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Época ideal para colheita de sementes de diferentes híbridos de milho

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ABSTRACT

The aim of this study was to identify the ideal maize seed harvest moment by different characteristics, as black layer formation, milk line development, seed moisture content and seed dry matter accumulation. Three simple hybrids from Syngenta Company were used in this work; ears from plants in the same development stage were collected, the first harvesting began 40 days after flowering, at four days interval until all seeds in an ear had the black layer formation. The characteristics evaluated were: black layer formation, milk line development, seed moisture content and seed dry matter. Seed physiological quality was evaluated by germination test, cold test, accelerated ageing and electrical conductivity. Results obtained in this study showed that the best indicative to identify the ideal maize seeds harvest moment is milk line stage 4 (75% of solidified endosperm). This stage occurs at different time for each genotype studied, 60DAF to hybrids 1 and 3, and 52DAF to hybrid 2, due to genetic differences among the hybrids.

Key words: **Zea mays**, milk line, black layer.

RESUMO

O objetivo deste estudo foi identificar o ponto ideal de colheita de sementes de milho por diferentes características, como formação da camada negra, desenvolvimento da linha de leite, conteúdo de umidade da semente e máximo acúmulo de massa seca. Três híbridos simples da empresa Syngenta foram utilizados neste estudo, cujas espigas foram coletadas de plantas de milho no mesmo estádio de desenvolvimento, sendo a primeira época de colheita aos 40 dias após o florescimento, utilizando-se intervalos de quatro dias entre épocas até que todas as sementes da espiga estivessem com a camada negra visível. As características avaliadas foram: formação da camada negra, desenvolvimento da linha de leite, conteúdo de umidade da semente e conteúdo de massa seca. A qualidade fisiológica das sementes foi determinada através dos testes de germinação, frio, envelhecimento acelerado e de condutividade elétrica. O melhor indicativo para determinar a época ideal de colheita de sementes de milho é quando elas estão com a linha de leite no estádio 4 (75% do endosperma solidificado). Esse estádio ocorreu em períodos diferentes para cada material estudado, 60 dias após a antese, para os híbridos 1 e 3, e 52 dias após a antese, para o híbrido 2, em função das variações nas características genéticas de cada um.

Palavras - chave: **Zea mays**, linha de leite, camada negra.

INTRODUCTION

Among the factors that contribute to obtain high physiological quality of seeds produced is the harvest in the proper time. During seeds maturation process, the occurrence of adverse environmental conditions, insect and microorganisms attacks contributes to accelerate seeds deterioration process and considering this fact, seeds harvest delay negatively affects physiological and sanitary quality of seeds (HENNING et al., 2011) and because this, studies to determine the ideal seeds harvest moment to different species are necessary.

The proper time to seeds harvest is as close as possible to the physiological maturity point, where qualitative and quantitative seed losses are at the minimum and the highest seed quality is obtained (DELOUCHE, 1976; HENNING et al., 2011). However, in the physiological maturity point, seeds have high moisture content which makes the

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mechanical harvest impossible, except to maize, where large part of seeds harvest is performed in ears allowing seeds with high moisture content to be harvested near the physiological maturity point. This approach results in higher physiological seed quality due to low exposure to adverse environmental conditions (JORGE et al., 2005).

Morphological and physiological changes that occur during maturation process are used as parameters to identify ideal maize seeds harvest moment, therefore studies are necessary to determine the seed harvest moment of interesting genotypes by precise and practical methods. Methods frequently used to identify ideal maize seed harvest moment are black layer formation, seed dry matter and seed moisture content (DAYNARD & DUNCAN, 1969; RENCH & SHAW, 1971; DAYNARD, 1972; HENNING et al., 2011). These characteristics are also used to identify seeds harvest moment to popcorn and sweet corn; the black layer is an efficient visual characteristic to identify the physiological maturity point of popcorn seeds (DAVID et al., 2003), similar results were observed in study performed with sweet corn seeds according to ARAÚJO et al. (2006).

There are other methods used to estimate the ideal maize seed harvest moment, like the milk line development which is a result of endosperm solidification. The endosperm solidification process beginning at apex and ending at the base of each seed, being a characteristic easily detected in the field and does not need special equipments. Many works have been conducted suggesting that the milk line can be used to identify the physiological maturity point and the ideal maize seed harvest moment (AFUAKWA & CROOKSTON, 1984; HUNTER et al., 1991, TEKRONY & HUNTER, 1995; VIEIRA et al., 1995; FESSEL et al., 2001; FARIA et al., 2005; HENNING et al., 2011).

Due to exposed, the developing of studies that compare different parameters to determine the proper time to maize seed harvest is important to avoid seed physiological quality losses. So, the aim of this study was to identify the ideal seeds harvest moment, for three maize simple hybrids, by different characteristics.

MATERIAL AND METHODS

This experiment was carried out in seed production fields from Syngenta Company, in Uberlândia - Minas Gerais (MG), cultivated under central pivot irrigation. Three simple hybrids from Syngenta Company were used in this study, these were genotypes called H1 (Hybrid 1), H2 (Hybrid 2) and H3 (Hybrid 3).

The plot sizes were 100 meters in length and 5 meters in width with four replications of each plot and sowing density of 55 plants m^{-2}; at flowering plants in the same development stage were marked. The first harvesting began 40 days after flowering when ears from marked plants were collected; other samples were performed at intervals of four days, until all seeds in an ear showed the black layer formation. Three ears per replication were collected to evaluate the black layer formation and milk line development and 50 ears per replicate were collected to evaluate seed physiological quality. After harvest, seeds were dried at 35ºC until 12% moisture content and stored at temperature of 10ºC and 50% of relative humidity.

Characteristics evaluated

- Seed moisture content: at harvesting moment, the moisture content was determined by the oven method at 105°C for 24 hours, using four replicates of 4,5g according to The Rules for Seed Analysis (BRASIL, 2009).

- Black layer: it was detected using four replications of three ears on each stage and identified by visual analysis of a thin black layer observed in the seed base, according to DAYNARD & DUNCAN (1969).

- Milk line: milk line stage 4 (corresponding to 75% endosperm solidification) was detected by visual analysis using the same ears from black layer identification; this evaluation was based on HUNTER et al. (1991).

- Seed dry matter: this evaluation was performed concurrently with seed moisture content using the same seeds number and the same replicates. Seeds dry matter was calculated by dividing the total sample dry weight by the number of seeds and expressed as mg.

Seed physiological quality

- Germination test: was performed with four replications of 100 seeds, using germitest paper imbibed in distilled water at a proportion of 2.5 times the paper weight. Samples were incubated in a germination chamber at 25°C and counts were performed four (first count) and seven days after sowing. Normal seedlings were evaluated according to The Rules for Seed Analysis (BRASIL, 2009) and data informed as percentage.

- Cold test: was performed in germitest paper, with four replications of 100 seeds imbibed in distilled water at a proportion of 2.5 times the

paper weight. Samples were incubated at 10°C for seven days (BARROS et al., 1999) and after this time were maintained in a germination chamber at 25°C. Counts were performed four days after and normal seedlings were evaluated according to The Rules for Seed Analysis (BRASIL, 2009) being data reported as percentage.

- Accelerated ageing: was carried out with four replications of 100 seeds. Seeds were placed on a screen tray, which was inserted into a gerbox chamber containing 40mL of distilled water. Gerbox chamber was incubated at 42ºC for 96h (MARCOS FILHO, 1999); after this time, the germination test was performed according to The Rules for Seed Analysis (BRASIL, 2009) and normal seedlings were evaluated and informed as percentage.

- Electrical conductivity: was performed with four samples of 50 seeds, which were soaked in 75mL of deionized water for 24h at 25ºC, after which the conductance of the soaking water was measured with a dip cell attached to a Digimed conductivity bridge. Conductivity was measured and expressed as $\mu S\ cm^{-1}\ g^{-1}$ (VIEIRA & KRZYZANOWSKI, 1999).

- Statistical analysis: the design was completely randomized with four replicates, the data were submitted to variance and regression analyses at the 5% probability level. Statistical data processing was performed using the Winstat Software (MACHADO & CONCEIÇÃO, 2003).

RESULTS AND DISCUSSION

As there was uneven harvesting periods among the hybrids, due to the speed of maturation process, each one was analyzed as a separate experiment. In relation to the H1 at 40DAF the seed moisture content was practically at 50% and there were any seed with 75% solid endosperm (milk line stage 4) or with black layer developed; this situation remained up to 48DAF where the seed moisture content was at 44% (Table 1).

As to physiological quality is concerned, all four tests (germination, cold test, accelerated ageing and electrical conductivity) showed significant difference and the maximum quality was obtained at 60DAF. In this stage, the percentage of seed with

Table 1 - Moisture content, milk line stage and black layer of three maize hybrids in relation to harvesting periods after flowering.

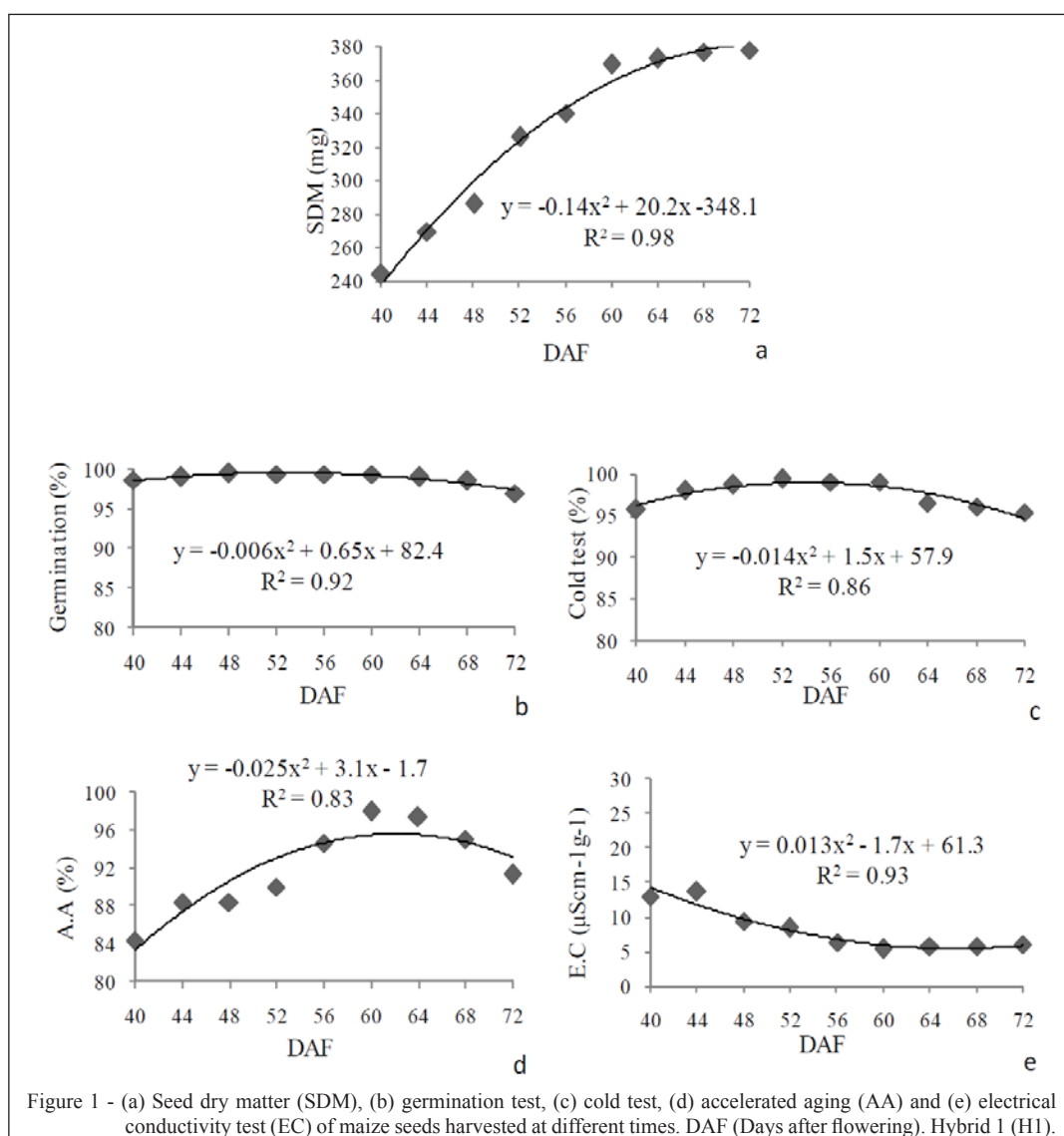| Hybrids	Harvesting periods (Days)*	Seed moisture content at harvest	Milk Line stage 4 (%)**	Black layer
		---%---		
1	40	49	0	0
	44	46	0	0
	48	44	0	0
	52	37	92	2
	56	36	96	13
	60	34	97	26
	64	31	100	65
	68	30	100	78
	72	25	100	99
2	40	43	62	1
	44	39	84	2
	48	34	99	92
	52	31	100	99
3	40	44	2	0
	44	40	4	0
	48	38	50	0
	52	37	78	52
	56	34	97	74
	60	32	98	89
	64	31	100	100

*Days after flowering.
**75% endosperm solidification.

black layer reached 26% and 97% of seeds presented more than 75% with solid endosperm and moisture content was 34% (Table 1).

In relation to seed dry mater, the maximum was obtained at 72DAF with a coefficient of determination of 0.98 (Figure 1); it is important to point out that the maximum seed dry weight was obtained at few days later than the maximum seed physiological quality (Figure 1). These results are in agreement with FARIA et al. (2002) and SANTOS et al. (2005), who found high seeds physiological quality in harvest performed before the physiological maturity point. This can be explained on the basis that there is a non uniformity in maturation among the seeds in a population, were some are still at the filling stage where other are already mature waiting

to be harvested and can deteriorate reducing its physiological quality. Thus, based on the maturation process of a population of seeds, the point of physiological maturity is of a single seed, where the maximum seed dry weight is the same as its physiological quality.

In relation to H2, the seed moisture content of the first harvesting time was at 43% and 12 days after it was lower than 31%, showing a fast seed moisture loss, one percentage points/day; this moisture reduction rate is similar to that observed by FESSEL et al. (2001). In the first harvest of H2, it was observed that 1% of the seeds already presented black layer and 62% of those had more than 75% of the endosperm solid. The back layer remained at 2% four days later, however with eight days after the first harvesting, 92%

Figure 1 - (a) Seed dry matter (SDM), (b) germination test, (c) cold test, (d) accelerated aging (AA) and (e) electrical conductivity test (EC) of maize seeds harvested at different times. DAF (Days after flowering). Hybrid 1 (H1).
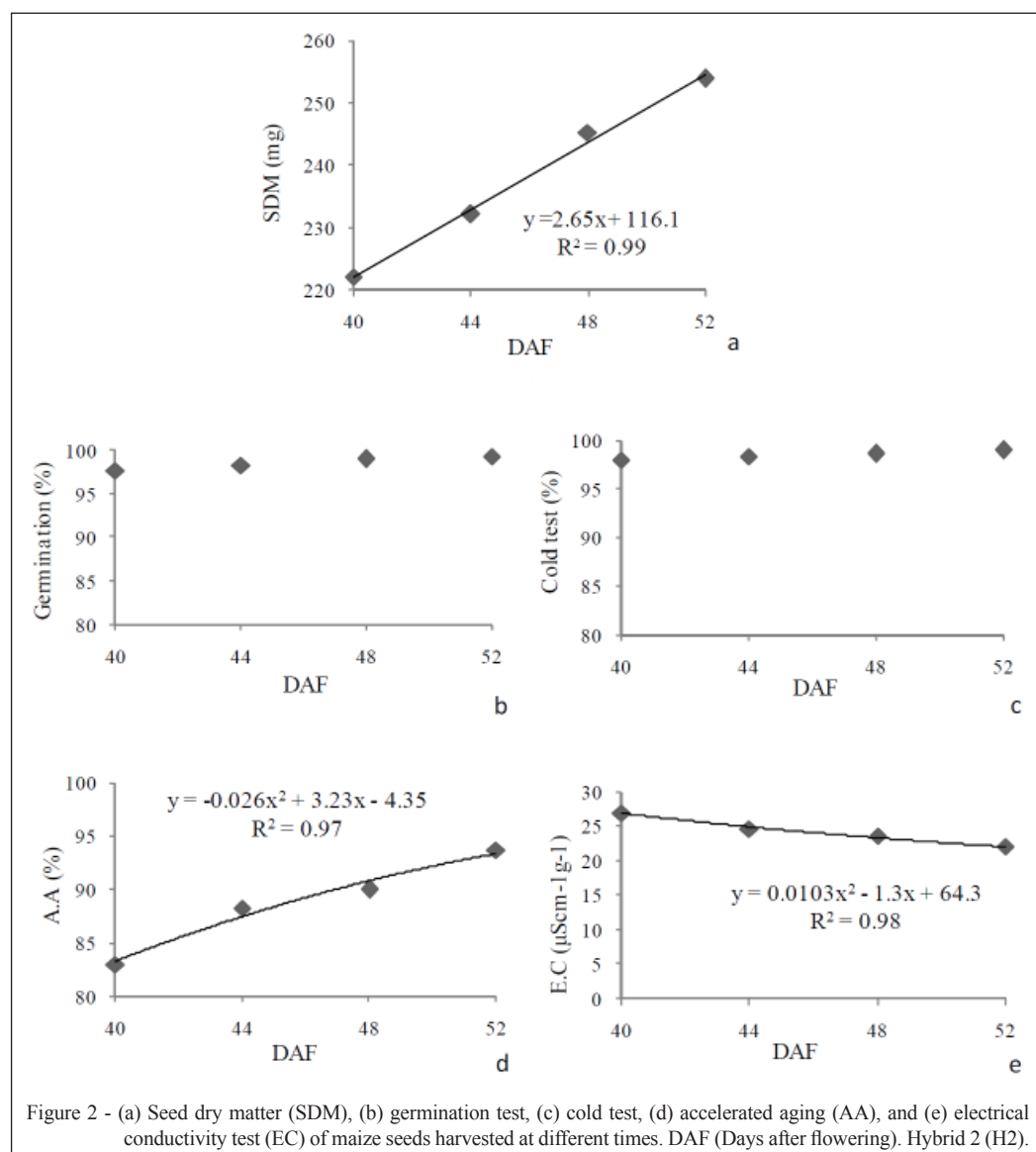
of seeds presented the black layer developed and 99% showed milk line (stage 4) (Table 1).

As to dry weight is concerned, it was observed that there was a tendency to increase as the days after flowering increased up to the last harvesting, what means that seed filling occurred up to the last harvesting or, on other words, there were seeds in the population that did not complete maturation after 52 days after flowering. The seed physiological quality of H2 did not show significant difference for the germination and cold tests, however, the accelerated ageing and electrical conductivity tests showed differences as the harvesting time increased (Figure 2).

In relation to H3 it was observed at 40DAF that the seed moisture content was at 44%

which decreased at a rate of 0.5% per day up to 64DAF, showing a unique characteristic for this hybrid (Table 1). At 48DAF, 50% of the seed were already with more than 75% of their endosperm solidified, while the black layer was not developed yet on any seeds. However at 60DAF, 98% of the seeds presented more than 75% of their endosperm solidified and 89% of the seeds had developed black layer, showing that the majority of the seeds had completed maturation (Table 1).

As seed physiological quality is concerned, the germination and the cold tests did not show statistical difference among the harvesting times, on the other hand accelerating aging and the conductivity tests showed differences, being the maximum

Figure 2 - (a) Seed dry matter (SDM), (b) germination test, (c) cold test, (d) accelerated aging (AA), and (e) electrical conductivity test (EC) of maize seeds harvested at different times. DAF (Days after flowering). Hybrid 2 (H2).
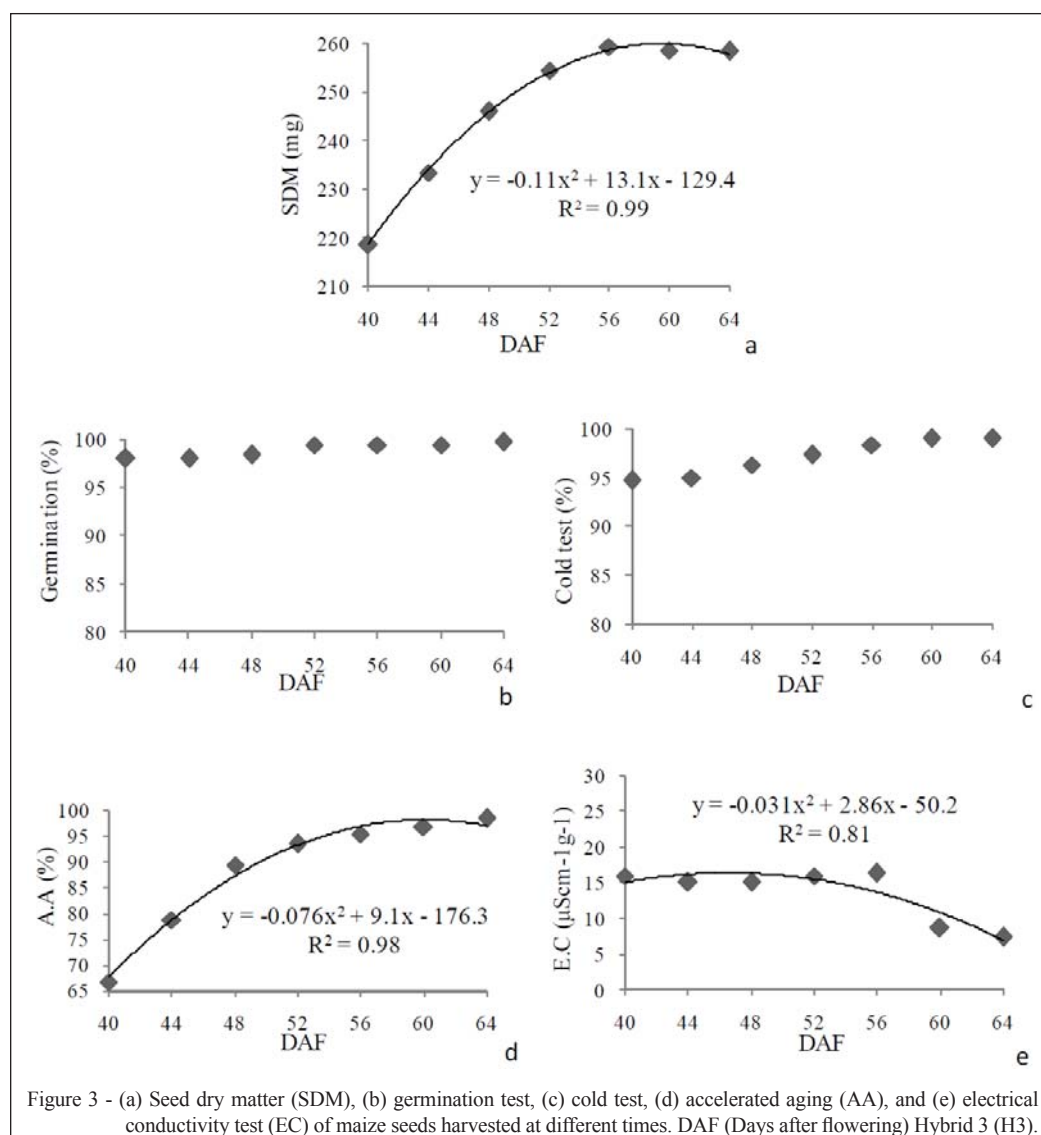
obtained at 60DAF. According to the accelerating aging test, the seed quality presented a sharp increase from 40DAF to 60DAF and then it remained leveled with tendency to decrease at 64DAF (Figure 3).

The best seed harvest time was 60DAF to hybrids 1 and 3, and 52DAF to hybrid 2, showing differences in maturation rate to different genotypes studied, at this time seeds showed moisture content ranging from 31% to 34%. These results are not in accordance to FARIA et al. (2002) that observed moisture content ranging from 35 to 42% as the best. It is important to consider that the maturation heterogeneity among seeds in a population is really high even using procedures to minimize it, as was done in this study by using ears at the same stage of development. At commercial maize seed production,

the heterogeneity will be even higher and as harvesting is done just in on procedure, knowing the maturation characteristics of each material will help to determine the best harvest time.

In relation to parameters used as indicative for the ideal maize seed harvest moment, the best characteristic was the milk line stage 4 (75% endosperm solidification) to all genotypes evaluated, because this parameter avoid seeds exposure to adverse environmental conditions, whereas the harvest point indicated by black layer occurs late and can negatively affects physiological and sanitary quality of seeds. In addiction it was observed that the maximum seed physiological quality is obtained when still a few seeds in the population are not mature and did not accumulate de maximum seeds dry matter.

Figure 3 - (a) Seed dry matter (SDM), (b) germination test, (c) cold test, (d) accelerated aging (AA), and (e) electrical conductivity test (EC) of maize seeds harvested at different times. DAF (Days after flowering) Hybrid 3 (H3).

Maize seeds harvested in milk line stage 3 present high physiological quality indicating that harvest can be performed in this stage according to FARIA et al. (2002), however, results obtained in this work showed that harvest in earlier stages, affected seeds physiological quality which can be confirmed by the accelerated aging and electrical conductivity tests, that showed lower seed quality in the first harvest time in relation to later periods (Figure 1-3). This pattern of variation values in electrical conductivity test during seed maturation process is reported by POWELL (1986), being associated with the development of cellular membranes and their structural organization accompanying physiological maturity.

CONCLUSION

The best indicative to identify the ideal maize seeds harvest moment is milk line stage 4 (75% of solidified endosperm), this stage occurs at different time for each genotype, 60DAF to hybrids 1 and 3, and 52DAF to hybrid 2, due to genetic differences among these hybrids.

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