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Seed Quality in Winter Squash (*Cucurbita maxima L.*) Seeds Stored at High Moisture Content in the Fruit after Harvest

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Summary

Seed quality of winter squash (*Cucurbita maxima* L.) seeds was studied during storage in the fruit up to 150 days after harvest of the fruit. Seeds were extracted from the fruits 12, 35, 63, 92, 150 days after harvest in 1999, and 30, 60, 90, 120, 150 days after harvest in 2000. Total seed germination following drying changed between 87 and 97 % in 1999, between 98 and 100 % in 2000. However, normal germination percentages and seed vigour assessed by cold test, accelerated ageing and emergence tests gradually increased until 60 days but significantly declined subsequently. Thus, maximum seed quality was obtained from seeds of 60 days in winter squash after harvest.

Zusammenfassung

Qualität von in der Frucht unter hohen Feuchtigkeitsbedingungen gelagertem Kürbissaatgut (*Cucurbita maxima* L.). Gegenstand der Untersuchungen ist die Qualität von Kürbissaatgut (*Cucurbita maxima* L), das bis zu 150 Tage nach der Ernte in den Früchten belassen wurde. 1999 wurden die Samen 12, 35, 63, 92 und 150 und im Jahr 2000 30, 60, 90, 120 und 150 Tage nach dem Fruchterntetermin entnommen. Die Keimrate im Anschluss an eine Trocknung der Samen betrug 1999 zwischen 87 und 97 % und 2000 zwischen 98 und 100 %. Die Rate normal gekeimter Sämlinge und die Keimenergie, die nach einer Kältebehandlung ermittelt wurden, stiegen bis 60 Tage nach der Fruchternte an und fielen im weiteren Verlauf deutlich ab. Die beste Saatgutqualität wurde deshalb 60 Tage nach Ernte der Kürbisse erzielt.

Key words. Squash – *Cucurbita maxima* L. – seed storage – germination

Introduction

Winter squash, a fleshy fruited summer vegetable, is widely grown in Turkey and harvested in late summer (October). The mesocarp of the fruit is consumed until March of the following year. The later fruits are marketed after harvest, the higher the price producers get between October and March. Therefore, fruits with seeds inside are stored in warehouses at room temperature for several months and seeds are extracted along with marketing throughout the winter period. It would be a good combination of seed production and fruit marketing if seed quality remains high during the storage in the fruit.

In winter squash similar to fleshy fruited vegetables such as tomato, pepper, marrow and melon, seeds do not dry during maturation unlike legumes and cereals (DEMIR and ELLIS 1993, TEKRONY and EGLI 1997) and seed moisture content remains stable at about 30–35 % at fruit harvest. Storage of seeds in the fruit at such a high moisture content might cause a rapid loss of viability, since winter squash is an orthodox seed (ROBERTS 1973). In addition, the high moisture content may induce viviparious seed germination in the fruit as reported for fleshy fruited vegetables such as tomato (DEMIR and SAMIT 2001). In this study, seed quality of squash seeds was tested during storage in the fruit at room temperature up to 150 days after harvest in two subsequent years.

Materials and Methods

Plant husbandry and seed extraction periods

Plants of squash cultivar 'Arican 97' (*Cucurbita maxima* L.) were grown at the Experimental Field of the Horticulture Department, Agriculture Faculty, Ankara University in 1999 and 2000 with direct sowing with plant spacing of 2 m between, and 1 m within rows. Plants were fertilised with the equivalent to 8 kg P_2O_5, 5 kg K_2O and 5 kg N per 1000 square meter at the first true leaf stage. One simultaneously open female flower per plant was tagged and harvested about 150 days after sowing . Thirty harvested fruits per year were dipped into 0.2 % thiram (v/w) for 5 seconds to prevent fungal infection on the fruit surface during unheated room storage (maximum temperature: 27 °C, minimum temperature: 6 °C). Seeds from six fruits per period were extracted by hand after 12, 35, 63, 92, 150 in 1999 and 30, 60, 90, 120, 150 days of storage in 2000. Seeds from the 6 fruits bulked into one lot in each period. Seed moisture content was determined by drying in an oven at 130±1 ° C for one hour (ANONYMOUS 1996). Seeds were then left on top of filter paper at room temperature (20±2 °C) for three days to dry to approximately 8 % moisture content (fresh weight basis).

The remaining seeds from each lot after drying at 20±2 °C were kept in glass jars at fridge until last sample was taken from storage in each year. Seed dry mass

was determined by two replications of 50 seeds per lot at 130 °C for 1 hour.

Following quality tests were conducted on remaining seeds in each period:

Germination test, seedling fresh and dry mass. Germination tests of fresh and dried seeds were conducted using four replicates of 50 seeds each at 25 °C between wetted rolled filter papers (Filtrak Gmbh, Post Borenstein, Germany). Fifty seeds were placed between three (two down one up) of 10x10 cm sized filter papers wetted with 18 ml of distilled water. Rolled papers were placed in polyethylene bags and kept in the dark. Germination was counted after 8 d (ANONYMOUS 1996). Both, fresh and dry seedling masses were determined per plant. Dry mass was determined following drying the seedlings at 80 °C for 24 h.

Water potential measurement. Fruit flesh just around the seeds were put in to –20 °C and sap was extracted by thawing and water potential of the sap was measured in each harvest in 2000 only with Vapro vapour pressure osmometer (Vapro, Vapor pressure osmometer, Model 5520, Wescor, UT, USA).

Accelerated ageing test. Four replicates of 25 seeds each from each extraction period were used. The test was conducted according to procedure described by ANONYMOUS (1995). Distilled water (40 ml) was added to each plexiglass box (11x11x4 cm). Seeds were placed on wire mesh trays approximately 2 cm above the bottom of the tray and aged at 45 °C for 48 hours. Following this period, the seeds were removed and a standard germination test (radicle emergence) conducted as described above.

Cold test. Cold test was conducted by using four replicates of 25 seeds each. Seeds were placed between three (two down one up) of 10x10 cm sized wetted (18 ml) rolled filter papers (Filtrak Gmbh, Post Borenstein, Germany) and were put in to polyethylene bags. They were then kept in the dark at 10 °C for 7 days. Then, transferred to 25 °C and normal seedlings were counted after 8 days.

Seedling emergence test. Seeds (four replications of 25 seeds of each lot) were sown 2 cm deep in compost (Plantaflor-Humus Verkaufs-GmbH, Germany) in seedling trays (32x20x5 cm). Seedlings were grown in unheated glasshouse (daily mean temperature between 12 and 28 °C) for 20 days. The progress of emergence (criterion: appearance of hypocotyl at the surface) was monitored.

Means of the replicates of the each test were compared with LSD (P=0.05). The statistical analysis was carried out by using MSUSTAT (Oregon State University, USA).

Results and Discussion

Seed moisture content of the seed lots of 0, 12, 35, 63, 92 and 150 in 1999 and 0, 30, 60, 90, 120 and 150 days after harvest in 2000, changed between 31.4 and 36.2 % and 30.9 and 37.6 %, respectively. Total germination percentages of fresh seeds of all lots were above 97 % except germination of the lot prior to storage in 2000. Drying reduced germination of all seed lots in 1999. Ungerminated fresh seeds at the end of the test was dead (moulded, fungal affected). Contrarily, drying promoted germination of the first lot but was ineffective in the rest of lots in 2000. Maximum normal germination at 25 °C was observed as 90 and 98 % in 1999 and 2000 in seed lots of 63 and 60 days, respectively. The same seed lots also showed the minimum percentage of abnormal seedlings as 6 % in 1999 and 2 % in 2000. Seed dry mass varied between 472 and 512 mg/seed in 1999; 252 and 346 mg/seed in 2000 among the lots (Table 1).

Seedling fresh mass did not change significantly among the lots (about 600 mg/plant) but seeds of lot 12 days gave maximum seedling dry mass in 1999. Seeds of 60 days gave maximum seedling fresh weight as 1724 mg/plant in 2000. It was significantly different

Table 1. Changes in quality of winter squash seed lots stored in the fruits after harvest for 0, 12, 35, 63, 92 and 150 days in 1999 and 0, 30, 60, 90, 120 and 150 days in 2000.

	1999 Seed lots*							2000 Seed lots*						
Tests	0	12	35	63	92	150	LSD**	0	30	60	90	120	150	LSD**
Seed moisture cont. (%)	34.3	35.1	35.4	31.4	36.2	34.7	1.1	32.3	34.5	30.9	31.1	37.6	31.6	2.1
Germination fresh (%)	98	99	100	99	97	100	1.3	78	98	99	100	99	98	5.4
Germination dry (%)	87	87	90	96	91	97	7.1	100	100	100	98	100	98	1.6
Normal germination(%)	61	65	77	90	83	88	6.2	84	88	98	93	87	80	7.0
Abnormal germination (%)	26	22	13	6	8	9	6.2	16	12	2	7	13	18	7.1
Seed dry mass (mg)	468	472	482	490	512	490	23.9	346	336	338	317	252	276	40.5
Cold test (%)	81	82	86	93	74	69	12.3	91	92	93	73	68	62	13.2
Accelerated Ageing (%)	87	82	86	90	79	63	7.6	92	87	93	71	67	61	9.7
Emergence (%)	89	82	84	91	78	68	9.3	88	90	93	65	67	70	10.3
Seedl.fresh mass (mg)	610	600	670	670	600	670	86.0	746	1344	1724	1369	1116	1224	270
Seedl.dry mass (mg)	230	240	210	210	180	180	30.0	266	250	218	248	240	228	14.4

* Extracted days after harvest, ** P=0.05

from the rest of the seed lots. In 2000, maximum seedling dry mass was obtained from the control being 266 mg/plant which was significantly different from the rest of the lots.

Water potential of the mesocarp of the fruits changed between –1.38 and –1.59 MPa being minimum in lot of 30 days and maximum in the lot of 90 days.

Germination of seed lots after cold, accelerated ageing and emergence tests increased gradually until lots of 63 and 60 days in 1999 and 2000, respectively. It declined significantly ($P<0.05$) in subsequent harvests and were recorded as 69, 63 and 68 % in 1999, 62, 61 and 70 % in 2000 after cold, accelerated ageing and emergence tests in final lot, respectively. Results showed that winter squash seeds should not extract from the fruit immediately after harvest in order to get maximum quality. Storage of the seeds in the fruit for 60 days after harvest enhanced seed germination and vigour. Such an enhancement was also reported in pepper seeds (EDWARDS and SUNDSTROM 1987). One approach might be extracting seeds about 60 days after harvest, when seed quality was at maximum, and keeping dried seeds in low moisture contents until sowing.

There is no work that reports changes in quality of the very moist seeds (30–35 %) stored in the fruit after harvest in winter squash. However, in air dry storage, repair mechanism (longer survival) takes place in seeds that were kept at elevated moisture contents. Moisture content above which the seed ageing trend is reversed and longer survival occurs was reported as 15 % in lettuce (IBRAHIM and ROBERTS 1983), 18 % in onion (WARD and POWELL 1983) and 25 % in wheat (PETRUZELLI 1986). The same mechanism might be effective in seeds stored at high moisture content (30–35 %) within the fruit. However, further investigations should be conducted to elucidate this assumption.

Vigour is considered as a fundamental part of seed quality and is correlated with field performance more than viability (TEKRONY and EGLI 1997). Stored squash seeds in the fruit maintained reasonably high total germination (radicle protrusion) following drying (87 %< in 1999, 98%< in 2000) until 150 days. However, seed vigour assessed by normal germination, cold test, accelerated ageing and emergence tests declined significantly subsequent to lot of 60 days (Table 1). Then, to obtain maximum vigour in turn a better stand establishment, squash seeds should be extracted from fruits subsequent to 60 days of storage in the fruit.

Viviparious (precocious) germination was not observed even in the last lots in both years. Precocious germination was prevented by accumulation of osmotic solutes that maintains seed water content below the threshold required for germination in muskmelon (WELBAUM 1999). It appears to be that winter squash seeds also did not reach to threshold water content for germination during storage in the fruit. On the other hand in late harvests severe fruit decomposition might occur in muskmelon (WELBAUM 1999) and marrow (DEMIR and ELLIS 1993), but not in winter squash. This might be due to the hard fruit tissue and higher dry matter content (less watery) of fruit flesh in this species. Water potential of the flesh sap of squash fruit was also found low enough to prevent germination (about –1.5 MPa) during storage.

As a conclusion, high quality winter squash seeds can be obtained from seeds extracted 60 days after harvest. In subsequent lots, particularly seed vigour reduced despite total germination percentage remains high.

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