THE USE OF X-RAYS FOR SEED VIGOR ASSESSMENT OF COTTON

R. R. Otoni[1], M. B. McDonald[2] and D. Tay[3]
[1] Department of Agriculture, University Federal of Lavras, 37200-000, Lavras, MG, Brazil (e-mail ribasotoni@yahoo.com.br)
[2] Department of Horticulture and Crop Science, The Ohio State University, Columbus, Ohio, 43210, USA
[3] Ornamental Plant Germplasm Center, The Ohio State University, Columbus, Ohio, 43210, USA

INTRODUCTION

X-rays have been studied for a long time. In particular, x-ray machines have been very useful in seed assessment, such as for maize (*Zea mays* L.) (Carvalho, 1999), cotton (Ferguson and Turner, 1971), forest tree species (Machado, 2002) since it is a faster and non-destructive method to assess seed quality. By using x-rays, it is possible to evaluate both the internal and external anatomy of the seed and still use the same seeds in other seed quality tests, such as standard germination and vigor tests. Another potential use of x-rays, and the objective of this study, was to classify seeds according to the fill size of embryo in the embryo cavity. Ferguson and Turner (1971) showed a significant difference in emergence and survival of cotton seedlings among half filled (50%), 75% filled and filled cotton seeds. The first objective of this study was to show how useful x-rays can be as a seed quality test, being used alone or in combination with other vigor tests, such as the Seed Vigor Imaging System (SVIS) where human errors are avoided and standardization of seed vigor tests can be achieved. The second objective of this study was to show how important the use of high quality seeds is compared to mechanically damaged seeds.

MATERIALS AND METHODS

Acid delinted cotton seeds were classified into four categories: High, Medium and Low quality seeds based on the size of embryos in the embryo cavities, and Mechanically Damaged seeds based on the presence of any damage on the seed coat (figure 1). A Faxitron MX-20 x-ray machine was used to classify the seeds (figure 1). The seeds were exposed to 20 Kv for 20 sec.; the images captured on the computer and then analyzed for fill of the embryo in the cavity. Each seed was classified into one of four categories. To confirm seed quality differences among these classes, a representative sample of the seeds was submitted to routine vigor tests including accelerated aging, cool test and conductivity test. Standard germination and the OSU Seed Vigor Imaging System (SVIS) were also used.

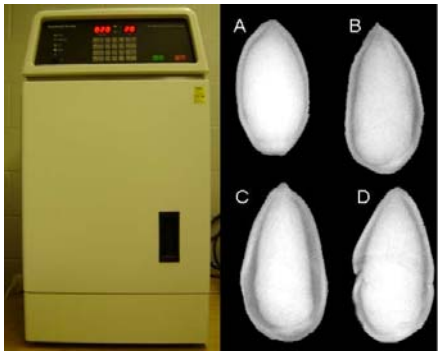

Figure 1. Faxitron MX-20 x-ray machine and x-rays classes, high (A), medium (B), low (C) and mechanically damaged (D).

RESULTS AND DISCUSSION

SVIS (growth, uniformity and overall vigor) results showed a significant difference among the four different x-ray classes (table 1). High quality seeds had higher growth and overall vigor compared to medium quality seeds, which were higher than low and mechanically damaged seeds (table 1). When exposed to accelerated aging (AA), high quality x-ray seeds showed the same trend as SVIS results where superior growth and overall vigor were observed in the high x-ray class compared to the medium, low and mechanically damaged seed classes. But, in this case, mechanically damaged seeds were significantly affected by the AA treatment and showed marked decreases in seedling development (table 1). In a cool stress test, high and medium quality seeds had higher growth, uniformity and overall vigor than low quality and mechanically damaged seeds. Seedlings in a cool stress test were smaller than seedlings exposed to SVIS or AA test conditions, results that were not surprising in light of the 18°C germination temperature. For standard germination, no significant differences were found among high, medium and low quality seeds showing that this seed quality test was unable to differentiate these seed quality classes. In contrast, mechanically damaged seeds had significantly lower germination (table 2). Douglas *et al.* (1967) reported a significant reduction in germination when cotton seeds were mechanically damaged, especially during harvest. However, different results occurred when these seeds were submitted to accelerated aging conditions. High quality seeds had higher performance compared to the other classes, with medium and low quality seeds being superior to mechanically damaged seeds (table 2). Basra *et al.* (2003) showed that accelerated aging had a significant effect on germination when seeds were exposed to stress conditions for more than three days and this reduced seedling growth following only two days of germination. For the cool test, high and medium quality seeds were not significantly different, but they were superior to low quality and mechanically damaged seeds (table 2). These findings confirm that the accelerated aging test can differentiate high quality cotton seeds identified by the x-rays. The same results for standard germination test were found with the conductivity test (table 2). The lower performance of mechanically damaged seeds in these tests can be explained by the damaged seed coat which caused leakage from nutritional reserves. This reduces the potential of the seeds for growth and makes them susceptible to microorganisms that are attracted to these nutrients resulting in secondary infections. These results demonstrate that traditional seed vigor tests provide varying appraisals of the quality of cotton seedlings separated using x-ray analysis (table 2). The standard germination and conductivity tests could only differentiate mechanically damaged seeds. The AA test separated high quality seeds, but failed to distinguish between medium and low quality seeds. In contrast, SVIS results following standard germination and the AA test were able to clearly differentiate the varying x-ray classes (table 1). SVIS was less successful following the cool test and this may be a result of the relatively small seedling size that made significant differences in seedling growth more difficult to detect (table 1). Additional time in test might alleviate this situation.

Table 1. SVIS parameters (growth, uniformity and overall vigor), accelerated aging (AA) and cool test results after 96 h germination of High, Medium, Low and Mechanically Damaged X-Ray classes in cotton seedlings.

X-Ray Classes	SVIS Parameters								
	SVIS			AA			Cool		
	Growth	Unif.	Vigor	Growth	Unif.	Vigor	Growth	Unif.	Vigor
High	744a†	847a	795a	928a	894a	911a	203a	831a	517a
Medium	633b	823a	728b	780b	797b	770b	225a	810a	517a
Low	514c	730b	622c	647c	763b	711b	101c	614b	332c
Mech. Dam.	501c	708b	604c	300d	300c	265c	165b	661b	413b

† Within columns, numbers with different letters are statistically different at $p \leq 0.05\%$.

Table 2. Standard germination (SG), accelerated aging (AA), cool test and conductivity test results of High, Medium, Low and Mechanically Damaged X-Ray classes for cotton seedlings.

Tests	X- Ray Classes			
	High	Medium	Low	Mech. Dam.
	%			
S.G.	81a†	73a	69a	35b
A.A.	85a	65b	60b	12c
Cool Test	82a	79a	64b	54b
	µmhos/cm			
Conductivity	324 a	301 a	321 a	496 b

† Within row, numbers with different letters are statistically different at $p \leq 0.05\%$.

CONCLUSION

These results show that x-ray analysis of cotton seedlings can differentiate seeds into quality classes that influence seedling growth as measured by SVIS. These findings have practical implications in seed grading. Using x-rays, a seed company can non-destructively classify seeds into high, medium and low quality categories. This allows them to apply different prices for the seed grades and ensure that the seeds they are selling to growers are of exceptional quality. Low quality seeds can be discarded thereby improving overall seed lot quality.

REFERENCES

Basra, S.M.A., Ahmad, N., Khan, M.M., Iqbal, N. and Cheema, M.A. (2003). Assessment of cottonseed deterioration during accelerated aging. *Seed Science & Technology*, **31**, 531-540.

Carvalho, M.L.M., Van Aelst, A.C., Van Eck, J.W. and Hoekstra, F.A. (1999). Pre-harvest stress cracks in maize (*Zea mays* L.) kernels as characterized by visual, X-ray and low temperature scanning electron microscopical analysis: Effect on kernel quality. *Seed Science Research*, **9**, 227-236.

Douglas, A.G., Brooks, G.L., and Perry, C.E. (1967). Influence of mechanical harvester damage on cotton seed germination and seedling vigor. Proceedings of the Beltwide Cotton Production Research Conferences, 129-134.

Ferguson, D. and Turner, J.H. (1971). Influence of unfilled cotton seed upon emergence and vigor. *Crop Science*, **11**, 713-715.

Machado, C.F. (2002). Metodologia para a condução do teste de germinação e utilização de raios-X para a avaliação da qualidade de sementes de aroeira-branca (*Lithraea molleoides* (Vell.) Engl.). Piracicaba. 2002. 51f. Dissertação (Mestrado em Fitotecnia). Escola Superior de Agricultura Luiz de Queiroz.