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IMPROVEMENT OF TOMATO SEED LONGEVITY USING SOME DRY SEED PRE-STORAGE TREATMENTS

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ABSTRACT

Pre-storage treatment to retard seed deterioration could either involve application of synthetic chemicals or plant/organic products. This study was conducted to determine the efficacy of some organic dry seed treatments and inorganic chemical treatments on the viability of stored seeds of four tomato (*Solanum lycopersicum*) varieties. The study was a factorial experiment fixed in completely randomized design. It comprised of four tomato varieties (Roma, UC-82, 2-lobes and 3-lobes) and five dry seed treatment materials (neem leaves, scent leaves, red chili, bleaching and Apron plus powders) in three replicates. Seeds stored without any treatment were used as the control. The tomato seeds were stored for 240 days under ambient condition (average temperature 30ºC and 75% relative humidity). Half-life of the stored seeds ranged from 286 to 2105 days. Generally, organic treatment doubled the longevity when compared to the control treatment. Performance of seed treatments depended on tomato seed variety. Use of *neem leaf* and *scent leaf* powders had greater potentials to replace the commercial inorganic seed treatment materials for tomato seed preservation under the same environmental conditions.

Keywords: Seed treatment, Probit model, Seed deterioration, seed longevity, *Solanum lycopersicum*.

INTRODUCTION

Major avenues of seed deterioration during storage include microbial infection and insect infestation (Schmidt, 2000). Inevitably during storage, seeds also undergo physiological changes associated with ageing that include loss of food reserves caused by respiration, accumulation of toxic or growth-inhibiting by-products of respiration, and loss of activity of enzyme systems that occur irreversibly (Gregg *et al.,* 1994). These lead to some physical damages and concomitant economic and viability losses. Most of the damages are related to oxidation of proteins, membranes, DNA, mRNA and lipids (Groot, 2014). Scientific evidences are available in literature showing that loss of viability of seeds is directly proportional to reduction of antioxidant capacity of the seed cells (Chen *et al*., 2013). Therefore, seed pre-storage treatment would either prevent microbial infection, insect infestation or augment the depleting antioxidant capacity of stored seeds or their combined effects. For practical purposes, a systematic screening of available of pre-treatment methods for efficacy and cost-effectiveness is therefore required.

Pre-storage seed treatment to retard deterioration could either involve application of synthetic (inorganic) chemicals or plant (organic) products (Pal and Basu, 1995 and Oyekale *et al.* 2012). The treatments may involve soaking of seeds in liquids (aqueous or non-aqueous) followed by drying off the liquid or dressing the seeds with dry materials. Organic products applied as powder have been reported with different levels of preservative efficacies. Prominent among them are neem leaf, moringa leaf, scent leaf, dried red chilli pepper fruit, garlic fruit, ginger and black pepper fruit powders. Pal and Basu (1995) recorded high germination and seedling vigour of wheat seeds when treated with neem leaf powder at 2g per kg after 7 months of storage under ambient condition while sesame retained more than 80% of seed quality parameters when stored for 18 weeks after treatment with neem leaf and chilli pepper powders (Oyekale *et al.,* 2012) Many of these forms of organic treatments have been reported by the authors to reduce storage pest infestation, fungal and bacterial deterioration effects on stored seeds.

Adebisi *et al.* (2017) studied effects of synthetic chemical, neem leaf and chilli powders on the viability and vigour of sesame seeds and reported that treatment with neem leaf and chilli powders performed better in retaining viability and vigour of the seeds than the synthetic chemical. Kehinde *et al.* (2020) reported use of neem leaf and clove basil leaf powder much better for maintaining germinability and seedling vigour than inorganic material. It has also been confirmed that deterioration occurs at variable speed and intensity depending on initial physiological quality of seed (viability and vigour among others), post-harvest treatment and genetic make-up of the genotypes (Adebisi and Oyekale, 2005; Adebisi *et al.*, 2008).

Access to high quality tomato seeds is one of the major constraints in tomato production in Nigeria (Abdul *et al.*, 2020) like in some other African countries (Karuku *et al.*, 2017). Most farmers rely on self-persevered tomato seeds from previous harvests (Iwuchukwu *et al.*, 2017). Farmers use several traditional approaches to preserve and store their seeds. Many of these are sometimes not effective probably due to absolute reliance on their experience of seed dressing and storage. This underscores the need for farmers to have adequate knowledge and skills of low cost and simple seed preservation techniques.

Tomato *(Solanum lycopersicum)* seeds quality has been linked to a number of factors such as genetic make-up (Kazmi *et al.*, 2017) and fruit maturity (Demir and Samit, 2001; Dias *et al.*, 2006) Like any other seed, tomato seed viability is liable to decrease during storage. Several strategies have been deployed to increase seed longevity during storage. These include harvesting of fruit at the physiological maturity time, keeping of prepared seed under proper storage conditions (temperature, relative humidity), packaging and seed pre-treatment to slow down deterioration even in the most appropriate storage conditions. However, studies on pragmatic approaches to preserve tomato seed quality over storage life are very limited. Due to increasing interest in reducing use of synthetic chemicals in agriculture, several studies have been conducted to determine the potentials of replacing inorganic or synthetic chemicals with cheaper, more eco-friendly and safer organic alternatives.

This study was therefore conceived to compare the effects of three organic materials (neem leaf, scent leaf and red chilli fruit powders) with two commercial pre-treatment chemicals (apron plus and bleaching powders) on the viability of four varieties of tomato seeds stored under ambient conditions.

MATERIALS AND METHODS

Fresh mature fruits of four tomato varieties were sourced from National Institute of Horticultural Research and Training (NIHORT), Ibadan, Nigeria. These varieties were UC-82, Roma, two JM series-(2-lobes and 3-lobes) which are commonly grown in Nigeria and are found to be high yielding. The seeds were scooped out of the fruits with knife, gently washed in running water and thereafter dried for two weeks under ambient conditions (temperature 30±3ºC and RH 74±5%) to reduce the moisture content to the minimum (7%). Basal quality test (moisture content and germination percentage) was determined according to FAO (2006).

Well dried and clean tomato seeds were treated with three organic and two inorganic powders and a control (no treatment) in the Laboratory of Plant Breeding and Seed Technology, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The neem leaf (*Azadirachta indica*) and scent leaf (*Ocimum grafissimum*) powders were applied at a dosage of 10 g/100 g of seeds while red chili (*Capsicum frutescens*) fruit powder was applied at dosage of 10 g/kg of seeds. Apron plus and bleaching powders were applied at dosages of 5 g/kg and 2 g/kg of seed, respectively**.** The study was a factorial experiment in completely randomized design comprising of four tomato varieties (Roma, UC-82, 2-lobes and 3-lobes) and five dry seed treatment materials (neem leaves, scent leaves, red chili, bleaching and Apron plus powders) with a control in three replications.

Five hundred grams of seeds from each variety were placed into plastic bottle (1.5 L) and respective doses of each treatment were added and agitated thoroughly for 3 minutes per day for 2 days. Hundred grams of the treated seeds of each variety were placed inside a well labelled plastic container (0.5 L) and then tightly covered with lids. Packaged treated seed lots of each variety replicated thrice were kept in seed store at the Seed Processing and Storage Unit, FUNAAB under ambient conditions (average temperature 30ºC and 75% relative humidity) for a period of 240 days (8 months). Fifty treated seeds were taken from each plastic container for germination percentage at 60 days interval for a period of 240 days. The viability of the stored seeds was determined as germination percent (GP) as follows:

GP (%) = 100 × Total number of germinated seed/Total number of planted seed (1)

The germination ratio (GR) was calculated as the germination percent (G_t) observed after a period of storage divided by the original germination percent (G_o)

$$GR = G_t/G_o \quad (2)$$

GP values were first transformed to their probit equivalents. The probit data was fitted to the linear probit equation according to Ellis and Roberts (1980):

$$v = Ki - p/\sigma \quad (3)$$

v is the seed viability (in probits) was plotted against p (days in storage). Ki is the linear intercept (a measure of the initial seed viability (in probits). The slope of the regression line ($1/\sigma$) was then derived as the rate of deterioration (per day) while σ is the time for viability to fall by 1 probit. Half-life or time elapsed for viability to decline by 50 % ($p50$) was then calculated using the equation (Nagel and Borner, 2010):

$$p50 = Ki \times \sigma \tag{4}$$

Pearson's correlations, linear and non-linear regression modelling of the experimental data were done using analysis of variance at $p<0.05$.

RESULTS AND DISCUSSION

Germination pattern

Since the initial germination percent (GP) was not uniform, the effect of each treatment was shown by calculating germination ratio (GR) as the ratio of GP at each period (G_t) to that of the original GP (G_o). This is capable of showing the effect of seed treatment on seed quality as storage progressed. Changes in the tomato seed GR over the storage period (Figure 1) was sigmoid. For all the tomato varieties and pre-treatment, the original GP got reduced by 20% after 80 days. Thereafter, there were rapid losses of GR. Regardless of treatment, Roma showed the greatest retention of original GP value as it showed 20% loss of GP only after about 120 days of storage. The most rapid loss of GP was observed in the control tomato seeds. Generally, higher GP retentions were observed in organically-treated stored seeds of 3-lobes varieties after 240 days (Figure 1). The sigmoidal shape of the curves is characteristic of most stored seeds reported (Demir *et al.* 2016, Hay and Whitehouse 2017, Ozden, *et al.* 2017,)

Seed Deterioration Rate

The deterioration rate ranged between 0.0024 and 0.0217% per day across all pre-treatments and seed (Fig 2). All the treatments showed ability to delay the rate of seed deterioration relative to the control across the four tomato varieties except for 2-lobes where the rate of loss was higher in all the treated seeds than the control. The varietal influence ($p=0.145$) explained the variability in seed deterioration better than treatment ($p=0.945$).

Dry seed treatment can exert their preservative effects on stored seeds from either antioxidative or antimicrobial mechanisms. If seeds are taken as porous materials, it could be assumed that exertion of antioxidative effect of solid dressing materials is through release of volatile substances that permeate the storage container space and gradual diffusion into the seed over the storage period. Studies to confirm this mechanism are scarce in literature. Most reported studies that confirm effectiveness of solid dressing material is increasing the longevity of stored seeds were observatory. Sousa Neto *et al.* (2019) studied the volatile components of neem leaf. The authors reported γ-Elemene (24.06%), 3,7 (11)-eudesmadiene (6.83%), caryophyllene (6.40%), and 10s,11s-himachala-3(12),4-diene (6.36%) as the major volatile constituents. There are evidences that volatiles (mainly eugenol) from *O. gratissimum* have strong antioxidant activity (Trevisan *et al.*, 2006).

Seed Longevity

Tomato seed deterioration pattern closely followed a zero order (Fig 2). Therefore, it is plausible to determine the total storage life of the seeds as twice the half-life of the seeds. This amounts to 7.3 to 54.0 months at the atmospheric storage conditions. Similar longevity (24-35 months) was reported by Ariyarathna *et al.* (2020) for some tomato seed varieties. The half-life (P_{50}) values of stored seeds have been used as index of longevity in many of the past studies on seed storage life (Whitehouse *et al.*, 2019). P_{50} values obtained ranged from 286 to 2105 days. It appears that the performance of the seed treatment was variety specific. *O. gratissimum* showed better performance than *A. indica* and *C. frutescens* organic treatment for Roma and UC-82 whereas *A. indica* performed better than *O. gratissimum* and *C. frutescens* treatment for 2-lobes and 3-lobes. *O. gratissimum* performed better than Apron plus for preserving Roma seeds. This observation could be due to greater antimicrobial and antioxidative potency of the former.

Regardless of seed treatment, 3-lobes showed the highest longevity values while UC-82 had the least. Also, for Roma and 3-lobes, the organic seed treatments resulted in higher longevity, whereas inorganic treatment of UC-82 and 2-lobes resulted in higher longevity than the organic treatment. Among the organic treatments, *A. indica* and *C. frutescens* showed the highest and the least protective effect on the stored seeds by giving average longevity values of 961 and 782 days, respectively, regardless of seed variety. Effectiveness of organic seed treatment materials as preservatives has been hinged on the relative abundance of the active compounds capable of trapping free radicals as antioxidants, antioxidant-synergist and radio protective agents (Adebisi *et al.*,2008). Sahrawat *et al.* (2018) reported that acetone extract of *A. indica* showed the highest antimicrobial potency.

In this study, the organic materials were chosen based on previous reports of their inherent effectiveness in melting down free radical reactions as antioxidants, antioxidant-synergist and radio protective agents (Mandal and Basu 1986, Mandal *et al.,* 2003; Adebisi, 2008). Capsicin derived from *Capsicum frutescens* is a known inhibitor of lipids peroxidation (Mandal *et al.*,2003).

Correlations between seed quality parameters

There was a siginifcant relation between the initial quality of the seeds exemplified by the probit intercept and their rate of deterioration exemplified by the probit slope (Fig. 3). The signifcant correlation between the two parameters imply that the initial seed quality could have had some influence on the rate of deterioration. However, the low correlation coefficient implies that the half life of the seeds might also depend on other factors such as the genetic versus storage environment interactions. The rate of deterioration has been reported to be dependent of several factors including the type of crop (Nagel and Borner, 2010), storage conditions such as relative humdity and temperature (Pradhan and Badola, 2012), biological factors (spoilage organisms like fungi), and pretreatment. Seeds of tomatoes as obeserved in this study have longer half-life than those of maize stored under similar storage conditions (Fig. 4) as reported by Daniel (2007) .

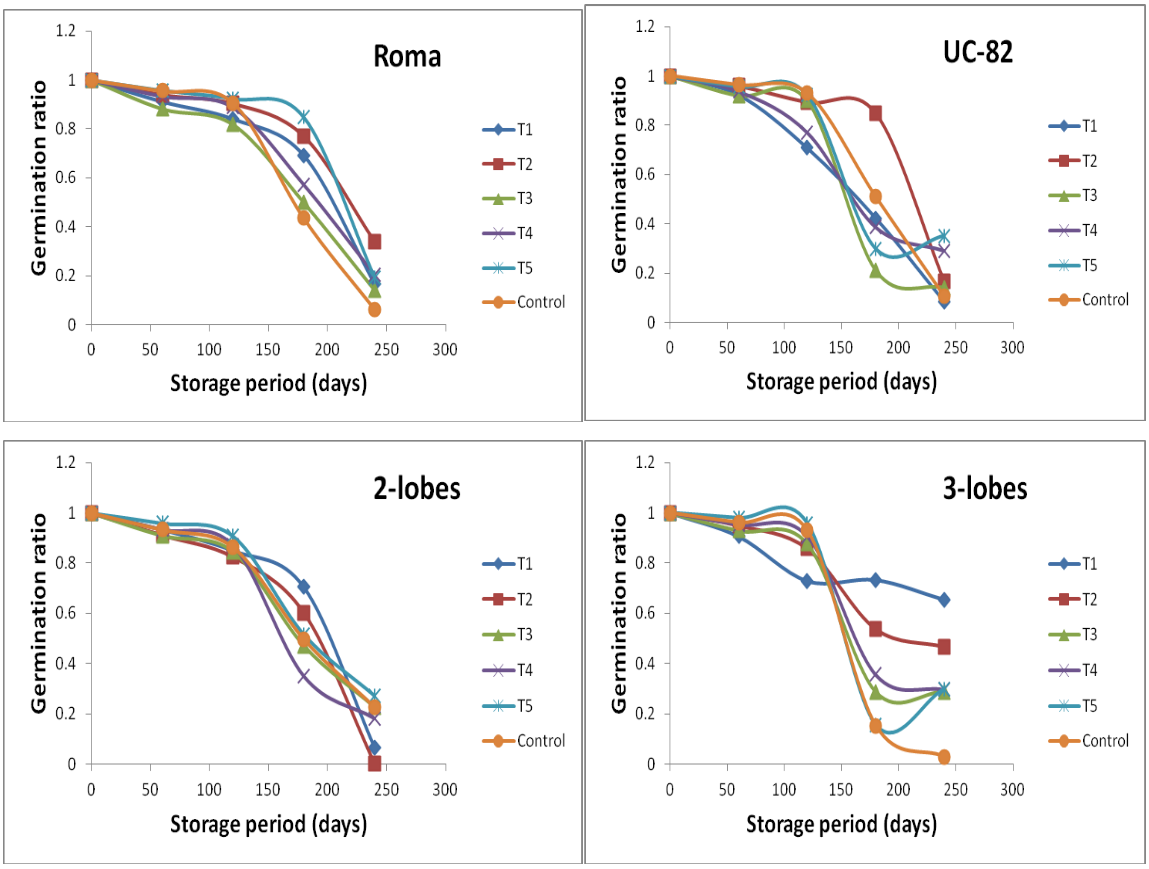

Figure 1: Plot of germination ratio against the seed storage period as affected by different pre storage-treatments (T1: *A. indica* powder; T2: *O. gratissimum* powder; T3: *C. frutescens*; T4: Apron plus; T5: $Ca(ClO)_2$ powder)

Table 1: Probit parameter for the tomato seeds as affected by variety and dry seed treatment

Variety	Dry seed treatment	1/σ [per day]	Σ	K_i	P_{50} [days]	*% Δ	R^2
Roma	*A. indica*	-0.0064	156	5.777	901	226	0.879
	O. gratissimum	-0.0050	200	5.760	1152	289	0.770
	C. frutescens	-0.0067	149	5.489	818	205	0.936
	Apron plus	-0.0062	161	5.627	906	227	0.894
	$Ca(ClO)_2$	-0.0060	167	5.655	944	237	0.692
	Control	-0.0153	65	6.133	399	-	0.698
UC-82	*A. indica*	-0.0133	75	5.509	413	76	0.641
	O. gratissimum	-0.0083	120	5.416	650	120	0.552
	C. frutescens	-0.0084	119	5.677	676	125	0.819
	Apron plus	-0.0055	182	5.313	967	178	0.914
	$Ca(ClO)_2$	-0.0065	154	5.670	873	161	0.791
	Control	-0.0108	93	5.824	542	-	0.738
2-Lobes	*A. indica*	-0.0133	75	5.672	425	45	0.681
	O. gratissimum	-0.0183	55	6.053	333	35	0.681
	C. frutescens	-0.0111	90	5.407	487	51	0.796
	Apron plus	-0.0134	75	5.819	436	46	0.789
	$Ca(ClO)_2$	-0.0057	175	5.575	976	103	0.861
	Control	-0.0058	172	5.517	949	-	0.879
3-Lobes	*A. indica*	-0.0024	417	5.048	2105	736	0.568
	O. gratissimum	-0.0050	200	5.835	1167	408	0.840
	C. frutescens	-0.0049	204	5.625	1148	401	0.844
	Apron plus	-0.0052	192	5.758	1106	387	0.741
	$Ca(ClO)_2$	-0.0144	69	6.316	436	152	0.437
	Control	-0.0217	46	6.208	286	-	0.795

A. indica: *Azadirachta indica*, *O. gratissimum*: *Ocimum gratissimum* *C. frutescens*: *Capsicum frutescens*
* % $\Delta = 100 * P50_{Treatment} / P50_{Control}$

CONCLUSIONS

This study has shown that tomato seeds storage life can be significantly elongated by treatment with cheaper and safer organic materials. Likewise, response of seed varieties to type of treatments differed significantly. Organic treatment gave higher longevity to Roma and 3-lobes seeds than others. *Azadirachta indica* had the greatest preservative effect on the seeds with an average half-life value of 481 days. From the results of this study, there is high potential of replacing commercial inorganic seed treatment materials with some organic treatments. However, the choice of the specific treatment would depend on the tomato variety.

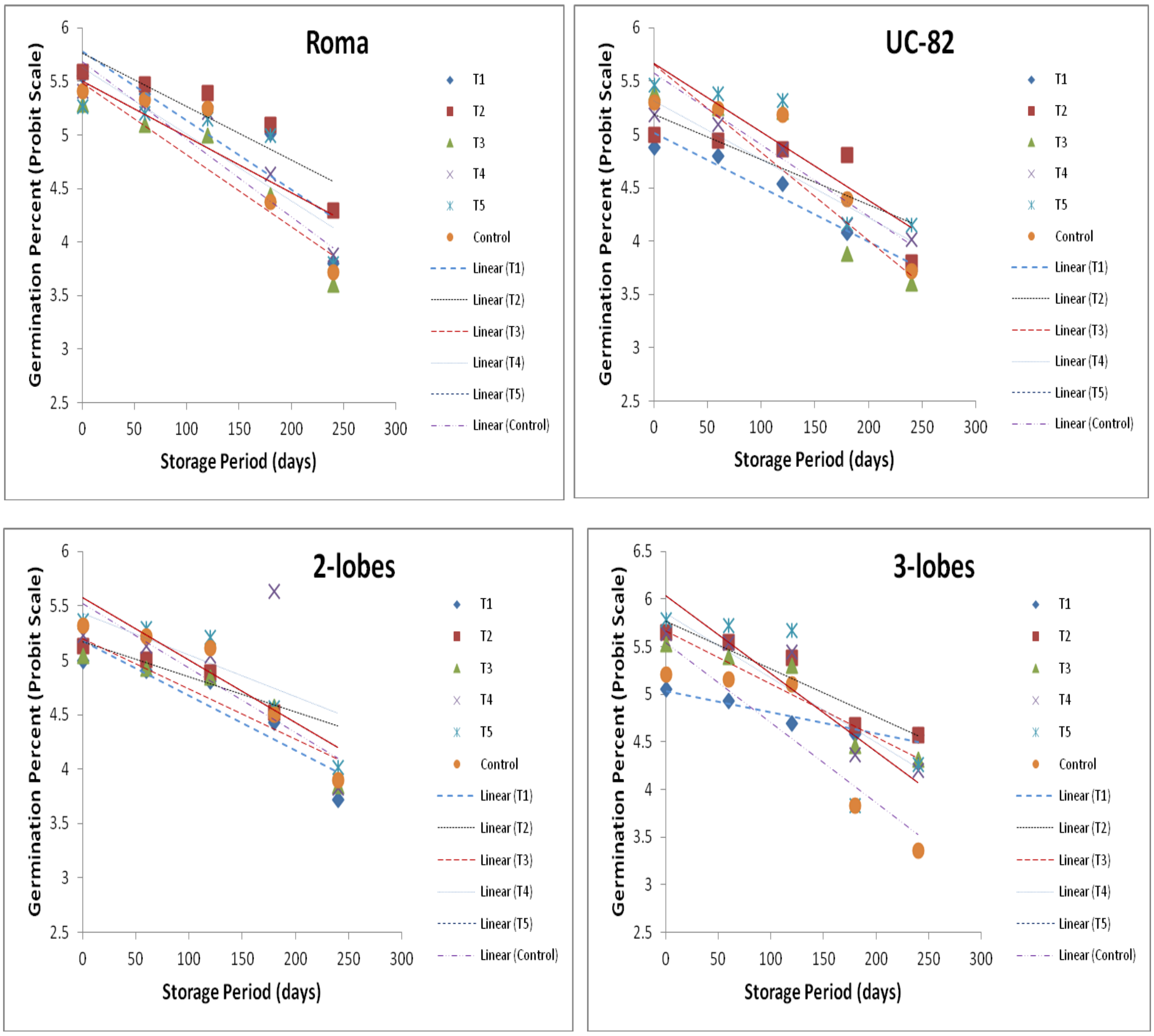

Figure 2: Probit plot of germination percent against the seed storage period as affected by different pre-treatments (T1: *A. indica* powder; T2: *O. gratissimum* powder; T3: *C. frutescens*; T4: Apron plus; T5: $Ca(ClO)_2$ powder)

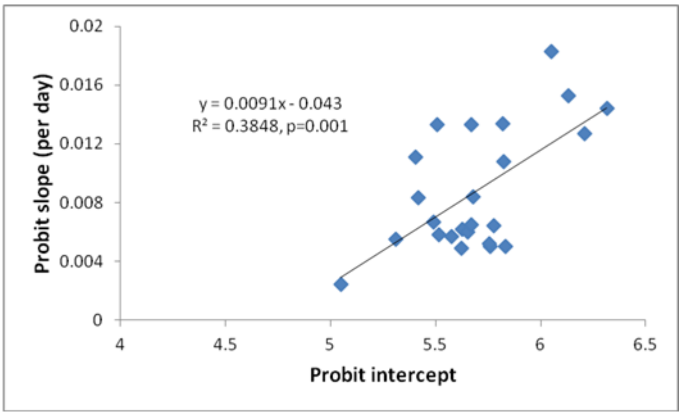

Figure 3: Linear correlation plot between probit slope (seed deterioration rate) and probit intercept (initial seed quality)

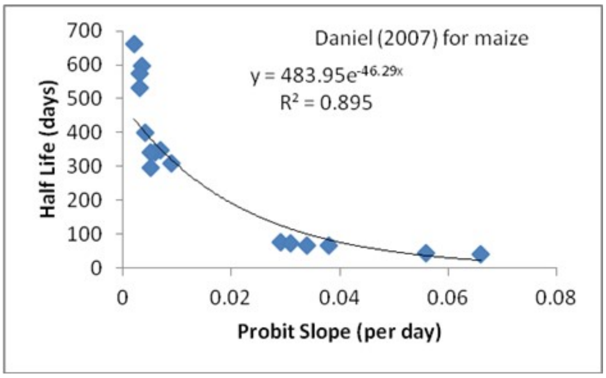

Figure 4: Correlation between the probit slope and the half-life of maize (Daniel, 2007) and tomato seeds (This experiment)

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