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Differential Responses for Harvesting Times and Storage on Hardness of Different Varieties of Okra

Ghadir MOHAMMADI[1], Ebrahim M. KHAH[1], Mohammad BANNAYAN AVAL[2*]

[1]*University of Thessaly, School of Agriculture, Department of Crop Production and Rural Environment, Greece*

[2]*Ferdowsi University of Mashhad, Faculty of Agriculture, P.O. Box 91775-1163, Mashhad, Iran; mobannayan@yahoo.com (*corresponding author)*

Abstract

Okra seed hardness results in slow and nonuniform germination. This study was conducted to determine the effects of time of harvest and storage on seed germination of four different cultivars of okra (*Abelmoschus esculentus* L.). The study was carried out at Agricultural faculty of Razi University in years 2009 and 2010. The experimental design was a randomized complete block under factorial arrangement with three replications. Four different cultivars of okra included, 'Boiatloy', 'Beloudo', 'Clemsson Seinless' and 'Pleas' and six harvesting times of 20-25-30-35-40 and 50 days after flowering were considered in the present study. The results showed that seed germination increased in 2009 from 3.4%, at first harvesting time, to 46.4% at fifth harvesting time, and in 2010 from 2.9%, at the first harvesting time, to 49.7% at fifth harvesting time. Different cultivars varied in seed germination. In 2009 'Plea' and in 2010 'Clemson' cultivars showed the highest germination. Seeds from different parts of the plant also showed different germination rate. In 2009 seeds from the middle part of the plant with 54.3% and in 2010 seed from the lower part with 50.3 % showed the highest germination. In 2009 seeds from the lower part of pod showed more germination, whereas in 2010 seeds from middle part of pod produced higher germination. By increasing time to harvest, the percentage of seed germination after storage highly increased. Different cultivars during storage showed different behaviors on germination. 'Beloudo' cultivar produced more seed germination than other varieties after storage, and 'Pleas' after storage produced lower seed germination. Seeds from the middle part of plant and middle part of pod showed a higher germination after storage.

Keywords: harvesting time, okra, seedhardness, seed storage.

Introduction

Germination is a crucial stage in life cycle of plants (Mokhtar *et al*., 2009). Seed germination initiated by water imbibition, which results in the enhancement of key enzymes involved in the catabolism of seed storage reserves. These events are under the control of the seed's genetic make-up, but environmental conditions are also effective (Gusta *et al*., 2004). The testa, including the endosperm, has been shown to be a major barrier to radicle protrusion for many seeds (Kermode, 2005). *Abelmoschus esculentus* shows a particular kind of seed dormancy, called delayed permeability caused due to structure of the seed coat and particularly by the chalazal plug. There is a direct relationship between the seed moisture content and delayed permeability with variances between cultivars and moisture contents (Anonymous, 2005). The occurrence of hardseedness and the low percentage of seed germination are major challenges in growing okra (Luis Felipe *et al*., 2010). The percentage of seed germination of okra is frequently low, due to tegument impermeability (hard seeds). This is the major barrier to the emergence of okra seeds for commercial producers (Luis Felipe *et al*., 2010). There are differences among the okra cultivars in relation to hardseedness, resulting in lack of uniformity in seed germination. In some cultivars, the occurrence of hard seeds becomes more frequent the longer the pods remain in the plant (Luis Felipe *et al*., 2010). Hardseededness can be variable in a population of seeds. It increased by environmental (dry) conditions during seed maturation, and during seed storage (Baskin and Baskin, 1998). Harvesting slightly immature seeds and preventing them from completing desiccation can reduce hardseededness.

Okra (*Abelmoschus esculentus* (L.) Moench) crop exhibits seed hardness that complicates its management. This seed hardness interferes with seed germination, weed control, harvesting and other management factors. Hardseed coats in okra may cause slow and erratic emergence which is exacerbated at sub-optimal conditions. The degree of hardseedness in seeds of this species is influenced by a number of factors such as seed moisture content, time of harvest and drying rate during seed maturation (Demir, 2001). The hardseed coat of okra interferes water uptake and is a major physiological constraint to uniform stand establishment and performance (Marsh, 1992; Standifer *et al*., 1989). Demir (1997) reported that harvesting seeds at earlier stages of development, when seed moisture is still high (28 /40%) and drying seeds within the pod (slow drying) might eradicate the occurrence of hard seed coat and stimulates germination. If the combination of slow

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drying and after-ripening improves germination in seeds harvested at earlier stages of development (before seeds are dry and hardness has developed), then it may be possible to improve the germination of okra seed simply by modifying the traditional time of harvest, and introducing new drying procedures (Demir, 1994). Passam and Polyzou (1997) observed that the formation of hard seeds was particularly noticed when the capsules ripened during periods of high temperature. However, in Brazil, Setubal *et al*. (1994) observed that the proportion of hard seeds significantly increased when the harvesting was delayed until senescence of the plant. Chauhan and Bhandari (1971) reported that the best time for harvesting pods of 'Pusa Sawani' was 30 days after anthesis, when the pods were fully matured and dry seed germination recorded was 86%. Fruits of cultivar 'Amerilinho', harvested 55 days after anthesis, showed the highest (92%) seed germination in Brazil (Zanin *et al*., 1998). The developing seed attained germination capability at 21 days after anthesis, with the highest germination and vigor values at 30-36 days after anthesis. Similar observations for the 'Pusa Sawani' cultivar were recorded by Velumani and Ramaswamy (1976).

Okra seeds show conventional storage behavior in which the longevity is improved with desiccation and storage at chilling temperatures. High storage temperatures and high relative humidity reduces the storage life of seeds. Therefore, dry cool conditions are to be maintained for longer storage. Low seed moisture, preferably 5%-7%, is ideal for seed storage (Dhankhar and Singh, 2009). Agrawal (1980) stored okra seeds (10% moisture) for 37 months at ambient conditions. Moisture content of 13.6% or less was ideal for maintaining high seed viability for short periods, while 8% moisture maintained viability for several years at room temperature (Dhankhar and Singh, 2009). Low storage temperature is congenial for long-term storage. However, seeds with high moisture content are not suitable for sealed storage at low temperature. Seed viability rapidly decreased at higher storage temperatures, which promotes the leaching of electrolytes and solute sugar from the seeds (Doijode, 1986).

The aim of this work was to evaluate the effects of different harvesting time and storage on increasing germination and decreasing seedhardness of different okra cultivars.

Material and methods

The experiment was conducted at the Agricultural Faculty of Razi University, Iran, with the geographic longitude of 47°20'E and latitude of 34°20'N and elevation of 1351 meters above the sea level, in two years, 2009 - 2010. Climate characteristics of experimental location were shown in Tab. 1. The experiment was laid out in randomized complete block design under factorial arrangement with three replications. Four different cultivars of okra including, 'Clemson Seinless', 'Boiatloy', 'Beloudo' and 'Pleas' and six harvesting times (harvesting pods after flowering) were studied. Six harvesting times were as fallow:

T_1= Harvesting pods 20 days after flowering
T_2= Harvesting pods 25 days after flowering
T_3= Harvesting pods 30 days after flowering
T_4= Harvesting pods 35 days after flowering
T_5= Harvesting pods 40 days after flowering
T_6= Harvesting pods 50 days after flowering

Land preparation operations including plowing, disk and trowel to the desired way, before planting was done in the first half of May in both years. After taking track, map test was implemented on the ground. Planting okra cultivars as a spring planting on 30th of May was performed by hand. Each experimental unit of four rows was established. Each replicate contained 24 plots and each plot was 12 m^2 (3×4). Total area of the land was 1152 m. Crop was irrigated regularly once a week. Between the two replicates two meters distance was considered. The seeds were planted 3 cm deep on the sowing lines. Weeds were controlled by hand. After crop started flowering they were tagged and saved in envelops. 20, 25, 30, 35, 40 and 50 days after tagging, pods were collected. Each individual crop of okra divided in 3 different parts and pods tagged as a pod of low, middle and upper part of plant. Every pod was also divided into 3 different parts and seeds inside the pod tagged as low, middle and upper part of pod. Seeds in the pods were dried in shadow under air temperature. Initial and final seed moisture contents were calculated by the high temperature oven method (ISTA, 1985). Seed germination experiment was conducted using four replications of 25 seeds per each treatment. Seeds were sterilized using Mankuzeb fungicide and were placed on double layered Wathman No.1 filter paper moistened with distilled water

Tab. 1. Climate characteristics of experimental location 2009-2010

Month	Minimum temperature (°C)	Maximum temperature (°C)	Minimum humidity (%)	Maximum humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)	Minimum humidity (%)	Maximum humidity (%)
	2009				2010			
May.	8.6	24.3	27	76	9.1	9.1	32	86
Jun.	11	31.9	12	55	13.5	13.5	11	50
July.	25.6	37.7	7	34	16.5	16.5	7	34
Aug.	25.3	37.9	8	30	19.7	19.7	8	30
Sep.	14.6	34.1	13	40	15.4	15.4	9	37
Oct.	10.7	28	12	44	10.4	10.4	13	46
Average	15.9	32.3	13.1	46.5	14.1	14.1	13.3	47.1

in sterilized Petri dishes. Finally, all Petri dishes were placed in a germinator at 25°C for 21 days and every 2 days the number of germinated seeds were counted and removed, and in the case of moisture deficiency distilled water was added. A seed was considered germinated when the tip of the radicle had grown free of the seedcoat (Auld *et al.*, 1988, Wiese and Binning, 1987). For seed storage, seeds harvested in 2009, kept in freezer at 5°C for 12 months, were submitted to germination tests. Data were analyzed by using SAS statistical program and Duncan test was employed to classify mean values of different treatments when F-values were significant ($p<0.05$).

Results and discussion

The results of this study showed that in 2009 seed germination increased from 3.4%, at first harvesting time (T_1) to 46.4%, at fifth harvesting time (T_5), and in 2010 from 2.9%, at first harvesting time(T_1) to 49.7 (%), at fifth harvesting time (T_5) (Fig. 1). Most seedhardness occurred at sixth harvesting time (T_6) in both years, at this harvesting time only 20.2% of seeds, in 2009 and 19.5% of seeds, in 2010 germinated. Study of climate characteristics (Tab. 1) showed that in sixth harvesting time (T_6) seeds were faced with lower temperature, and this may be temperature induced impermeable layer occurrence in seeds. Temperature during pod development also influenced seed germination as it influenced the development and the hardness of the seed coat (Dhankhar and Singh, 2009). Seed moisture content at the time of harvest from the first harvesting time (T_1) to the last one (T_6) was declined, in this case dramatic decrease of 32% and 32.7% occurred from the fifth harvesting time (T_5) to the sixth harvesting time (T_6) in 2009 and 2010, respectively (Tab. 2). It seems that by reduction of seed moisture content, seedhardness was increased in seeds that at 50 days after anthesis. This result is consistent with the result of Demir (2001), which mentioned that seed coat impermeability increased as moisture levels of the seed decreased. The number of hard-seeds in garden beans was also found to increase as seed moisture decreased lower than 15% (Quinlivan, 1971). The highest and lowest seed moisture after drying was monitored in 2009 at second harvesting time (T_2) and last harvesting time (T_6) and in 2010 at first harvesting time (T_1) and last harvesting time (T_6), respectively (Tab. 2). It seems when immature okra fruits were harvested, the amount of dry matter of such fruits was fairly low, and this caused the seeds of these fruits not to have capability of good germination. Several studies are available on development of the seed within the capsule and the days to physiological maturity and harvesting. The highest seed germination was recorded when the pods were harvested 35 days (Ewete, 1980; Kanwar and Saimbhi, 1987) and 40 days after anthesis (Neupane *et al.*, 1991). Delay in harvesting reduced seed weight and germination percentage. Percentage of seed germination after storage by increasing

Tab. 2. Effects of different harvesting times on seed moisture content at 2009 and 2010

Harvest time (DAA)	Seed moisture (%) when harvested		Seed moisture (%) after drying	
	at 2009	at 2010	at 2009	at 2010
20	59,3	58,2	8,9	9,3
25	58,4	52,5	9,2	9,1
30	52	51,2	8,6	8,8
35	48,6	48	8,4	8,6
40	44,6	46	8,3	8,4
50	12,6	13,3	8,1	8,3

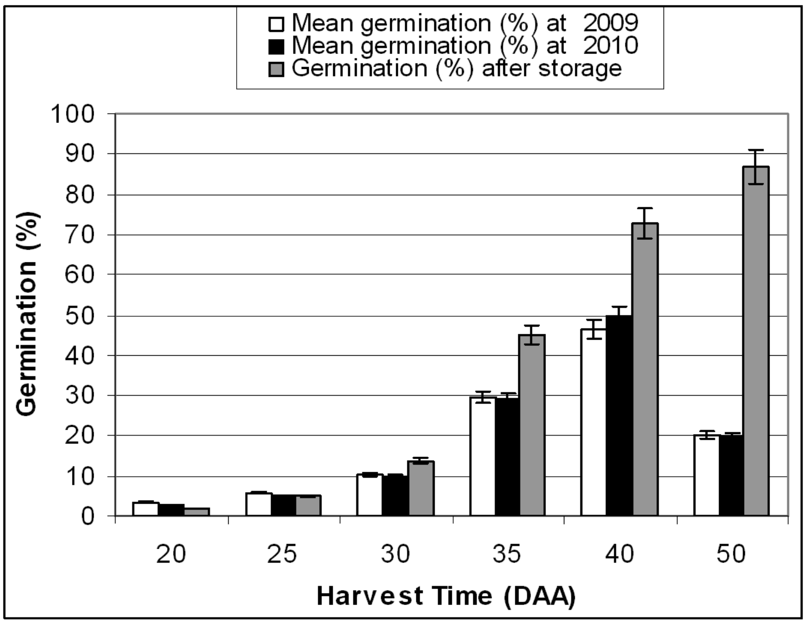

Fig. 1. Effect of different harvesting times and seed storage on mean germination in 2009 and 2010

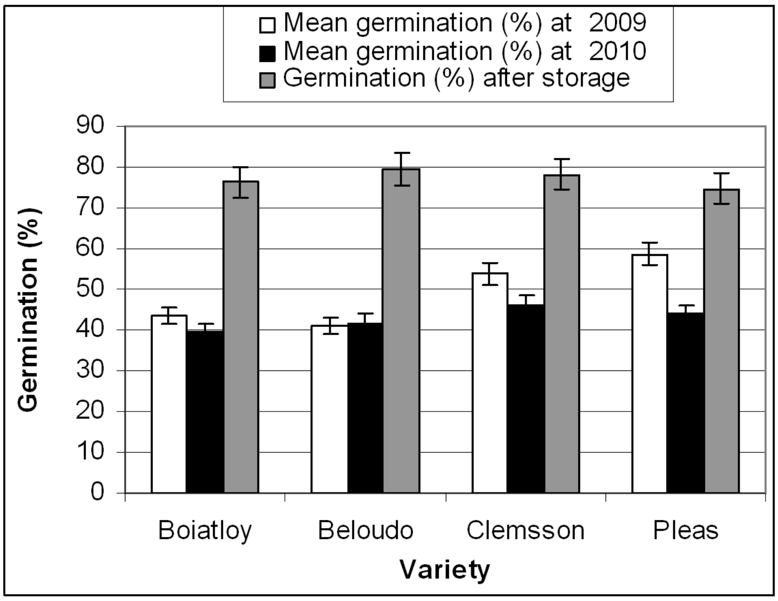

Fig. 2. Effects of variety and seed storage on germination in 2009 and 2010

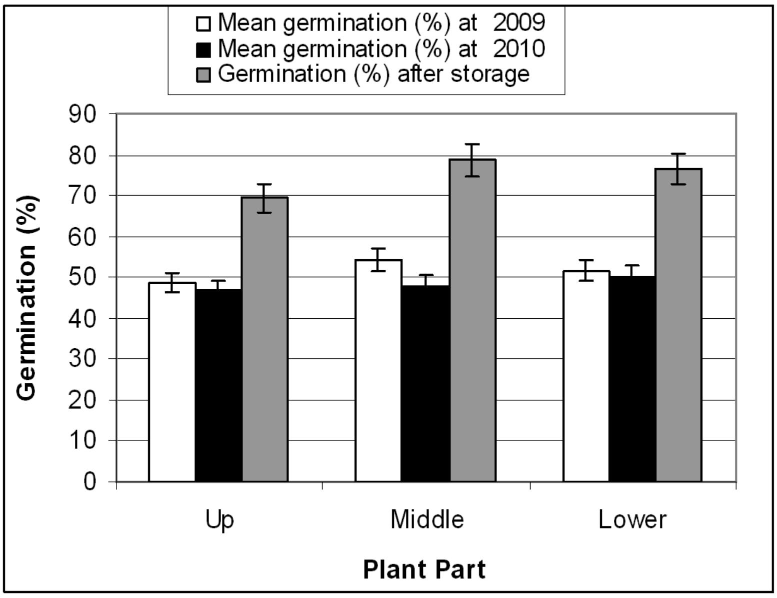

Fig. 3. Effects of different parts of plant and seed storage on germination in 2009 and 2010

time of harvest dramatically increased. Harvesting at 50 days after anthesis (T_6) in first germination test showed more seed hardness, subsequently after storage showed more seed germination (86.8%) (Fig. 1). It seems that storage of seeds, with a hard seed coat, for 12 months at 5°C caused overcome of seed hardness, so they germinate better. Okra seeds show conventional storage behavior in which the longevity improved with desiccation and storage at chilling temperatures. Low seed moisture, preferably 5%-7%, was ideal for seed storage (Dhankhar and Singh, 2009).

Different varieties showed different seed germination. In 2009 'Pleas' and 'Beloudo' varieties, while in 2010 'Clemson' and 'Boiatloy' varieties showed higher and lower germination, respectively. Considering lower germination of 'Beloudo' variety in 2009 and of 'Boiatloy' variety in 2010, it seems that these two had more seed hardness that caused less seed germination (Fig. 2). Study of seed moisture of different varieties showed that 'Pleas' variety in 2009 and 'Clemsson' variety in 2010 had more moisture content at the time of harvest and after drying. 'Boiatloy', which showed less seed germination in 2010, had less seed moisture content at the time of harvest, but after drying 'Clemsson' variety, in 2009, and 'Pleas' variety, in 2010, showed higher moisture content (Tab. 3). There is a direct relationship between the seed moisture content and delayed permeability with variances between cultivars and moisture contents (Demir, 2001). After storage, different varieties showed different germination behavior. Variety of 'Beloudo' after storage produced more germinated seeds than other varieties, while 'Pleas' variety after storage showed less germinated seeds (Fig 2). It seems a genetic

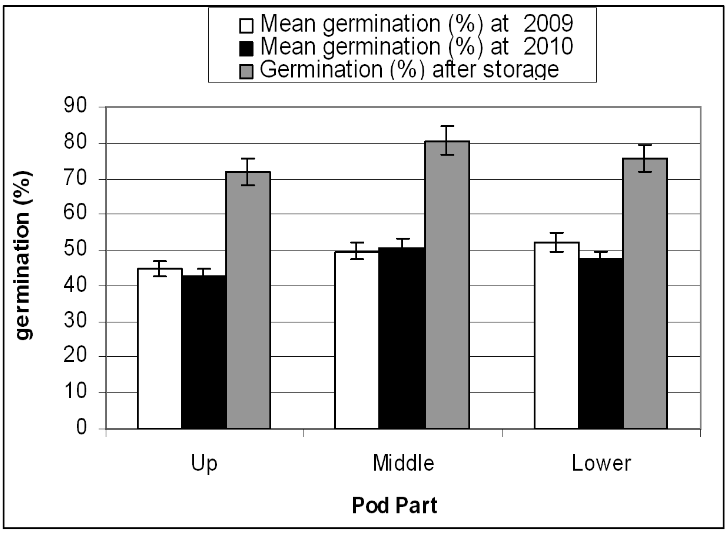

Fig. 4. Effects of different pod parts and seed storage on germination in 2009 and 2010

difference between varieties that caused different germination after storage. In okra, seed germination is influenced by the position of the fruit on the plant and the cultivar as well, Bhatt and Srinivasa Rao (1998) found considerable reduction in seed germination under field conditions compared to controlled conditions in different cultivars of okra. In some cultivars, the occurrence of hard seeds becomes more frequent the longer the pods remain on the plant (Purquerio *et al.*, 2010).

Tab. 3. The effects of the variety on seed moisture in 2009 and 2010

Variety	Seed moisture (%) when harvested		Seed moisture (%) after drying	
	at 2009	at 2010	at 2009	at 2010
'Boiatloy'	36,3	37	8.4	7.9
'Beloudo'	36	37.8	8.2	8.3
'Clemsson'	42.1	49.8	8.8	8.7
'Pleas'	49.4	49.2	8.5	9.2

Tab. 4. Effect of different plant parts on seed moisture in 2009 and 2010

Plant Part	Seed moisture (%) when harvested		Seed moisture (%) after drying	
	at 2009	at 2010	at 2009	at 2010
Up	49.3	47.3	7.9	8.1
Middle	52.0	51.7	8.7	8.9
Lower	48.7	48.5	8.3	8.4

Tab. 5. Effect of different parts of pod on seed moisture in 2009 and 2010

Pod Part	Mean germination (%) at 2009	Mean germination (%) at 2010	Germination (%) after storage
Up	44,6	42,5	71,8
Middle	49,7	50,6	80,6
Lower	52,3	47,4	75,6

Seeds from different part of plant showed different germination potential. In 2009 seeds from the middle part of the plant and in 2010 seeds from the lower part of the plant showed higher germination rate (Fig. 3). The same result was reported by Yadav *et al.* (2001), higher values of seed per fruit, test weight, germination, vigor index, and seed yield in fruits harvested from lower positions on the plant at Hisar, India under semiarid conditions. Also Naik *et al.* (2004) and Prabhakar *et al.* (1985) reported that quality of seeds harvested from the fruits born on lower nodes (up to the 8th node) were superior under tropical conditions at Bangalore, India. In their study the lowest value for these parameters was from seeds harvested from upper part of the plant. Study of seed moisture content showed that in both years, seeds from the middle part of the plant had more seed moisture content at the time of harvest and after drying (Tab. 4). Result showed that after storage, seeds from the middle part of plant showed more germination. In this study seeds from upper part of the plant after storage produced less germination (Fig .3).

Study of different parts of the pod showed that there is a difference between seeds in germination capacity. In 2009, seeds from the lower part of pod had more germination, whereas in 2010 seeds from the middle part of pod produced more germination (Fig. 4). Seeds from the upper part of pod in both years germinated less than other parts (Fig. 4). Purquerio *et al.* (2010) explained that seeds from pods located in the middle of the plant presented higher germination capacity than those extracted from pods located in upper parts of the plant. Seeds from different pod parts after storage also had different germination behavior. Seeds from the middle part of the pod after storage produced more germination. In this study seeds from the upper part after storage had less germination (Fig. 4). Malik *et al.* (2000) reported that seeds obtained from the pods of bottom and middle nodes have better germination even after the ambient storage of 32 months, whereas seeds obtained from pods just turning yellow and positioned at the bottom, middle, or top of mother plants maintained poor germination up to 8 months after harvest and latter lost their germinability and vigor very fast.

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