International Scholars Journals

International Journal of Agricultural Sciences ISSN 2167-0447 Vol. 10 (12), pp. 001-006, December, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Effect of moisture content and maturity on hardseededness and germination in okra (*Abelmoschus esculentus* L. Moench)

El Balla M. M. A.[1], Saidahmed A. I.[1] and Makkawi M.[2]*

[1]Department of Horticulture, Faculty of Agriculture, University of Khartoum, Shambat 13314, Sudan.

[2]Seed Technology Unit, Dhaid Research Station, Ministry of Environment and Water, United Arab Emirates.

Accepted 22 October, 2020

Hardheadedness is induced in the wild and the majority of seeds of the cultivated okra. Seed moisture content was highly significantly affected by cultivar and seed maturity. Seed moisture content within each cultivar significantly decreased with the increase in seed maturity. Averaged over seed maturity, Higairat had the highest moisture content percentage. On the other hand, Afreeta had the lowest moisture content percentage. Effect of interaction between cultivar and seed maturity on seed moisture content was not significant. Germination percentage and hard seed percentage were significantly affected by cultivar and seed maturity in both seasons. Averaged over cultivars, percentage germination increased significantly as harvest time was delayed. There was a significant interaction between seed maturity and cultivar on germination percentage. Cultivar and seed maturity had a highly significant effect on hard seed percentage of okra. Percentage of hard seed increased significantly as harvest time was delayed. The results also showed a significant interaction between cultivar and seed maturity on hard seed percentage. The correlation between seed moisture content, seed germination and hard seed percentage was highly significant. Moisture content was correlated positively to germination percentage (0.98) and negatively to hard seed percentage (-0.97), while germination percentage was negatively correlated to hard seed percentage (- 0.99). To analyze further, the relationship between seed moisture, germination percentage and hard seed percentage linear regression parameter and coefficient of determination were calculated. Linearity test showed that the relationship between moisture content and germination percentage and hard seed percentage was linear.

Key words: Okra cultivars, seed moisture content, maturity, hardseededness, germination.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) of the family Malvaceae is one of the most popular vegetables in Sudan. Its association with the local food in the different regions of the country created a great stable demand for it. It can be consumed after cooked as green pods and it is also used after dehydration (dried) and grinding as powder. The dried okra pods locally called "Waika" and are mostly obtained from the wild types found in the rain-fed areas of the Sudan, where wide natural genetic variability of okra exists.

Thick walls in some okra seeds delay germination. The seeds coats are often hard and the embryo can be slow to develop during germination. Consequently, treatments to seed coats which overcome hardseededness are generally required for germination. Ellis et al. (1985) reported that most of the annual cultivated *Hibiscus* spp. produces few hard seeds, whereas hard seed is prevalent in seed lots of wild *Hibiscus*. Hard seed coat is reported as the major reason for okra seed dormancy (Egley and Elmore, 1987). Some of the domestic cultivars

*Corresponding author. E-mail: mamakk_2000@yahoo.com.

e.g. White velvet produced few hard seeds which failed to survive longer than 3 months in the soil, while other domestic cultivars e.g. Dwarf Green Long Pod and Clemson spineless produced no hard seeds, which failed to survive over winter in the soil. At harvest, seeds of the cultivated *Hibiscus* spp. can show considerable dormancy.

Seeds of *Hibiscus esculentus* L. (Moench) at 13% moisture content tend to show little or no hardseededness, but once the seeds have been dried to 4 to 6% moisture content, hardseededness becomes prevalent, presenting a problem in germination tests of *H. esculentus* L. (Moench). The germination of okra seed was reported to be at maximum after 27 to 30 days after anthesis (Purewal and Randhawa, 1947; Chauhan and Bhandari, 1971; El- Hag, 1979). Manohar (1969) indicated that seeds of okra harvested at 21 days from flowering had the maximum germination (97%). Demir (1997) reported that okra seeds (cv Akkoy) failed to germinate until 32 DAA and that percent of hard seeds increased to 52% when the moisture content dropped to 10% and remained stable in later harvests. The highest germination percentage was obtained from seeds harvested at 39 and 43 DAA with a high moisture level (32 to 44%). Slow drying stimulated germination of seeds harvested at earlier stages of development and at higher moisture contents (Demir, 1997).

Most of the cultivated okra lines in the Sudan are local selections from the indigenous types, and are characterized with high degree of variability. Okra's growers in the Sudan continuously complain from the poor and erratic seed germination of some cultivars, where some of the seed germinate and the others remained in the soil for weeks and sometimes months. This lack of uniformity in germination in most cases forced the farmers to re sow. It was decided, therefore, to carry out this study to investigate the effects of seed maturity on seed germination and dormancy of some of the local strains and cultivars of okra.

MATERIALS AND METHODS

Field experiment

This study was carried out in the demonstration farm of the Faculty of Agriculture, Shambat, Sudan (Latitude 15°, longitude 32° 31'E). Healthy seeds of five cultivars and strains of okra namely; Raiba, Higairat, OL11, Pusa sawani, Khartoumia, Kassala and a wild strain called "Afreeta" were planted in the field during "summer" and "Kharief" in a randomized complete block design. Seeds of Afreeta were submerged before planting in concentrated sulfuric acid for 6 h to circumvent seed coat impermeability, then thoroughly washed, dried and planted in the field within the experiment. Seeds were planted in holes in rows on top of ridges, at spacing of 70 cm between ridges and 30 cm between holes.

The plots were irrigated on the same day of planting, then at interval of 5 to 7 days between irrigations. Plants were thinned to two plants per hole after two weeks from sowing. At flowering, approximately 25 flowers per plot were randomly tagged and bagged at the day of anthesis for a period of 12 days with 3 days interval. Seeds were harvested after 21, 24, 27, 30 or 33 days from the day of anthesis.

Seed moisture determination

Random samples were taken for seed moisture content determination immediately after picking following the method described by Robert and Robert (1972) . Fresh seeds were weighed and dried in an oven at 105°C for 24 h, and then weighed again and percent moisture content was calculated on wet basis.

Germination test

The seeds were evaluated for germination capability after drying for 4 days at room temperature (approximately 30°C). Four replicates of fifty seeds from each sample were planted in moist, germination paper towels and placed in polyethylene bags, labeled, then placed in upright position in a germination cabinet adjusted at 25°C for a period of 21 days. Germination counts were made at 4 and 21 days after planting. The germination criterion was taken as the visible protrusion of the radicle through the seed coat. Ungerminated seeds, which failed to imbibe water, were referred to as hard seed. Numbers of germinated and hard seeds were recorded at the end of the germination test.

Statistical analysis

The data are transformed by using square root transformation according to Gomez and Gomez (1984) then subjected to analysis of variance and means compared by least square differences (LSD).

RESULTS

Effects of genotypes and seed maturity on seed moisture content

Seed moisture content was highly significantly affected by cultivar and seed maturity. Seed moisture content within each cultivar significantly decreased with the increase in seed maturity (Table 1). At averaged over seed maturity, Higairat had the highest moisture content percentage (53.6). On the other hand, Afreeta had the lowest moisture content percentage (29.88). Effect of interaction between cultivar and seed maturity on seed moisture content was not significant.

Effects of genotypes and seed maturity on germination percentage

No germination was recorded in Afreeta; due to this, the data of Afreeta was excluded for the purpose of statistical analysis. Germination percentage and hard seed percentage were significantly affected by cultivar and seed maturity in both seasons. At averaged over cultivars, percentage germination increased significantly as harvest time was delayed from 21 to 24, 24 to 27, 27

Table 1. Effect of genotypes and seed maturity on seed moisture content (%).

Genotype	Seed maturity (days after flower anthesis)											
	First season						Second season					
	21	24	27	30	33	Means	21	24	27	30	33	Means
Pusa Sawani	63.1	55.0	44.5	32.1	11.9	41.3	62.2	54.2	44.6	31.7	11.3	40.8
OL 11	75.1	64.8	55.1	41.0	17.9	50.8	74.0	65.2	54.5	40.5	17.5	50.2
Higairat	77.2	70.0	61.2	44.3	18.8	54.3	76.0	69.0	60.4	43.8	19.0	53.6
Khartoumia	75.3	63.8	53.1	36.0	14.7	45.6	74.0	64.0	52.0	37.5	15.0	48.5
Raiba	68.6	59.0	48.1	35.2	12.3	44.6	69.0	60.1	49.2	34.5	13.0	45.2
Kassala	59.0	52.0	41.2	30.1	9.00	38.3	58.8	51.4	42.5	30.6	10.4	38.7
Afreeta	45.0	38.6	32.0	21.0	8.10	29.0	44.8	39.5	33.2	24.9	7.0	29.9
Mean	66.2	57.6	47.9	34.3	13.2	43.8	65.5	57.6	48.1	34.8	13.3	43.9
LSD for genotype				1.29						0.53		
LSD for maturity				1.09						0.45		
LSD for genotype*maturity				NS						NS		

Table 2. Effect of genotypes and seed maturity on germination percentage of okra seed.

Genotype	Seed maturity (days after flower anthesis)											
	First season						Second season					
	21	24	27	30	33	Means	21	24	27	30	33	Means
Pusa Sawani	7	27	32	37	39	28	5	37	31	35	37	29
OL 11	7	39	69	72	71	52	8	41	69	73	72	53
Higairat	4	46	65	76	77	54	5	54	68	64	76	54
Khartoumia	5	33	56	64	65	45	4	32	58	64	64	44
Raiba	7	41	57	63	62	46	6	39	56	61	60	44
Kassala	5	18	30	43	45	28	4	20	31	42	44	28
Afreeta	0	0	0	0	0	0	0	0	0	0	0	0
Mean	6	34	52	59	60	42	5	36	52	59	59	42
LSD for genotype				0.82						0.52		
LSD for maturity				0.75						0.54		
LSD for genotype*maturity				1.83						2.05		

to 30 days. Seeds harvested after 33 days had the highest germination percentage, however no significant difference was observed between seeds harvested after 30 and 33 days (Table 2).

At averaged over seed maturity, the highest germination percentage was reported by Higairat followed by OL11. No germination was reported in Afreeta in both sowing dates. There was no difference between Kassala and Pusa sawani in both sowing dates and the germination of Khartoumia and Raiba was also similar in the first sowing date.There was a significant interaction between seed maturity and cultivar on germination percentage. Seed germination increased in all cultivars with the delay in harvest time from 21 to 24, 24 to 27, 27 to 30 days. Delaying harvest from 30 to 33 days had no effect on germination percentage in most cultivars, except in Kassala in the first sowing and Higairat in the second sowing date (Table 2).

Effects of genotypes and seed maturity on hard seed percentage

Cultivar and seed maturity had a highly significant effect on hard seed percentage of okra. Percentage of hard seed increased significantly as harvest time was delayed from 21 to 24, 24 to 27, 27 to 30 and 30 to 33 days (Table 3). The highest number of hard seed was recorded on Afreeta followed by Pusa sawani, and the lowest percentage was obtained from Higairat in both sowing dates. The results also showed a significant interaction between cultivar and seed maturity on hard

Table 3. Effect of genotypes and seed maturity on hard seed percentage of okra seed.

Genotype	Seed maturity (days after flower anthesis)											
	First season						Second season					
	21	24	27	30	33	Mean	21	24	27	30	33	Mean
Pusa Sawani	5	27	48	53	54	37	6	29	49	55	55	39
OL 11	4	5	14	19	21	13	3	3	13	18	20	11
Higairat	1	4	10	16	16	9	3	2	11	13	14	9
Khartoumia	3	12	21	25	26	17	4	15	23	26	27	19
Raiba	3	11	25	33	34	21	5	9	26	29	31	20
Kassala	1	19	39	48	50	31	2	18	39	43	45	29
Afreeta	26	50	69	86	91	64	24	57	67	85	92	65
Mean	6	18	32	40	42	28	7	19	33	39	41	27
LSD for genotype	1.10						1.18					
LSD for maturity	0.93						1.00					
LSD for genotype*maturity	2.47						2.47					

Table 4. Correlation coefficients.

Test	Moisture content	Hard seed
Germination test	0.98	-0.99
Moisture content		-0.97

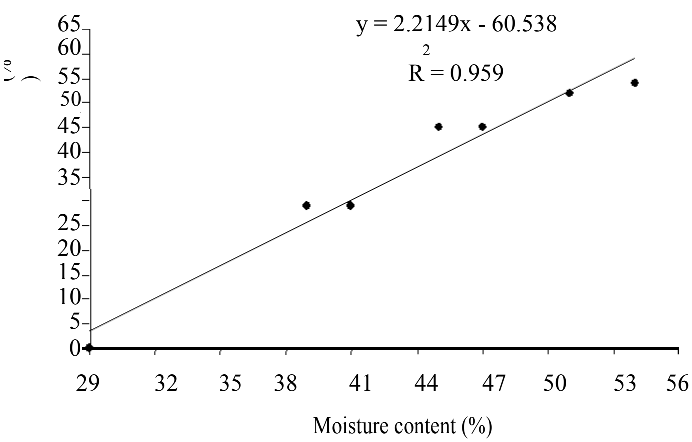

Figure 1. Relationship between moisture content and germination percentage in okra.

seed percentage. The hard seed percentage increased significantly as harvest time was delayed from 21 to 24, 24 to 27 and 27 to 30 days after anthesis in all cultivars. However, no significant difference was observed between seed harvested after 30 and 33 days from anthesis, with the exception of Afreeta (Table 3).

The correlation studies were calculated. The correlation between seed moisture content, seed germination and hard seed percentage was highly significant. Moisture content was correlated positively to germination percentage (0.98) and negatively to hard seed

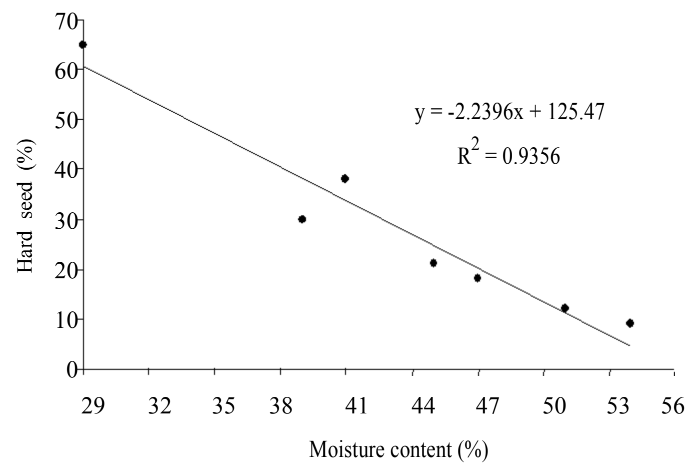

Figure 2. Relationship between moisture content and hard seed percentage in okra.

percentage (-0.97), while germination percentage was negatively correlated to hard seed percentage (-0.99) (Table 4). To analyze further, the relationship between seed moisture, germination percentage and hard seed percentage linear regression parameter (slope and intercept) and coefficient of determination were calculated. Linearity test showed that the relationship between moisture content and germination percentage and hard seed percentage was linear, the equations were; $y = 2.21x - 60.5$; $R^2 = 96\%$ (Figure 1) and $y = 125.5 + 2.24x$; $R^2 = 94\%$ (Figure 2), respectively, while germination and hard seed percentage was $y = 64.4 - 1.01x$; $R^2 = 98\%$ (Figure 3).

DISCUSSION

The cultivars had a highly significant effect on hard seed

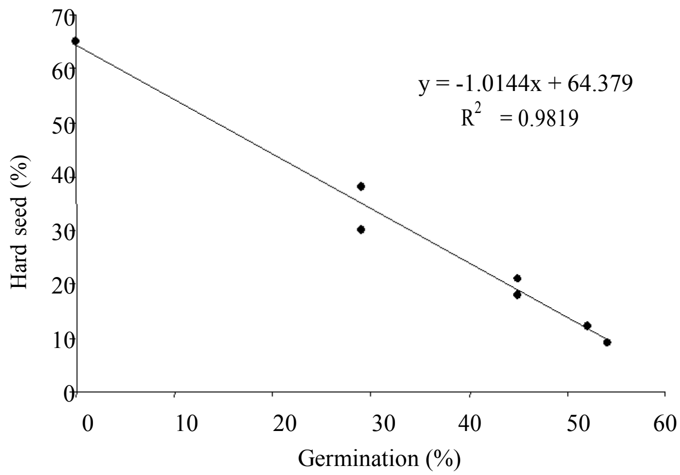

Figure 3. Relationship between germination and hard seed percentage in okra.

percentage and germination percentage. Higairat had the highest mean germination percentage while Pusa sawani and Kassala had the lowest germination percentage. On the other hand, Afreeta had the highest hard seed percentage while Higairat had the lowest hard seed percentage. These differences between cultivars may be due to differences in the structure of their seed coat, while differences between cultivated and wild okra may be due to difference in seed size and/or difference in hardness of the seed coat.

El Hassan (1982) obtained similar results on two collections of wild okra. Edmond and Drapala (1959) found marked and consistent varietal differences in percentage of germination of five varieties of okra. Cseresnyes (1979) indicated that seed dormancy in sunflower (*Helianthus annus*) seed varied with cultivars. Ellis et al. (1985) and Standifer et al. (1989) emphasized that germination and hardseededness in okra vary among cultivars. The hard seed percentage increased significantly in all cultivars with the increase in the maturity of seed. This may be due to the deposition or development of hard cuticle or impermeable cell layer of the seed coat during the later stages of seed development. Helengeson (1932) reported that seed of sweet clover (*Melilotus alba*) changed from permeable to impermeable as the seed mature. Marbach and Mayer (1975) observed that dormancy in wild pea (*Pisum elatus*) seed increased as seed maturity increased. Similarly, Egley (1979) noted that impermeability in showy crotalaria (*Crotalaria spectabilis*) seed was acquired during the later stages of maturation on the parent plants.

The hard seed percentage increased and the seed moisture content decreased as seed matured. It seems probable that seed moisture content is an important factor in the development of hard seed. Hyde (1954) found that moisture content during seed ripening on *Trifolium patense*, *Trifolium repens* and *Lupinus arborcus* fell rapidly to about 25% and thereafter more slowly until the seed coat became impermeable at a moisture content of 14%. Similar results were reported by Quinlivan (1971), Ellis et al. (1985) and Standifer et al. (1989) suggesting that seed moisture is an important factor in hard seed development with the critical level of moisture required for germination varying among cultivars.

Results of this experiment show that in all cultivars tested, the germination percentage significantly increased as seed maturity increased. However, no significant differences were observed between seeds harvested after 30 and 33 days from anthesis. It seems that seeds of most of the cultivars reached maturity after 30 days from anthesis. Chauhan and Bhandri (1971) reported that okra seeds harvested at 30 days from anthesis had the maximum percentage. While, Demir (1997) reported that okra seeds (cv Akkoy) failed to germinate until 32 DAA and that the highest germination percentage was obtained from seeds harvested at 39 and 43 DAA with a high moisture level (32 to 44%) . The variation in the number of days to full maturity is attributable to climatic conditions especially the variation in the prevailing temperature during seed maturation. The work reported by Demir (1997) was conducted in Turkey under relatively low temperature, while that of Chauhan and Bhandri (1971) was conducted under relatively warm temperature similar to the present study. This may also be due to maturity of the cultivars, where some cultivars were early maturing cultivars with earlier seed maturation.

REFERENCES

Demir I (1997). Occurrence of hardseededness in relation to seed development in okra (*Abelmoschus esculentus* L). Plant Varieties Seeds, 10: 7-13.

Chauhan KS, Bhandri YM (1971). Pod development and germination studies in okra. Indian J. Agric. Sci., 41: 852-856.

Cseresnyes Z (1979). Studies on the duration of dormancy and methods of determining the germination of dormant seeds of *Helianthus annus*. Seed Sci. Technol., 7: 179-188.

Edmond JB, Drapala WJ (1959). The effect of temperature and immersion in H_2SO_4 and acetone on germination of five varieties of okra seed. Proc. Am. Soc. Hortic. Sci., 74: 601-606.

Egley GH (1979). Seed coat impermeability and germination of showy crotalaria (*Crotalaria spectabilis*) seeds. Weed Sci., 27: 355-361.

Egley GH, Elmore CD (1987). Germination and the potential persistence of weedy and domestic okra (*Abelmoschus esculentus* L.) Moench) seeds. Weed Sci., 35: 45-51.

El Hassan GM (1982). The effect of soaking in concentrated sulfuric acid for different period and filling on the germination of wild okra. Sudan Agric. J., 10:112-115.

Ellis RH, Hong TD, Roberts EH (1985). Handbook of seed technology for gene banks. Compendium of specific germination information and test recommendations. Int. Board Plant Genet. Resour., Rome, II: 211-667.

Helengeson EA (1932). Impermeability in mature and immature sweet clover seed s as infected by condition of storage Wisconsin Academy of Science. Cited by Crocker and Barton, 1957. Physiol. Seed, 27: 193-206.

Quinlivan BJ (1971). Seed coat impermeability in legumes. J. Aust. Inst. Agric. Sci., 37: 283-295.

Marbach I, Mayer AM (1975). Permeability of seed coat to water as

related to drying conditions and metabolism of phenolics. Plant Physiol., 54(6): 817- 820.
Standifer LC, Wilson PW, Drummond A (1989). The effect of seed moisture content on hardseededness and germination in four cultivars of okra (*Abelmoschus esculentus* (L.) Moench). Plant Varieties Seeds, 2: 149-154.
Purewal SS, Randhawa GS (1947). Studies in *Hibiscus esculentus* (Lady's finger) 1. Chromosome and pollination studies. Indian J. Agric. Sci., 17: 129-136.
El-Hag MA (1979). Some aspects of okra seed production. M.Sc, thesis Faculty of Agriculture, University of Khartoum, Sudan, p. 120.
Manohar MS (1969). Pod development and germination of Bhindi (*Abelmoschus esculentus*). Exp. Agric., 7: 249-255.