4-week interval	Post + 4 wk
T_{10}	No weed control	Control

Pre-emergence herbicide: Diuron
Post emergence herbicide: Atrazine

Table 2: Mean squares from analysis of variance for the influence of weed control method maize seed quality

Source	DF	SG	SGRI	AAG	AARI	COND
Rep	2	124.00*	0.03	2.81	0.09	3.96
Method	8	58.75*	0.01	322.8***	0.46*	41.45**
Error	16	20.29	0.01	67.98	0.13	5.76
C.V.		5.20	2.25	11.15	8.22	25.29
R^2(%)		68.86	50.40	70.41	64.35	78.64

Table 3: Mean values for different weed control methods in physiological quality tests

Treatment	SG	SGRI	AAG	AARI	COND
2 wk	85.33abc	4.19ab	82.67a	4.22b	10.17abc
4 wk	89.00ab	4.28ab	70.00a	4.31b	7.28b
Pre + Post	88.67ab	4.22ab	79.33a	4.28b	7.55bc
Pre only	88.00ab	4.13a	72.67a	4.33b	8.37abc
Post only	81.67bc	4.32b	72.00a	4.26b	12.93ad
Pre + 2 wk	86.67ab	4.31ab	84.00a	4.16b	8.49abc
Pre + 4 wk	77.67c	4.27ab	84.00a	4.15b	11.96adc
Post + 2 wk	91.33a	4.26ab	51.33b	5.32a	2.97d
Post + 4 wk	90.67a	4.31ab	69.33a	4.83ab	15.71e
Control					

Mean values in a column with different letters are significantly different at $P<0.05$

SG- Standard Germination SGRI- Standard Germination Rate Index
AAG- Accelerated Ageing Germination AAGI- Accelerated Ageing Germination Rate Index
COND- Bulk conductivity

Table 4: Ranking of weed control methods in seed quality tests

Treatment	SG	AAG	COND	Rank Summation
2 wk	6	3	6	15
4 wk	3	7	2	12
Pre + Post	4	4	3	11
Pre only	8	6	4	18
Post only	7	5	8	20
Pre + 2 wk	5	9	5	19
Pre + 4 wk	9	8	7	25
Post + 2 wk	1	1	1	3
Post + 4 wk	2	1	9	12
Control				

SG- Standard Germination SGRI- Standard Germination Rate Index
AAG- Accelerated Ageing Germination AAGI- Accelerated Ageing Germination Rate Index
COND- Bulk conductivity