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The Use of Multiple Seed Vigour Tests to Predict Field Emergence and Potential Longevity in Three *Capsicum* Species

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ABSTRACT

Laboratory and field tests were conducted in 2009 and 2010 cropping seasons under rain-fed conditions in which vigour tests were used to rank seed quality and predict field emergence and seed longevity in three *Capsicum* species (*C. chinense*, *C. frutescens* and *C. annuum*). Fresh seeds from mature ripe fruits were extracted from the three species and tested for different seed vigour traits (seedling shoot length, seedling root length, seedling vigour index, and among others). Considerable differences in seed vigour traits among the species were observed. Standard germination provided a more sensitive parameter in ranking seed lot quality than other tests and provided best estimates of field emergence and seed longevity in three *Capsicum* species. Also germination index predicted field emergence in 2009 and 2010 especially in *C. frutescens* than other species. Mean field emergence was generally lower than standard germination in both years and the difference varied between species and sowing time. Seedling vigour index, plant height and plant vigour index had positive and significant correlations with field emergence in both years. *Capsicum chinense* had better seed vigour traits compared to other species.

Keywords: correlation, germination, seed-lots, seed quality, seedling vigour index
Abbreviations: FAO, Food and Agriculture Organization; **ISTA**, International Seed Testing Association

INTRODUCTION

Pepper (*Capsicum* spp.) is one of the most varied and widely used foods in the world. From various colours to the various tastes, peppers are important spices commodity and an integral part of many cuisines. It has been a part of the human diet since about 7500BC and has found wide uses and acceptance all over the world (MacNeish 1964; Gruben *et al*. 2004; Crosby 2008). Many of the early uses of pepper centre on medicinal purposes. Pepper has been credited with many numbers of useful cures and treatments, some of which are valid and some of which are folklore. Globally, pepper production exceeds 14 million metric tons (Kelly and Boyhan 2006). However, there is difficulty in obtaining proper seedling emergence under low temperature conditions (Pandlta *et al*. 2007). Several other problems that have been observed to affect the production and productivity of pepper include insect and disease attacks, low fruit yield, poor quality of fruit and seed, poor germination and seedling vigour. There has been much debate over the years as to how many species of *Capsicum* truly existed. The number fluctuated over the centuries from 1 to 9 (Kelly and Boyhan 2006). Pepper seeds do not germinate well unless the germination medium is well aerated and drained.

Seed quality can be defined as a collection of seed properties, which are considered to be of importance for the value of seed for sowing purpose (FAO 1999). In practice, the expression seed quality is used loosely to reflect the overall value of seed for its intended purpose (Copeland and McDonald 1995). Seed quality is a multiple concept comprising several components. The components are not of equal value nor are their relative importance the same in all circumstances (FAO 1999). Thompson (1979) and FAO (1999) suggested that these properties included analytical purity, species purity, freedom from weeds, variety purity, germination capacity, vigour, size, uniformity, health and moisture content.

Seed vigour is not a single measurable property like germination but a concept describing seed performance associated characteristics (Anonymous 1981). This encompasses potential seed performance both in the field and in storage (Hampton and Coolbear 1990). ISTA (1993) defined seed vigour as "the sum total of those properties of the seed which determines the level of activity and performance of the seed or seed lot during germination and seed emergence" (Hampton and TeKrony 1995). Woodstock (1969) also defined vigour as 'that condition of active good health and natural robustness in seeds which, upon planting permits germination to proceed rapidly under a wide range of experimental conditions.

The objective of standard germination test is to estimate the germination potential of a seed lot, which can then in turn be used to compare the value of field planting (ISTA 1999). The methodology of standard germination has been refined to high level of reproducibility and reliability; however, standard germination does not always indicate seed lot potential performances, especially if field conditions are less than optimal (Hampton and Tekrony 1995). Seed lots that do not differ in germination may differ in deterioration level (Delouche and Caldwell 1960) and may differ substantially in field or storage performance (Perry 1980; Naylor 1981; Powell and Matthews 1984; Kolasinka *et al*. 2000). Seed vigour tests therefore have been proposed to detect differences in potential seed lot performances.

From available literature, little information is available on the use of seed vigour tests to rank seed lot quality and predict field emergence and seed longevity in these three species of *Capsicum* grown in Nigeria. The result of this study would therefore help to determine seed lot quality and field emergence using seed vigour test in the various *Capsicum* species. Germination potential of seed lot can be used to compare the quality of different lots and to estimate the value of field planting.

The objectives of this study were; (i) to investigate the

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suitability of various laboratory vigour tests for their ability to rank quality of three *Capsicum* species; (ii) to predict seedling emergence and potential seed longevity in each of the *Capsicum* species under humid tropical field soil conditions and (iii) to determine the potential seed longevity in each of the three *Capsicum* species using methanol ageing test.

MATERIALS AND METHODS

Three *Capsicum* species (*C. frutescens*, *C. annuum* and *C. chinense*) were utilized for the trial. Seed samples were provided by National Horticultural Research Institute (NIHORT) Ibadan. Mature ripe fruits of each of the three *Capsicum* species were extracted manually and dried under ambient laboratory conditions. Laboratory and field tests were conducted in 2009 and 2010 at the Teaching Farms and Seed Laboratory of the Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta (UNAAB) Ogun State, Nigeria (Lat. 7° 37′ N and Long. 3° 89′ E). All seed samples were kept at 18°C before and during trials. Land was properly prepared and the field plot was laid in randomized complete block design. Four replicates of 100 seeds were sown by hand at a depth of 0.5–1 cm with spacing of about 1cm within row and 40 cm between rows. Emergence count started when the first seedling was visible and continued at 2-day intervals until no further seedling emerged (ISTA 1995). The plots were irrigated daily in the morning.

Standard Germination - The Petri dish method was used following ISTA (1995) procedure. Four replicates of hundred seeds from each lot were planted in moistened filter paper placed in the Petri dish and incubated at 25°C in the laboratory. Germination counts of normal seedlings started at the fifth day after sowing and continued at 2-day intervals till 14 days after planting (DAS). The number of normal seedlings was expressed in percentage.

Laboratory and field data collection

Seeds sown were assessed for the following seed quality parameters. Parameters i –vi were assessed in the laboratory while vi – viii were assessed in the field.

i. Standard germination =

$$\frac{\text{No. of germinated seeds at } 14^{th} \text{ day after sowing (DAS)}}{\text{No. of seeds sown}} \times \frac{100}{1}$$

ii. Germination index (ISTA 1985; Marli and Santana 2006)

$= GI = \sum (Gt/Tt)$

where Gt = germination percentage at 14^{th} day; Tt = day of germination test

iii. Seedling shoot length: shoot length of five seedlings was measured in cm on the 14^{th} day (Adebisi *et al*. 2003).

iv. Seedling root length: root length of five seedlings were measured in cm on the 14^{th} day.

v. Seedling vigour index (Kim *et al*. 1994) = % germination × plumule length.

vi. Field emergence (FAO 1999) =

$$\frac{\text{Seedling emerged at 14 DAS}}{\text{No. of seeds sown}} \times \frac{100}{1}$$

vii. Plant height (Adebisi *et al*. 2006): Plant height of five seedlings were measured in cm at 14 DAS.

viii. Plant vigour index (Adebisi *et al*. 2006) =

$$\frac{\text{Field emergence} \times \text{plant height}}{100}$$

Seed longevity – This was determined using methanol stress test of Tiwari and Hariprasad (1997) and Adebisi (2004). Three replications of 100 seeds per variety were used in which the seeds were first placed in a moist chamber at room temperature for two days. They were then soaked in 20% aqueous solution of methanol (i.e. 20% methanol to 80% of distilled water) for 2 h followed by soaking in distilled water for five minutes. The seeds were kept in Petri dishes for germination at 25°C and a germination count was taken after seven days to 14 days. This method yields more rapid result and hence is recommended in preference to ageing the seeds under ambient conditions (Tiwari and Hariprasad 1997).

Data analysis

All data collected were subjected to analysis of variance (ANOVA) and means were separated using Tukey's HSD at $P = 0.05$. Arcsine transformation was applied to values in percentages before analysis. Simple correlation coefficients were calculated to evaluate the associations between laboratory tests and field emergence as well as seed longevity for each species.

RESULTS

The result (**Table 1**) shows the mean values of seed vigour traits evaluated in three *Capsicum* species in 2009 and 2010. From the result, the ranking shows that *C. frutescens* gave the highest standard germination in 2009 and 2010 (80 and 83%, respectively) compared to two other species except *C. annuum* in 2010 with the value of 80%.

GI was highest in *C. frutescens* and *C. annuum* in 2010 compared to other species while the lowest germination index was recorded in *C. chinense* and *C. annuum* in 2009. Longest root length was recorded in *C. frutescens* and *C. annuum* in 2010 compared to other varieties while the shortest root length was obtained with *C. frutescens* in 2009 (0.70). Seedling vigour was highest in *C. frutescens* and *C. chinense* in 2010 while others were similar in vigour ranking. *Capsicum frutescens* recorded best field emergence in 2009 and 2010 as well as *C. annuum* (76.75%) in 2010.

Similar trend were observed in the three *Capsicum* species for the plant height and plant vigour index as *C. frutescens* in 2010 recorded highest value as well as *C. annuum* in both years while the poorest values were recorded in *C. chinense* in 2010.

Results in **Table 2** show correlation coefficients (r) between laboratory vigour traits and field emergence of seed lots of three *Capsicum* species tested in 2009 and 2010. For *C. frutescens* species, standard germination, germination index and seedling vigour showed a significant positive correlation with field emergence in both years. Also root length significantly correlated with field emergence in 2010 but not in 2009. On the other hand, plant height and plant vigour index significantly correlated with field emergence positively in 2009 but not in 2010. The other laboratory tests had no positive or significant correlation with field emergence in either year. With respect to *C. chinense*, only standard germination recorded a high and significant positive correlation with field emergence in both years. For *C. annuum* species only standard germination recorded a highly significant positive correlation with field emergence in both years while shoot length had negative and significant correlation with field emergence in 2009. Similarly plant vigour index and plant height also recorded a significant positive correlation with field emergence in 2010. Seedling vigour was also observed to be significantly correlated with field emergence in both years. The other laboratory tests were not correlated with the field emergence in either year. However, germination index significantly correlated negatively with field emergence in 2010 only.

Table 3 shows correlation coefficients (r) between laboratory vigour traits and seed longevity test of seed lots for three *Capsicum* species tested in 2009 and 2010. For *C. frutescens* none of the vigour traits correlated significantly with seed longevity in both years, while only seedling vigour significantly correlated (positively) with seed lon-

Table 1 Mean value of seed quality traits evaluated in three *Capsicum* species in 2009 and 2010.

Species	Year	Standard germination (%)	Germination index	Shoot length (cm)	Root length (cm)	Seedling vigour index	Field emergence (%)	Plant height (cm)	Plant vigour index
C. frutescens	1	80 a	4.38 b	1.925 b	0.700 c	36.78 b	73.50 a	0.525 b	0.387 b
	2	83 a	11.85 a	2.600 a	3.275 a	58.50 a	78.50 a	0.875 a	0.686 a
C. chinense	1	66 b	1.88 c	1.350 b	1.150 b	38.35 b	60.75 b	0.650 b	0.395 b
	2	64 b	4.65 b	1.850 b	1.650 b	36.50 c	61.00 b	0.400 b	0.244 c
C. annuum	1	54 c	2.05 c	1.525 b	1.075 b	44.38 b	49.50 c	1.050 a	0.520 a
	2	80 a	11.40 a	2.975 a	3.100 a	54.03 a	76.75 a	0.875 a	0.671 a
S. E.		5	0.61	0.357	0.387	4.396	5.234	0.138	0.088

Means followed by the same letter are not significantly different along the column
S.E.: Standard error

Table 2 Correlation coefficient (r) between laboratory vigour traits and field emergence test of seed lots of the three *Capsicum* species evaluated in 2009 and 2010.

Seed quality traits	*C. frutescens*		*C. chinense*		*C. annuum*	
	2009	2010	2009	2010	2009	2010
Standard Germination	0.948*	0.983*	0.99**	0.99**	0.914**	0.948**
Germination index	0.949*	0.983*	0.524	-0.231	-0.56 ns	-0.499 ns
Shoot length	-0.536 ns	0.146 ns	0.636	-0.639	-0.890*	-0.536 ns
Root length	-0.774	0.939*	0.478	0.77	0.028 ns	-0.774 ns
Seedling vigour	0.853*	0.824*	0.733	-0.179	-0.093*	-0.853*
Plant Height	0.809*	-0.618 ns	0.632	0.195	0.697 ns	0.809*
Plant vigour index	0.861*	-0.574 ns	0.491	0.797	-0.486 ns	0.861*

Significant at * $P \leq 0.05$ or ** at $P \leq 0.01$

Table 3 Correlation coefficient (r) between laboratory vigour traits and seed longevity test of seed lots of the three capsicum species evaluated in 2009 and 2010.

Seed quality traits	*C. frutescens*		*C. chinense*		*C. annuum*	
	2009	2010	2009	2010	2009	2010
Standard Germination	0.302 ns	0.538 ns	-0.49 ns	0.158 ns	0.993**	-0.707 ns
Germination index	0.313 ns	0.538 ns	0.759 ns	0.457 ns	0.413 ns	-0.707 ns
Shoot length	0.07 ns	0.078 ns	0.686 ns	0.656 ns	-0.090 ns	-0.090 ns
Root length	0.524 ns	0.211 ns	-0.657	-0.299 ns	-0.100 ns	0.001 ns
Seedling vigour	0.478 ns	0.266 ns	0.472 ns	0.884*	0.100 ns	-0.77 ns
Plant Height	0.509 ns	-0.239 ns	-0.450 ns	-0.061 ns	-0.857*	0.358 ns
Plant vigour index	0.432 ns	-0.312 ns	-0.253 ns	-0.036 ns	-0.685 ns	0.001 ns

Significant at * $P \leq 0.05$ or ** at $P \leq 0.01$

gevity in *C. chinense* in 2010. In *C. annuum*, only standard germination was highly significantly and positively correlated with seed longevity in 2009. Plant height recorded a significant negative correlation with seed longevity in 2009 but not in 2010.

DISCUSSION

Most pepper seeds are small and some species have dormancy. They are generally difficult to germinate under adverse field conditions (Wang *et al*. 2001). The result of the ANOVA indicated that seed vigour traits evaluated significantly varied with the three pepper species as well as the year of evaluation. This provides opportunity to select species with the best seed vigour traits, similar findings were observed by Omotosho (2009) in three species of pepper.

There were considerable differences in seed vigour traits among the species probably due to differences in their genetic make-up. Also, there were variations in seed vigour traits in each of the species between the two years evaluated.

Field experiments conducted both in 2009 and 2010 under humid tropical conditions showed that field emergence varied and was substantially lower than standard germination. This was confirmed in both *C. annum* and *C. frutescens* species. Standard germination provided a more sensitive parameter in ranking seed lot quality than other tests as it showed a higher correlation with filed emergence than did seed longevity tests. In respect to seed vigour ranking among the three species in the two years of observation, *C. frutescens* was identified with the highest seed vigour trait (seed germination and field emergence) while other species recorded variable seed vigour traits under the two years of observation. The highest seedling vigour was obtained with *C. frutescens* and *C. chinense* in 2010 while others were similar in vigour ranking. The highest field emergence was obtained with *C. frutescens* in 2009 and 2010 as well as *C. annum* (76-75%) in 2010.

Also germination index is another sensitive parameter in ranking seed lot quality than other tests as it shows significant positive correlation with field emergence especially in *C. frutescens* species as it better predicted field emergence for both years than all other tests apart from standard germination.

Since standard germination had positive and significant correlation with field emergence in the three pepper species (*C. frutescens*, *C. chinense* and *C. annuum*). This implies that standard germination can be taken as a reliable predictor of field emergence in three *Capsicum* species.

From this study, it can be concluded that standard germination, field emergence and seed longevity have the potential to be developed as improved vigour tests for ranking seed lot quality and predicting field emergence in three *Capsicum* species.

CONCLUSION

Significant differences were recorded among the three species of *Capsicum* in terms of standard germination and field emergence. On the other hand most of the tests did not show significant difference with seed longevity. Standard germination is an important predictor of field emergence and seed longevity in *Capsicum* species. Standard germination, seedling vigour, plant height, plant vigour index, plant height had positive and significant correlation with field emergence. Standard germination, seedling vigour index, shoot length and plant height had significant positive cor-

relation with seed longevity in *Capsicum* species. Seed longevity test has the potential to be developed as vigour test for ranking seed lot quality and predicting seed performance. Seed longevity test yields more rapid result and hence, is recommended in preference to ageing the seed under ambient conditions. *C. frutescens* had better seed vigour traits compared to other species. It is therefore recommended that standard germination should *Capsicum* be taken as a reliable predictor of field emergence and seed longevity in species. Seed vigour test is an important test that can be used to rank seed lot quality and predict field emergence and seed longevity in *Capsicum* species.

REFERENCES

Adebisi MA (2004) Variation, stability and correlation studies in seed quality and yield character of sesame. Unpublished PhD thesis, University of Agriculture, Abeokuta

Adebisi MA, Ajala MO, Rasaki NO (2003) Comparison of laboratory seed vigour tests with field performance in sesame (*Sesamum indicum* L.). *Journal of Tropical Forest Resources* **19 (3)**, 21-33

Adebisi MA, Ajala MO, Daniel IO, Fasan KO (2006) Pre-sowing treatment for improved seed quality in West African rice varieties. *Nigerian Agricultural Journal* **37**, 159-167

Anonymous (1981) Perry DA (Ed) *Handbook of Vigour Test Methods*, International seed Testing Association, Zurich, Switzerland, 72 pp

Copeland LO, McDonald MB (1995) *Seed Science Technology* (3rd Edn), Chapman and Hall

Crosby MR (2008) Pepper. Microsoft® Encarta® 2009 [DVD], Redmond, WA: Microsoft Corporation, 2008. ©1993-2008 Microsoft Corp.

Delouch JC, Caldwell WP (1960) Seed vigour and vigour tests. *Proceedings of the Association of Official Seed Analysts* **50**, 124-129

FAO (1999) *Manual for Training in Seed Production*, Trivedi RK, Usman IA, Umeh JC (Eds), United Nations FAO, 116 pp

Grubben GJH, Tahir IM (2004) *Capsicum* species. In: Grubben GJH, Denton OA (Eds) *Plant Resources of Tropical Africa 2. Vegetables*, PROTA Foundation, Wageningen, Netherlands/Backhugsi, pp 154-163

Hampton JG, Coolbear P (1990) Potential versus actual field performance – can vigour test provide an answer? *Seed Science and Technology* **18**, 215-225

Hampton JG, TeKrony DM (1995) *Handbook for Vigour Test Method* (3rd Edn), International Seed Testing Association, Zurich, 117 pp

ISTA (1985) International rules for seed testing. *Seed Science and Technology* **13**, 307-513

ISTA (1993) International rules for seed testing. *Seed Science and Technology* **21 (Suppl)**, 288 pp

ISTA (1996) International rules for seed testing. *Seed Science and Technology* **24 (Suppl.)**, 355 pp

ISTA (1999) International rules for seed testing. *Seed Science and Technology* **27 (Suppl.)**, 27-32

Kelly WT, Boyhan G (2006) *Commercial Pepper Production Handbook*, Oxford University Press, Oxford

Kim SH, Choe ZR, Kang JH, Copeland LO, Elias SG (1994) Multiple seed vigour indices to predict field emergence and performance of barley. *Seed Science and Technology* **22**, 29-38

Kolasinka K, Szymer J, Dul S (2000) Relationship between laboratory seed quality tests and field emergence of common bean seed. *Crop Science* **40**, 470-475

MacNeish RS (1964) Ancient Mesoamerican civilisation. *Science* **143**, 531-537

Marli AR, Santana DG (2006) How and why to measure the germination process? *Revista Brasileira de Botanica* **29 (1)**, 1-11

Naylor EE (1981) An evaluation of various germination indices for predicting differences in seed vigour in Italian ryegrass. *Seed Science and Technology* **9**, 593-600

Omotosho AA (2009) Effect of seed weight and sun drying on seedling emergence and seedling vigour of *Capsicum* species. Project Report, Department of Plant Breeding and Seed Technology, University of Agriculture, Abeokuta, 39 pp

Pandlta VK, Anand A, Nagarajan S (2007) Enhancement of seed germination in hot pepper following pre-sowing treatments. *Seed Science and Technology* **35**, 282-290

Perry DA (1980) Seed vigour and field establishment. *Advances in Research Technology in Seeds* **2**, 25-40

Powell AA, Mathews S (1984) Prediction of storage potential of onion seeds under commercial storage conditions. *Seed Science and Technology* **12**, 641-647

Thompson JR (1979) *An Introduction to Seed Technology*, John Wiley and Sons, New York, 256 pp

Tiwari SP, Hariprasad AS (1997) Selection criteria for seed longevity in soybean (*Glycine max* (L) Merr). *Tropical Agriculture (Trinidad)* **74 (1)**, 70-74

Wang YR, Liu YL, Sheng YX (2001) An evaluation of seed vigour tests for forage species. *Acta Prataculturae Sinica* **10 (1)**, 48-57

Woodstock LW (1969) Seedling growth as a measure of seed vigour. *Proceedings of the ISTA* **34 (2)**, 273-280