ACTA SOCIETATIS
BOTANICORUM POLONIAE
Vol. 51, nr 3–4: 481–488
1982

Viability and vigour of ageing pea seeds with various densities

RYSZARD J. GÓRECKI

Institute of Plant Biology, Agricultural-Technical Academy, Olsztyn-Kortowo 40, 10-957 Olsztyn, Poland

(Received: November 23, 1981)

Abstract

Pea seed lots (of big and small densities and a control) were stored for six months in hydrostats in relative air humidity 90 and 50 per cent, at 21°C. Viability was determined on the basis of germination rate (energy) and capacity; vigour on the basis of sprout growth analysis, conductometric measurements and over-all dehydrogenase activity in the embryonic axes (tigella). Seeds stored in a high relative air humidity were losimg their viability and vigour more quickly than did those stored in a dry air. Seeds of big density were preserving better and ageing slower than seeds of small specific gravity.

INTRODUCTION

Vigour and viability are the main criteria for the seed qualification. The seed viability is defined as its ability to active or dormant life and production, under siutable conditions, of normal sprouts. The seed vigour is its capability to form healthy and well developing seedlings and plants within a wide range of environmental factors variation (Grzesiuk and Górecki 1981). Seed features discussed here change together with the seed age and dependent on the ageing rate, which differs in intensity in individual species (Heydecker 1972, Bass 1979, Perry 1980).

According to Grzesiuk and Kulka (1981) the internal causes of seed ageing are: 1) the genom damages and disturbances in transcription and translation, 2) the cytomembrane damages through phospholipides oxidation, 3) bioenergetic disturbances. The intensity of deterioration depends, to the great extent, on storage conditions and individual seed features like its stage of developement, chemical composition etc. (Perry 1976, 1980). There is a lack of information, in the available scientific literature, on the ageing of seeds of different size. That is why the viability and vigour of pea

seeds with various densities subjected to the accelerated ageing were investigated. Matthews (1980) and Perry (1980) suggest that the use of controled ageing as a good seed vigour test is possible.

MATERIAL AND METHODS

Pea seeds of the Flavanda variety, at full ripeness, collected in 1979 were investigated. The seeds were divided into two fractions: heavy (1438 kg/m^3) and light (1376 kg/m^3). Remaining seeds served as a conttol. The seed fractionation was performed in the monobasic sodium phospphate water solution ($NaH_2PO_4 \times H_2O$). Then the seeds were repeatedly washed with tap and redistilled water and dried with filter paper. The samples were placed in two isolation chambers at relative air humidity 90 and 50 per cent at 21°C. The humidity range in the chambers was controled with hygrographs. The seed viability and vigour were determined at the begining of experiment and after 2, 4, and 6 months of storage. The seed viability was assesed according to the rules (Polska Norma 1979) on the basis of germination rate and capacity.

Various methods were used to investigate the seed vigour. **Sprout growth analysis:** Seed samples (8 × 50) were placed on wet filter paper, which were rolled up and put into a thermostat, at 25°C. After 72 hours length of embryonic stems (epicotyls) and roots (radicles) was measured and the sprout dry weight was determined.

Conductometric measurements (Knypl 1979): Seed samples (8 × 50) were repeatedly washed with redistilled water, next placed in flasks with 250 ml of redistilled water each and kept in a thermostat at 21°C for 24 hours. Then the exudates electroconductivity was measured with a conductometre.

Evaluation of over-all dehydrogenase activity in the seed tigella: The investigations were held according to the information given in Budzyńska's (1965), Piatt and Sprinfield's (1973) papers. For each analysis 25 seeds were selected and soaked in redistilled water for 24 hours. Then the tigella were isolated. The isolated tigella were incubated in 10 ml of 0.7 per cent 2.3.5-triphenyltetrazolium solution in 0.1 M K-phosphate buffer (pH 7.2). After 24 hours the tigella were homogenized and formazane was extracted with 15 ml of acetone. The homogenate was centrifuged (3000 x g, for 10 min.). After the centrifugation the sediment was extracted with 10 ml of acetone. All the eluates were combined and the solution extinction was measured at wavelength 510 nm. Evalutions were repeated 8 times.

RESULTS AND DISCUSSION

The seeds of great density were bigger and more uniform than the light ones. It was determined (Górecki and Grzesiuk 1982) that the density of seeds of pulse plants depended on their anatomical structure. In the pea,

broad bean and yellow lupine seeds of big specific density the cotyledones and tigella weighed more and the seed testa less than in the seeds of small specific gravity.

The germination of the analised pea seed lots varied during the storage (Fig. 1). The highest germination rate and capacity values were recorded at the begining of the experiment. The seeds stored in the isolation chamber at relative air humidity increased to 90 per cent were losing their viability gradually in the course of storage. The pea seed germination depended clearly on their density. In all the experiments the values of germination rate and capacity of seeds of great density were higher than of the light ones and the control. Figure 1 shows also that as the time passed seeds of small density germinated slower and slower which indicates they were ageing fastest.

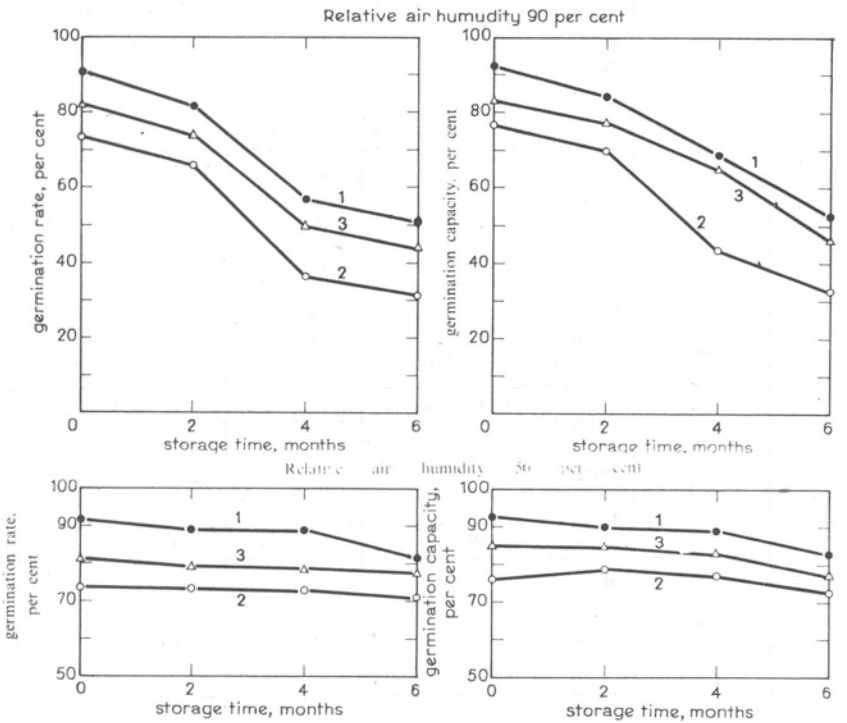

Fig. 1. Germination of pea seeds with various densities stored at high and low relative air humidity, at 21°C. ●—● seeds of big density, o—o seeds of small density, △—△ control

The seeds kept in a dry air were preserving well and after 6 months their viability only slingtly decreased (Fig. 1).

The biggest sprouts derived from the seeds with the highest viability (Table 1). The longest epicotyls and radicles belonged to the seeds with big density and those stored in a hygrostat at a low relative air humidity. The seeds

Table 1
Growth analysis of the sprouts of pea seeds with various densities stored at high and low relative air humidity, at 21°C

Storage time, months	Relative air humidity, per cent	Seed density	Epicotyl length, mm	Radicle length, mm	Sprout dry weight, g
0	—	big[x]	9.46	36.17	0.454
		small[xx]	8.56	31.15	0.355
		control	8.96	33.52	0.409
		LDS, P=0.05	0.47	1.58	0.5
2	50	big	9.40	34.65	0.460
		small	8.46	30.67	0.344
		control	8.81	33.08	0.420
		LDS, P=0.05	0.39	1.62	0.06
	90	big	8.87	32.32	0.349
		small	8.10	27.77	0.261
		control	8.39	30.67	0.322
		LDS, P=0.05	0.56	1.55	0.05
4	50	big	8.88	36.56	0.458
		small	8.56	29.20	0.320
		control	8.59	31.71	0.399
		LSD, P=0.05	0.58	1.17	0.08
	90	big	8.56	30.81	0.313
		small	7.21	23.19	0.166
		control	6.91	24.98	0.306
		LDS, P=0.05	0.46	2.32	0.04
6	50	big	7.89	30.01	0.407
		small	6.72	22.00	0.313
		control	7.61	25.34	0.389
		LDS, P=0.05	0.69	3.63	0.02
	90	big	5.52	18.15	0.147
		small	4.10	9.46	0.097
		control	4.61	18.08	0.117
		LDS, P=0.05	0.62	1.16	0.02

[x]—1437 kg/m^3; [xx]—1376 kg/m^3

stored for the longest time and not well developed gave the smallest sprouts. Sprout dry weight analysis indicated the same regularities.

According to Roberts (1972), Lityński (1977) and Wood et al. (1977) the initial rate of sprout and seedling growth depended on the amount of reserve materials stored in the seeds. Big seeds had usually big embryos and more food reserves so they gave seedlings that developed better.

On the basis of conductometric measurements great vigour changes were also determined (Fig. 2). Electroconductivity of the solutions obtained by soaking

of the best germinating seeds was lowest and of those grown old—highest. The latter was nearly twice higher, which indicated the considerable permeability of cytomembranes and high degradation of the seed vigour. The electroconductivity of solutions obtained by soaking of seeds of small density was significantly higher than those of great density. The seeds stored in the conditions of high and low relative air humidity followed the same regularities. Probably series injuries to the coats of seeds of small species gravity resulted in higher exudates conductivity as the coats of seeds of small density were much more damaged than those of two other lots.

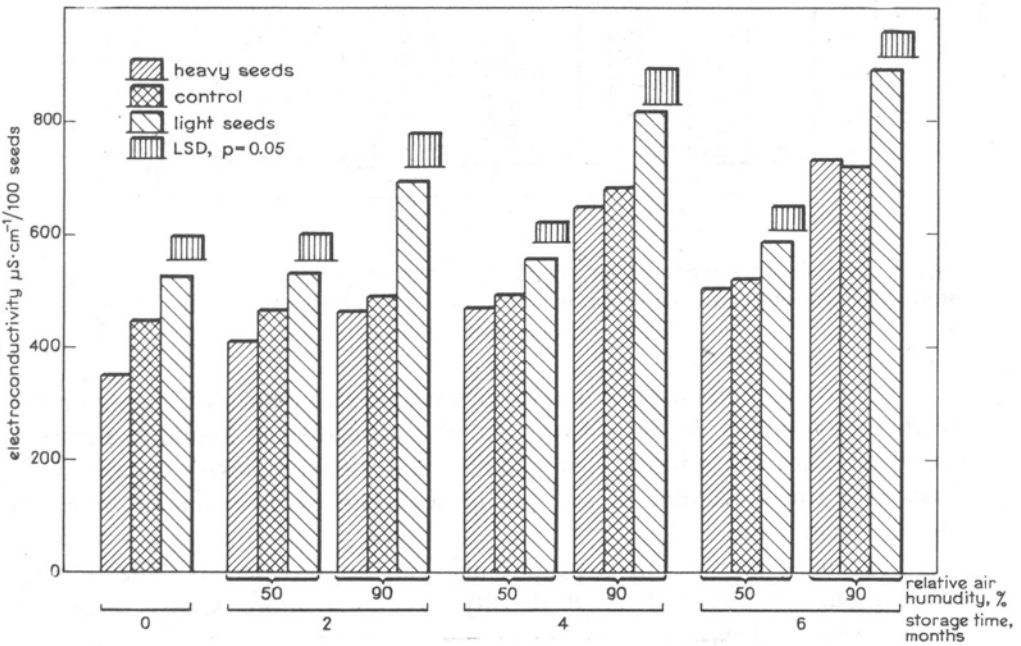

Fig. 2. Electroconductivity of exudates from pea seeds with various densities stored at high and low relative air humidity, at 21°C. (heavy seeds = seeds of big density, light seeds = seeds of small density)

Over-all dehydrogenase activity is a good index for the estimation of seed vigour (Maguire 1977, Grzesiuk and Górecki 1981). The decrease in in vigour assesed on the basis of sprout growth analysis and conductometric measurements was accompanied by the succesive decrease in over-all dehydrogenase activity in the tigella (Fig. 3). Also the dehydrogenase activity changes clearly indicated differences between the vigour and viability of seeds with various densities, stored in the conditions of high as well as low relative air humidity.

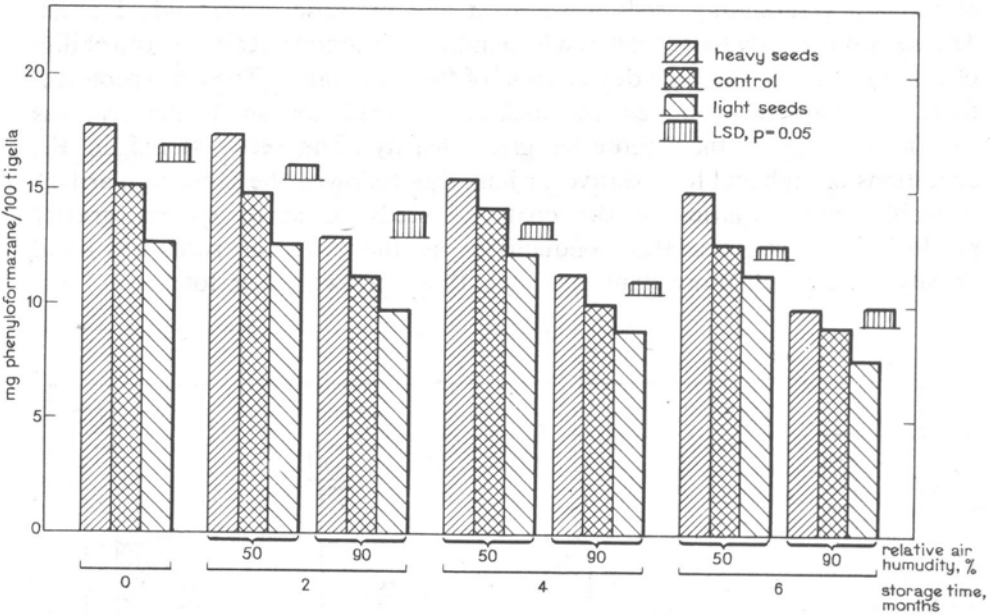

Fig. 3. Over-all dehydrogenase activity in the tigella of pea seeds with various densities stored at high and low relative air humidity, at 21°C (heavy seeds = seeds of big density, light seeds = seeds of small density)

The investigations showed that the pea seed ageing depended mainly on the relative air humidity. In the isolation chamber at relative air humidity increased to 90 per cent seeds losed their viability and vigour quickly. On the other hand. the small decrease in viability of seeds stored in a dry air indicated slower ageing rate.

The rate of seed ageing depended also on the seed density. The viability and vigour of seeds of great density decreased more slowly than did those of small density.

Furthermore the figures and tables show that the ageing pea seeds lost their vigour earlier than their viability. Heydecker (1972), and Perry (1980) got the similar results.

Although the seed vigour and viability were characterised here by various physiological features it is difficult to say which method gave the best information on the seed vigour. Statistical elaboration of the results permited to compare all the methods. The highest coefficient values were obtained for the correlation between germination rate and capacity and exudate electroconductivity (Table 2). There were strong relationships between over-all dehydrogenase activity and germination capacity and the latter and spout dry weight (correlation coefficients 0.870 and 0.903). The epicotyl and radicle lengths were the worst indices of the seed vigour. On the other hand the correlation between sprout dry weight and vigour assesed on the basis of conductometric measurements and over-all dehydrogenase activity occured.

Table 2
Correlation coefficients between various indices of the pea seed viability and vigour

Indices compared	Germination rate	Germination capacity	Epicotyl length	Radicle length	Sprout dry weight	Over-all dehydrogenases activity
Exudate electroconductivity	—0.934	—0.924	—0.748	—0.787	—0.841	—0.866
Germination rate	—	0.966	0.781	0.816	0.881	0.894
Germination capacity	—	—	0.847	0.884	0.903	0.870
Epicotyl length	—	—	—	—	0.782	0.731
Radicle length	—	—	—	—	0.810	0.785
Over-all dehydrogenases activity	—	—	—	—	0.871	—

$r_{0.05}=0.8114$, $r_{0.01}=0.9172$

REFERENCES

Bass L. N., 1979. Physiological and other aspects of seed preservation. In: The Plant Seed: development, preservation and germination. Rubenstein I. et al. (eds.). Acad. Press, New York-London-Toronto-Sydney-San Francisco, pp. 145-170.

Budzyńska J., 1965. Ocena potencjalnej zdolności kiełkowania nasion zbóż metodą tetrazolinową. IHAR, Radzików.

Górecki R. J., Grzesiuk S., 1982. Pozyskiwanie nasion grochu, bobiku i łubinu żółtego o najwyższym wigorze. Biul. IHAR (in press).

Grzesiuk S., Górecki J. R., 1981. Wigor nasion i metody jego określania. Post. Nauk Roln. 6: 39-56.

Grzesiuk S., Kulka K., 1981. Fizjologia i biochemia nasion. PWRiL, Warszawa.

Heydecker W., 1972. Vigour. In: Viability of seeds. Roberts E. H. (ed.). Chapman and Hall Ltd. London, pp. 209-252.

Knypl J. S., 1979. Assessment of soybean (*Glycine max*) vigour by the seed leachats conductivity assay. Acta Soc. Bot. Pol. 48: 267-277.

Lityński M., 1977. Biologiczne podstawy nasiennictwa. PWN, Warszawa.

Maguire J. D., 1977. Seed quality and germination. In: The physiology and biochemistry of seed dormancy and germination. Khan A. A. (ed.). North-Holland Publishing Company, Amsterdam-New York-Oxford, pp. 219-235.

Matthews S., 1980. Controlled deterioration: A new vigour test for crop seeds. In: Seed Production. Hebblettwaite D. P. (ed.). Butterworths, Toronto, pp. 647-660.

Piat J. R., Sprinfield H. W., 1973. Tetrazolium staining of *Clifrose* embryos. Proc. Assoc. Off. Seed. Anal. 63: 67-75.

Perry D. A., 1976. Seed wigour and seedling establishment. In: Advances in research and technology of seeds. Part 2. Thomson J. R. (ed.). Centre for Agricultural Publishing and Documentation, Wageningen, pp. 62-85.

Perry D. A., 1980. Seed vigour and seedling establishment. In: Advances in research and Technology of seeds. Part 5. Thomson J. R. (ed.). Centre for Agricultural Publishing and Documentation, Wageningen, pp. 25-40.

Polska Norma, 1979. Metody badania nasion. PN-79/R-6595. Wyd. Norm. Warszawa.

Roberts E. H., (ed.). 1972. Viability of seeds. Chapman and Hall Ltd, London.

Wood D. W., Longden P. C., Scott R. K., 1977. Seed size variation; its extent, source and significance in field crops. Seed Sci. Technol. 5: 337-352.

Żywotność i wigor starzejących się nasion grochu o różnym ciężarze właściwym

Streszczenie

Nasiona grochu odmiany Flawanda podzielono na partie o dużym i małym ciężarze właściwym i umieszczono w higrostach (w temp. 21°C) w 50% i 90% wilgotności względnej powietrza. Po 0, 2, 4 i 6 miesiącach badano żywotność nasion metodą kiełkowania oraz wigor na podstawie analizy wzrostowej siewek, ogólnej aktywności dehydrogenaz i pomiarów konduktometrycznych. Stwierdzono, że nasiona grochu przechowywane w higrostacie w 90% wilgotności powietrza szybko traciły żywotność i wigor. Szybkość starzenia się nasion zależała jednak od ich gęstości. Nasiona dorodniejsze tzn. o dużym ciężarze właściwym traciły żywotność i wigor wolniej od nasion o małym ciężarze włyściwym. Współczynniki korelacji pomiędzy wskaźnikami wigoru wykazały, że długość łodyżki i korzenia zarodkowego były najmniej wiernymi wskaźnikami wigoru nasion. Natomiast sucha masa kiełków wyraźnie korelowała z wigorem mierzonym metodą konduktometryczną i z ogólną aktywnością dehydrogenaz.

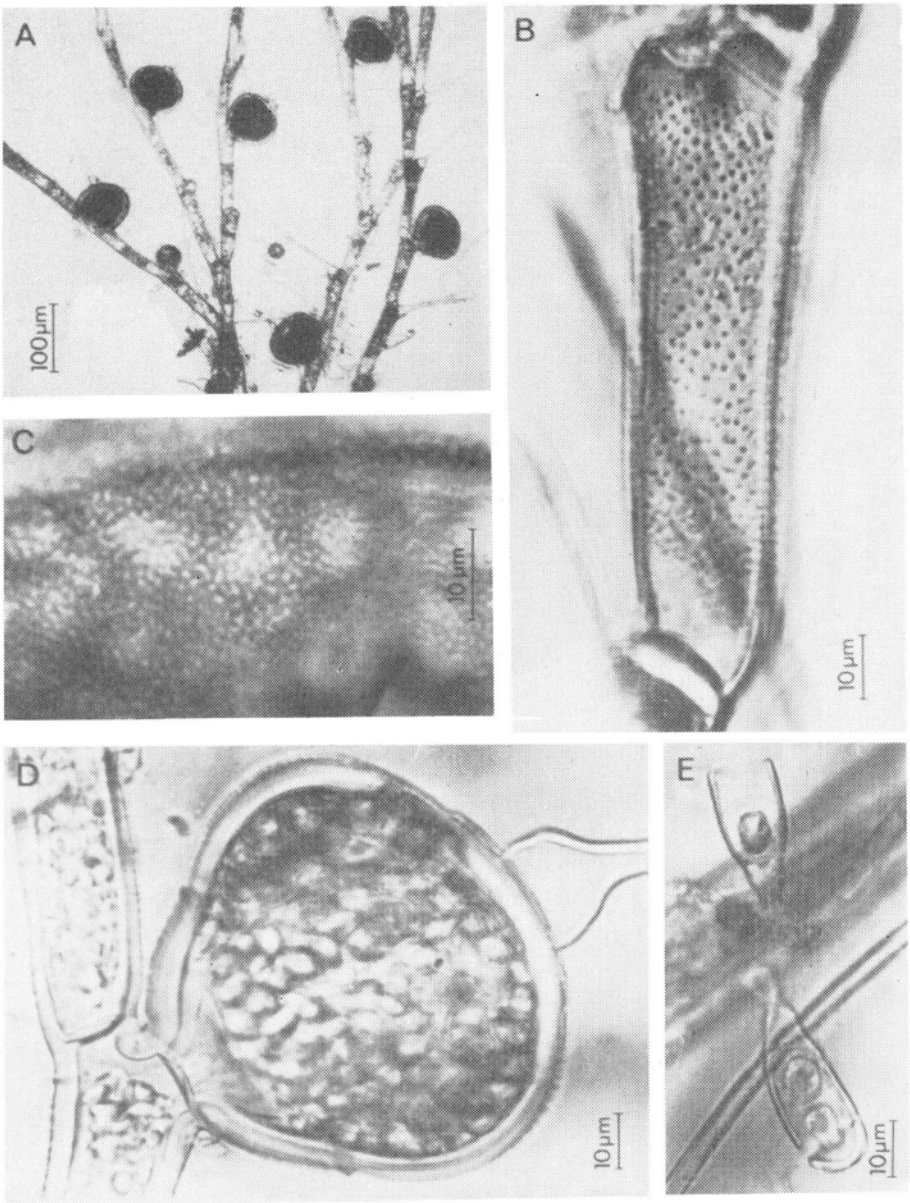

Fig. 2. *Bulbochaete augustowiensis*: A—fragment of thallus with oogonia, B—relief of vegetative cell, C—relief of oospore, D—oogonium, E—reduced male filaments