Effect of time of harvesting on the storability of chickpea (*Cicer arietinum* L.) seeds

K. OSEI-BONSU, R. H. ELLIS & E. H. ROBERTS
(K. O.-B. & R.H.E.: Cocoa Research Institute, P. O. Box 8, Tafo-Akim, Ghana; E. H. R.: Department of Agriculture and Horticulture, Earley Gate, Reading RG6 2AT, England)

SUMMARY

Chickpea (*Cicer arietinum* L. cv. Chaffa) seeds harvested at 77, 105 and 133 days after flowering were conditioned to 14.9-24.1 per cent moisture content and stored at 30 and 40 °C constant temperatures. The rate at which seeds from different harvests deteriorated was similar after storage in comparable temperature and moisture content conditions. The mean viability periods (P_{50}) for seed lots differed markedly between harvests and were related to the initial viability, K_i, of the seeds from the different harvests. The initial viability of seeds harvested at 77 days was 99.8 per cent (K_i equivalent to 2.96), those harvested at 105 days was 97.5 per cent (K_i equivalent to 1.97) and at 133 days it was 33.8 per cent (K_i equivalent to -0.42). The implications of delayed harvesting on subsequent storage longevity of the seeds are further discussed.

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RÉSUMÉ

Osei-Bonsu, K., Ellis, R. K. & Roberts, E. K.: *Effet du temps de la récolte sur la mise en stockage du pois* (Cicer arietinum *L*). Du pois (*Cicer arietinum* L. cv. Chaffa), récoltés à 77, 105 et 133 jours après la floraison ont été mis à des états de 14.9 à 24.1% de teneur en eau et puis mise en stockage à des températures constants de 30 et 40 °C. Le taux de la detérioration du pois de différents récoltes était similaire après la mise en stockage à des conditions de la temperature et teneur en eau comparables. Les variabilités moyennes des périodes (P_{50}) du pois, cependant, étaient très bien différent entre les récoltes et étaient en rapport avec les viabilités initiales (K_i) des récoltes différents. La viabilité initiale du pois récolté à 77 jours était 99.8% (K_i equivalent à 2.96) celle récolté à 105 jours était 97.5% (K_i equivalent à 1.97) et à 133 jours, elle était 33.8% (K_i equivalent à -0.42). Les implications de la récolte tardive sur la longévité de la mise en stockage subséquent du pois ont été discutées.

Introduction

Most seeds start deteriorating soon after maturity in the field except those with some mechanisms for dormancy . There are various views on when a seed (including embryo and endosperm) has attained physiological maturity. But whenever maturity is reached, the rate of subsequent deterioration tends to depend on the ambient environment of the mother plant (Tekrony *et al.* 1979; Moore, 1972; Roberts, 1972; Green, Cavannah & Pinnel, 1966). It is difficult to measure the level of incipient deterioration taking place in the seed soon after maturation except with very sophisticated instrumentation.

With successive sampling for seed-dry matter content, it has been found that the lowest moisture content in the seed is a good indicator of when the seed is mature. Thus, a number of workers have differentiated between physiological maturity with maximum dry matter production and harvest maturity which tends to give drier seeds (Milner & Geddes, 1946; Green *et al.*, 1966; Austin, 1972; Tekrony *et al.*, 1979).

There is also evidence that delayed harvesting reduces the initial viability of the seed (Tekrony, Egli & Balles, 1980); this tends to determine the storage potential of the seed (Roberts, 1972; Ellis, 1976 ; Ellis & Roberts, 1980, 1981; Ellis, Osei-Bonsu & Roberts, 1982). The rate of deterioration, measured by the standard deviation of the distribution of seed deaths over time (σ), remains the same under similar storage conditions. Thus, the duration of storage for differently processed seed lots of a species is predetermined by their initial quality (Ellis & Roberts, 1980, 1981; Ellis, Osei-Bonsu & Roberts, 1982).

The present study evaluates the initial quality and subsequent storage potential of chickpeas harvested at different intervals.

Materials and methods

Seeds of chickpea (*Cicer arietinum* L. cv. Chaffa) obtained from the International Institute for Crop Research for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, were planted on the University of Reading farm in three blocks measuring 2 m × 6 m each on 23 May 79 at a spacing of 30 cm × 10 cm. Triple superphosphate (P_2O_5) and muriate of potash (K_2O) fertilizers were ploughed into the soil at the rate of 25 kg/ha. Nitrogen from $(NH_4)_2SO_4$ at the rate of 25 kg/ha was applied at planting and 75 kg/ha applied later at flowering. Seedling emergence and establishment were very good and flowering started on 9 Jul 79. The first harvest was taken 77 days after flowering when 65 per cent of the pods had yellowed and at monthly intervals thereafter. In all cases, plants were harvested from 3.6 m^2 plots and the pods were shelled by hand in the laboratory. Initial as well as subsequent moisture contents (fresh weight basis) were determined in accordance with the INSTA (1976) rules.

Seeds at each harvest were dried to three approximate moisture contents of 25, 20 and 15 per cent over silica gel by intermittently sampling. Ten hermetically-sealed samples of 200 seeds each were stored in incubators kept at 30 and 40 °C and were sampled regularly, depending on the storage for germination using the rolled paper towel technique in alternating temperature (20 °C for 16 h and 30 °C for 8 h) incubators. Constant storage temperatures were used in these experiments because seed deterioration was temperature dependent (Roberts, 1972).

Results and discussion

A normal distribution of seed deaths with time was observed from the storage experiments. It was, therefore, possible to assess the survival curves by a probit analysis (Finney, 1962) and to fix a common intercept to survival curves from each harvest (Roberts, 1972; Ellis, 1976; Ellis *et al.*, 1982). Seeds with high (20-24 %) moisture contents showed signs of dormancy, and initial germination tests gave values which were much lower than the germination percentage of samples taken after sometime in storage. By omitting the first few germination results which showed dormancy trends from the probit analysis (Roberts, 1961), realistic common intercepts could be fitted to the survival curves.

It was then apparent that in comparable storage environments, seed survival curves as measured by the standard deviation of the distribution of seed deaths over time (σ) were very similar for the different harvests (Fig. 1). Thus, the rate of deterioration of seed lots was the same as far as storage environments were similar, confirming earlier suggestions by Ellis & Roberts (1980, 1981) and Ellis *et al.* (1982). For example, seeds of Harvest 1 stored at 14.9 per cent m.c. and 40 °C had a standard deviation of the distribution of seed death of 4.07 days whilst Harvest 2 at 15.2 per cent m. c. and 40 °C had 5.84 days. Similarly, at 21.2 per cent m. c., Harvest 1 gave a σ value of 2.12 days while Harvest 3 at 20.4 per cent and 40 °C gave 1.79 days. Considering the inaccuracies in moisture determination over the period when these experiments were conducted, these σ values were reasonably accurate. Nevertheless, the σ values were generally lower in seed moisture content for Harvest 3 than Harvest 1 and Harvest 2. This was probably due to errors in fitting survival curves to few data points in a distribution which was below 30 per cent viability or very close to death (Ellis & Roberts, 1980).

When the time taken to 50 per cent (P_{50}) seed survival at comparable storage environments across harvests was examined, there was considerable reduction between seed lots (harvests).

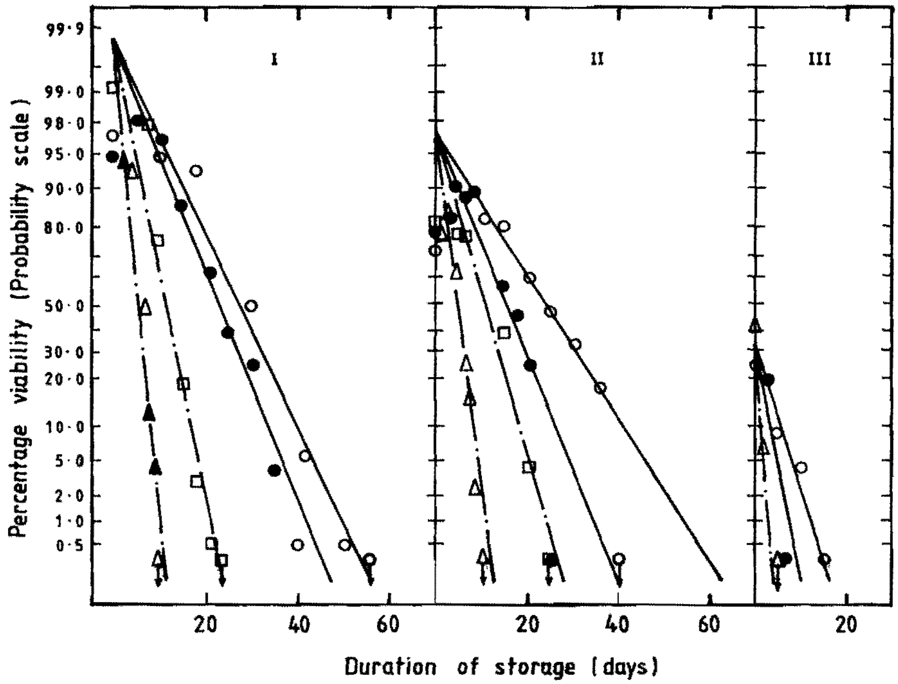

Fig. 1. Chickpea seeds cv. Chaffa harvested at three intervals for storage experiments at 30 °C (————) and 40 °C (——.——): I. Harvest 1 at 77 days after flowering stored at m.c. of 14.9% □ 21.2% 0, △; and 23.1% ●. II. Harvest 2 at 105 days after flowering stored with m.c. of 15.2% □; 20.0% 0, △; and 24.0% ●. III . Harvest 3 at 133 days after flowering stored with m.c. of 20.4% 0, △ and 23.4% ●

The P_{50} values from Harvest 1 were higher than those from Harvest 2. The disparity was sharp between Harvest 3 (where time to 5 per cent viability (P_5) was used instead) and the other harvests (Table 1). Since the slopes of the curves in comparable storage environments were not significantly different, it would appear that the differences were due to the intercept constants, K_i, for the three harvests which affected the P_{50} values from the formula $K_i = P_{50}/\sigma$ (Ellis & Roberts ,1980); where K_i is a measure of how far in standard deviation terms the intercept point (zero storage time) is from the mean viability (P_{50}). It was observed that there was a sharp decline in the initial viability K_i, between Harvest 1 and Harvest 2, and between either Harvest 1 or Harvest 2 and Harvest 3.

The first harvest (Harvest 1) had an initial viability of 99.8 per cent (or K_i of 2.96) ; Harvest 2 had a value of 97.5 per cent (or K_i of 1.97), whilst Harvest 3 was only 33.8 per cent viable (or K_i of -0.42). While this finding confirms suggestions that the most important criterion for estimating the storage potential of a seed lot is the initial quality of the seed (Ellis & Roberts, 1980), it also amplifies the need for timely harvest and processing as an agronomic requirement for obtaining seeds of good quality for breeding and conservation programmes (Tekrony *et al.* 1980; Green, Cavannah & Pinnel, 1966).

Only about 65 per cent of the pods had yellowed at the time the first harvest was taken at 77 days after flowering and seeds had a very high moisture content of 48.5 per cent but seed viability was highest. By the second harvest at 105 days after flowering, all the leaves had dropped,

TABLE 1

The Effect of Harvesting Date on the Storage Characteristics of Chickpea

Harvest (lots)	*Days after flowering*	*Initial m.c.%*	*Initial viability %*	*m.c.% storage*	*Standard deviation (σ) days*	*Temperature* 30 °C P_{50} (days) *Actual*	*Predicted**	*Standard deviation (σ) days*	40 °C P_{50} (days) *Actual*	*Predicted**
				14.9	-	-	-	4.07	12.1	36.1
1	77	48.5	99.8	21.2	9.20	27.2	31.4	2.12	6.3	6.6
				25.1	7.92	23.6	20.6	-	-	-
				15.2	-	-	-	5.84	11.5	21.8
2	105	24.6	97.5	20.0	11.97	23.5	27.6	2.70	5.3	5.8
				24.1	7.92	15.6	11.2	-	-	-
						P_5(days)			P_5(days)	
3	133	36.8	33.8	20.4	6.37	8.8	15.6	1.79	2.5	3.3
				23.4	4.48	4.5	8.1	-	-	-

* Predicted from equations $V = K_i - p/K_E - C_W \log_{10} m - C_H t - C_Q t^2$; where V is the viability at any given duration P_o; K_i is the initial viability of the seed lot; m.c. is moisture content (% f.w. basis) and t is temperature °C. K_E, C_W, C_H and C_Q are constants. K_E = 9.070; C_w = 4.829; C_H = 0.045; C_Q = 0.000324 (Ellis *et al.*, 1982).

the pods had browned, the seeds had a lower moisture content of 24.6 percent and had deteriorated considerably (K_i of 1.97 as against 2.96 for Harvest 1). It seems logical and advantageous, therefore, to harvest the crop between 77 and 105 days after flowering to maximize seed quality. Certainly, other support services like a good drier and sheller to immediately process the seeds are very essential for success.

The predictions of longevity (P_{50}) using the universal constants developed for chickpeas from a previous experiment (Ellis *et al.*, 1982) were compared with the results obtained in the study. Table 1 shows that the predictions from the universal equation closely agree with actual values recorded in these experiments. One anomalous result was the 14.9-15.2 per cent m.c. of seeds stored at 40 °C from Harvest 1 and Harvest 2. Seed survival curves (Fig. 1) were normally distributed and fitted the probit analyses accurately. However, the actual P_{50} recorded seemed to predict those of seeds stored at 18 to 20 per cent m.c. at 40 °C. Owing to this curious seed survival pattern, seeds from Harvest 3 at 15 per cent m.c. were dead before first sampling since predictions were based on the universal equations. Similarly, predictions for Harvest 3 were widely out of range with the expectations except for the 20.4 per cent m.c., 40 °C treatment. These observations may be the result of predicting from survival curves towards the tail end of the distribution where seed survival tends to be very erratic.

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