

INFLUENCE OF HARVESTING STAGE ON SEED QUALITY ASPECTS OF PUMPKIN (*Curcubita pepo* L.).

The availability of certified seeds to rural farmers is very important for sustainable agriculture in developing countries. Farmers usually harvest the fruits of pumpkin purposely for food then use the on seed at planting yet the fruit age at maturity may not coincide with the seed quality. This results in the mixture of mature and immature seeds at harvest hence causing poor seed quality. This study was done to examine the influence of harvesting stage-Days After Anthesis-(DAA) on seed quality aspects of pumpkin. Four harvesting stages (30 DAA, 40 DAA, 50 DAA and 60 DAA) were done on two pumpkin types at three sites. The seeds from fruits harvested at 60 DAA showed higher seed weight, germination and vigour compared to those from fruits harvested at an earlier stage of 30 DAA. This showed that seed physiological maturity occurred at 60 DAA. Seed weight, germination and vigour for the two pumpkin types were not significantly different at $P \leq 0.05$. In spite of the different harvesting stages and pumpkin types, the best seed qualities were observed for seeds harvested from Cheptebo compared to seeds from Kaiboi and Eldoret. This showed that higher temperature at Cheptebo favoured better physiological maturity evaluation in the pumpkin.

Key words: Harvest, Germination, Site, Maturity

INTRODUCTION

Pumpkin crop is very useful in curbing food insecurity because its fruits, leaves and seeds are edible and contain a high level of protein, oil, vitamin and minerals (Chukwudi and Agbo, 2014). Hull-less seeds are usually used in pharmaceutical products (Baxter et al., 2012).

Pumpkin fruit is rich in carbohydrate, protein and antioxidant activities. These antioxidants are required to boost the human body immunity against cancer and other deadly human diseases (Oswell et al., 2007). Pumpkin also enhances biodiversity which is important in crop improvement and adaptation to the changing environmental conditions, thus the sustainability of farming systems (Virchow, 2003). Pumpkin crop is extensively grown throughout the tropical and sub-tropical countries and thus considered a high value crop (Rhaman et al., 2013).

Even though pumpkin is highly nutritive, medicinal and has the potential of food biodiversity, its seed certification has not been looked into, hence low seed quality level. Farmers usually obtain on-farm seed after harvesting pumpkins, from their neighbours or at the market place where seeds are sold. The farmers usually harvest the pumpkin fruit at complete plant senescence, purposely for food and then use the seeds that are extracted from the fruit in planting for the following season, thus causing a long term poor pumpkin seed quality (Yao et al., 2012). According to (Laercio et al., 2012), production of high quality seed in *Curcubits* depends on the fruit age at harvest.

Harvesting of seeds at optimum stage of physiological maturity helps to obtain better quality seed. Harvesting stage influences the quality of seed in relation to germination, vigour, viability and also storability (Kole and Gupta, 2002). The maturity stages have been found to induce changes in moisture percentage, physical and chemical properties of the seed during their growth

and development. The rate of decline in vigour increases with increase in relative humidity, temperature and seed moisture after the seed attains physiological maturity. Seeds harvested at the right stage (physiological maturity) are well developed, matured and possess maximum viability and vigour (Kharif, 2004). Seeds that are harvested early have been found to be immature and poorly developed, therefore, are poor stores compared to seeds harvested at physiological maturity (Singh and Lachanna, 2005). Higher vigour seeds were obtained from fruits harvested at 60 or 70 DAA, and storage of such fruits before seed extraction could not improve their performance (Vidigal et al., 2009).

Farmers find pumpkins ready for harvest when the stalk becomes cracked and corky. The rind should also be hard for thumb or finger nail entry. The rind colour should also turn from being glossy to being dull. The maximum production of pumpkins is best at temperatures between 20°C to 35°C and can take about 13 to 25 weeks for it to mature depending on variety and climate (Napier, 2009).

MATERIALS AND METHODS

Site description

The experiment was done at three agro-ecological zones represented by Cheptebo AIC farm (0° 26' 34" North and 35° 36' 52" East), Kaiboi Technical Training Institute farm (00° 19' 00" North and 35° 10' 00" East) and University of Eldoret farm (0° 31' 0" North, 35° 17' 0" East) respectively of North Rift Region of Kenya.

Planting materials

Two local pumpkin (*Curcubita pepo* L.) seeds from round shaped fruit characterized by bulged seeds and oval-shaped fruit characterized by relatively flattened seeds obtained from the farmers

were planted during the rainfall season (from May to August 2015) at the experimental farm of University of Eldoret (Uasin-Gishu county), Cheptebo AIC farm (Elgeyo Marakwet county) and Kaiboi Technical Training institute farm in Nandi county at an intra-row and inter-row spacing of $4\text{m} \times 6\text{m}$.

To obtain vigorous seedlings, then good yield, Diammonium phosphate fertilizer was used at planting. This field was regularly maintained by three weedings. Approximately 150 pistillate flowers were tagged at anthesis, and 150 fruits which developed from them were manually harvested by simple rupture of stalk at 30, 40, 50 and 60 days after anthesis (DAA).

Experimental design

The experimental sowing design in the field was Randomized Complete Block Design laid in split plot, in which the whole plot was variety and the sub-plot was harvesting stage; done on two types of seeds (from round fruited pumpkin and oval fruited pumpkin), 4 fruit ages (30, 40, 50 and 60 DAA) blocked by 3 sites (Cheptebo, U.O.E, Kaiboi T.T.I). Completely Randomized Design was then used in the laboratory for seed testing.

Data collection and analysis

Seed tesing was done at the seed science laboratory, using a substratum made of sand. Pumpkin seeds from the harvested fruits of each age (30, 40, 50 and 60 DAA) were extracted, then they were thoroughly washed with running tap water and then sun-dried at ambient air ($22\text{-}32^{\circ}\text{C}$) for a period of one week until constant weight. A thousand seed weight from each site and harvesting stage was then collected.

4 subsamples of 25 seeds from each lot were placed in sand moistened with distilled water. The sowed pumpkin seeds were then incubated at 25°C . The first count was done at four days from

sowing and the last count eight days after sowing (ISTA, 1999). The results were expressed as a percentage of normal seedlings and the average percentage calculated to the nearest whole number. Seed vigour was recorded by the rate of seedling growth, which was done by measuring the seedling height from the fourth day from sowing to the tenth day from sowing so as to show the rate of growth.



FIGURE 1: Fruit morphology of two types of pumpkin; (A) Round fruited and (B) Oval fruited (C) Seeds of the Round fruit and (D) Seeds of Oval fruit harvested at 60DAA.

DATA STATISTICAL ANALYSIS

The data obtained for each parameter was subjected to ANOVA using General Linear Model; PROC GLM procedure for (SAS, 2012). The treatment means for each test was compared by protected Fischers test Least Significant Difference (LSD) at $P \leq 0.05$ level of probability. Standard errors of means were presented in tables and figures throughout the study.

a) Model for analyzing seed weight and germination

$$Y_{ijk} = \mu + V_i + S_j + VS_{ij} + H_k + VH_{ik} + \Sigma_{ijkl}$$

RESULTS

TABLE 1: A thousand seed weight in grams (g).

SITE	TYPE	HARVEST (DAA)			
		30	40	50	60
ELDORET	ROUND	4.03±0.22d	6.30±0.47c	9.05±0.89b	25.95±1.02a
	OVAL	2.45±0.44d	5.65±0.31c	8.35±0.52b	21.43±3.39a
KAIBOI	ROUND	6.55±1.80d	10.50±1.02c	15.80±0.37b	28.58±1.58a
	OVAL	4.15±0.66d	7.43±0.36c	10.85±0.48b	24.20±2.22a
CHEPTEBO	ROUND	7.83±0.52d	12.40±2.16c	27.00±0.62b	39.45±2.28a
	OVAL	5.93±0.28d	8.85±1.37c	22.80±2.55b	29.03±1.11a
	MEAN	5.15	8.52	15.64	28.10
	SD	1.98	2.62	7.29	6.10

DAA; Days After Anthesis.

Means with different letters are significantly different at $P \leq 0.05$ using protected Fischers test Least Significant Difference (LSD); $\pm$ SD n=4.

The different harvesting stages of pumpkin fruits from different sites showed a significant difference ($p < 0.05$). Harvesting at 60 DAA resulted in the highest germination percentage and was significantly different from 50 DAA, 40 DAA and 30 DAA but there was no significant difference from the harvesting stage of 40 DAA and 30 DAA (Figure 2).

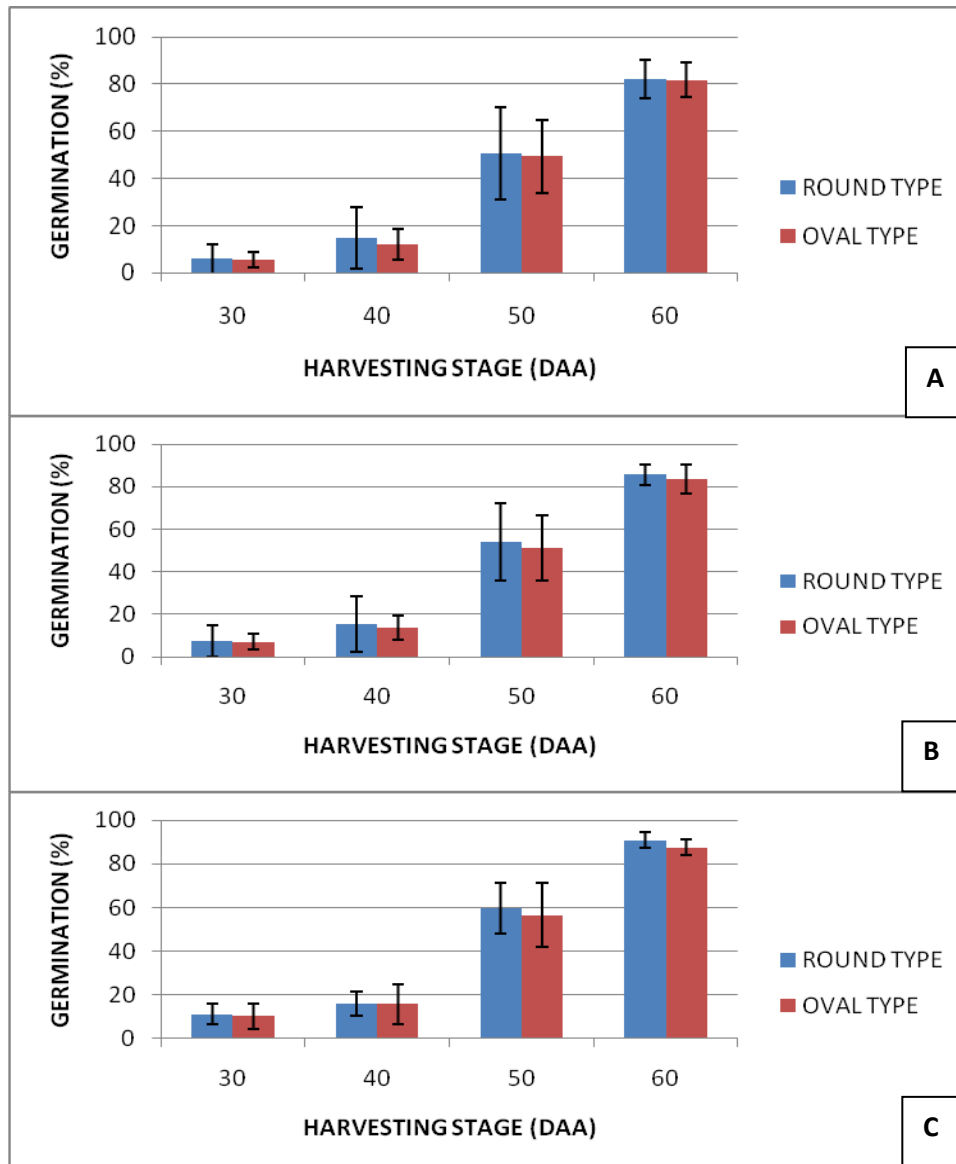


FIGURE 2: Germination percentage of pumpkin seeds harvested at different stages from A (Eldoret), B (Kaiboi) and C (Cheptebo). Error bars represent Standard Deviation (SD) n=15

Effect of harvesting stages on pumpkin seed vigour

The seedling growth rate at different harvesting stages of pumpkin fruits was significant at ($P \leq 0.05$). Harvesting at 60 DAA resulted in the highest seedling growth rate which was significantly different from 50 DAA, 40 DAA and 30 DAA. The two pumpkin types (round and oval shaped), were not significantly different at $P \leq 0.05$.

The seedling growth rate of pumpkin seeds from different sites was significant at $P \leq 0.05$. The pumpkins harvested from Cheptebo showed higher seedling growth rates compared to those harvested from Kaiboi and Eldoret (Figure 3 and Figure 4).

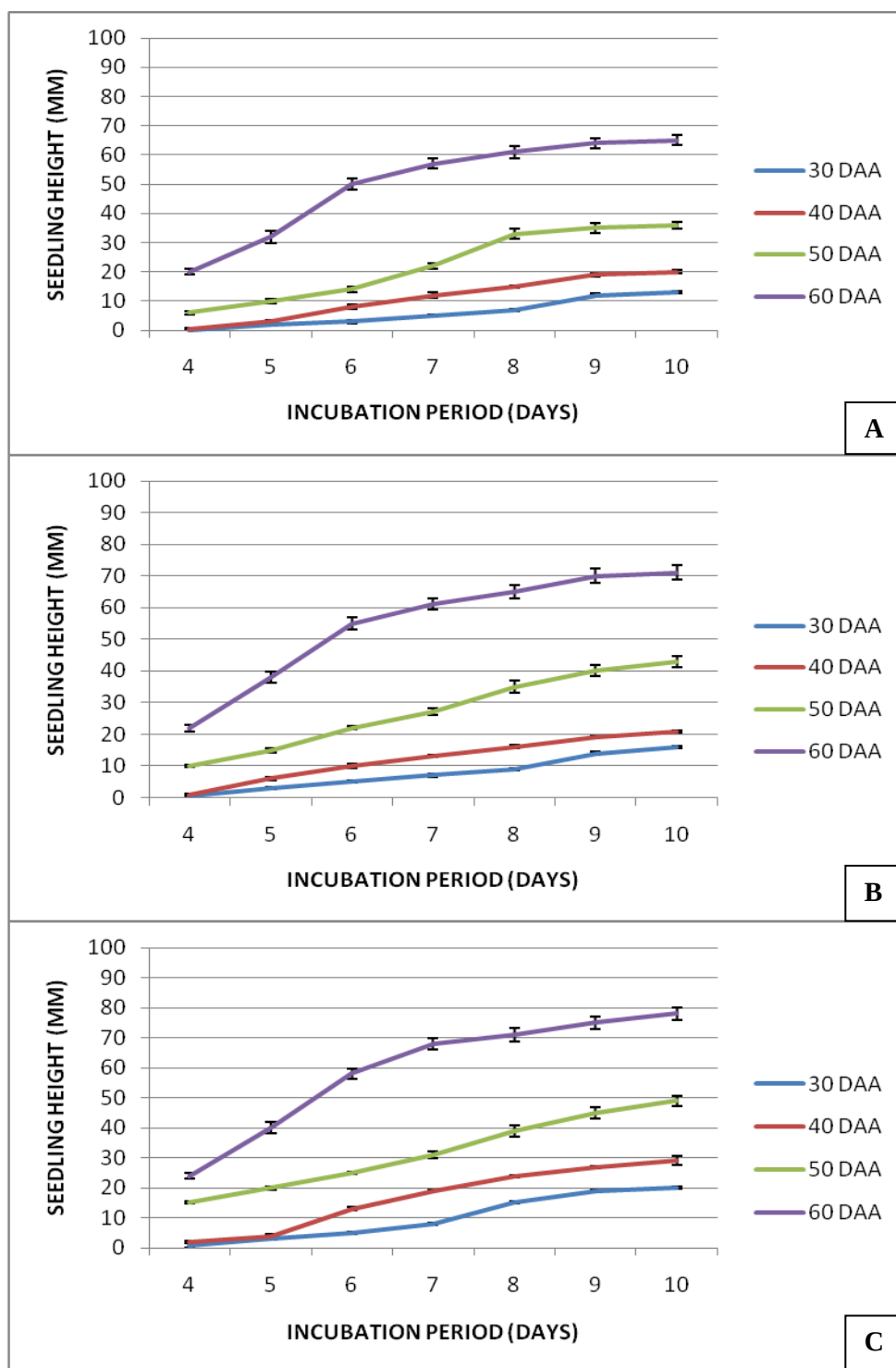


FIGURE 3: Round type of pumpkin from A (Eldoret), B (Kaiboi) and C (Cheptebo). Error bars represent Standard Deviation (SD) n=5

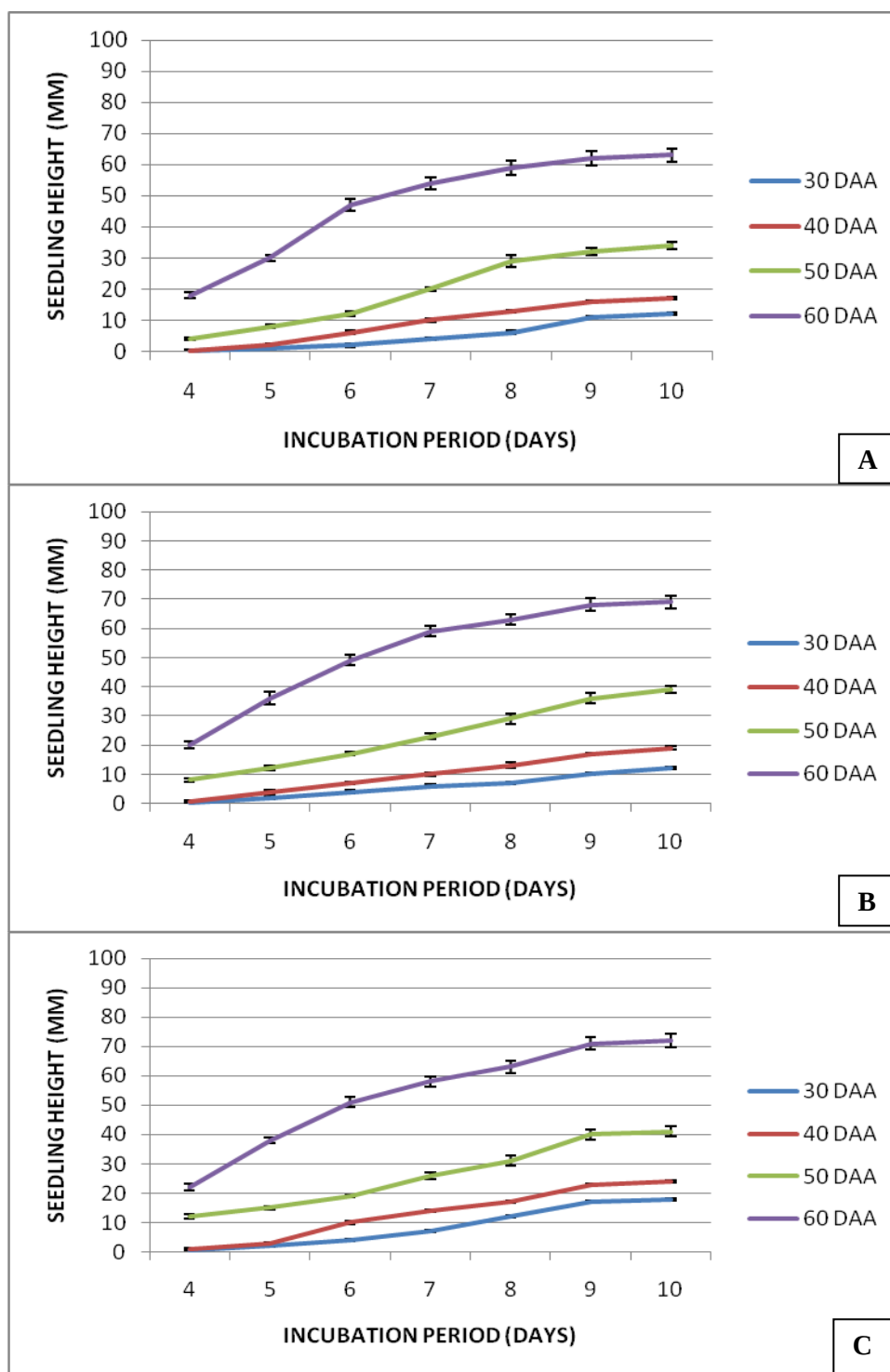


FIGURE 4: Oval type of pumpkins from A (Eldoret), B (Kaiboi) and C (Cheptebo). Error bars represent Standard Deviation (SD) n=5

TABLE 2: Electrical Conductivity (μsg^{-1}) test results for harvesting stages at (30, 40, 50 and 60 DAA) from Eldoret (UOE), Kaiboi (TTI) and Cheptebo (AIC).

SITE	TYPE	HARVEST (DAA)			
		30	40	50	60
ELDORET	ROUND	61.3 $\pm$ 5.24a	59.3 $\pm$ 4.7ab	48.0 $\pm$ 2.31bc	46.3 $\pm$ 2.33c
	OVAL	65.3 $\pm$ 3.29a	62.0 $\pm$ 4.51a	51.3 $\pm$ 0.88b	49.7 $\pm$ 0.88b
KAIBOI	ROUND	58.7 $\pm$ 4.91a	56.7 $\pm$ 4.37ab	46.0 $\pm$ 2.31bc	44.3 $\pm$ 2.33c
	OVAL	62.3 $\pm$ 2.9a	59.7 $\pm$ 4.84a	49.0 $\pm$ 0.58b	47.3 $\pm$ 1.2b
CHEPTEBO	ROUND	56.3 $\pm$ 5.24a	55.7 $\pm$ 3.85a	43.7 $\pm$ 2.03b	42.7 $\pm$ 2.6b
	OVAL	60.7 $\pm$ 2.96a	57.7 $\pm$ 4.84a	46.0 $\pm$ 0.58b	45.3 $\pm$ 1.2b
	MEAN	60.8	58.5	47.3	45.9
	SD	6.80	6.94	3.48	3.57

DAA; Days After Anthesis.

Means with different letters are significantly different at $P \leq 0.05$ using protected Fischers test Least Significant Difference (LSD); $\pm$ SD n=4.

TABLE 3: Weather conditions for Kaiboi, Eldoret and Cheptebo as of the year 2015

SITE	TEMPERATURE ($^{\circ}\text{C}$) (APRIL-AUGUST)	RAINFALL (MM) (APRIL-AUGUST)
KAIBOI	18	600
ELDORET	23.7	280.8
CHEPTEBO	30	107.5

DISCUSSION

The seed quality response to physiological maturity was carried out in pumpkin with respect to type and site of the experiment. The results showed that the effect of the different harvesting stages at different sites had effect on seed germination and seedling growth rate.

There was a significant increase in the dry weight of pumpkin seeds from 30 to 60 DAA. The dry mass was small in the early stages of fruit growth (30 DAA) while in the late and final stage of 60 DAA, the fruits had a higher dry matter accumulation. The seed dry mass is considered as one of the surest measures of seed maturity. These findings agree with (Costa et al., 2006), who say that seed reaches physiological maturity when it reaches maximum dry weight. This increase in seed weight also caused an increase in seed germination percentage due to the increase in seed embryo reserves from seeds extracted from fruits harvested at 60DAA compared to those extracted from fruits harvested at 30DAA.

The seedling growth rate was slow at 30 DAA, compared to the seedling growth rate at 60 DAA which was higher and faster. According to Acacio et al., 2015, these results indicate that initially, seeds had lower physiological quality, thus releasing high amounts of leachate due to the low structure and selectivity of the membranes hence a lower rate of seedling growth. Later there was a lower release of solutes as a result of proper cell membrane structuring as the physiological maturity approached and this led to a higher rate of seedling growth, thus, high seed vigour. These values can vary depending on the length of the vegetative cycle and cucurbit species.

The reduction in seed germination and vigour varied due to the different growing seasons because of the changes in temperature and rainfall conditions during vegetative, reproduction and harvesting periods. Seed quality was modified by the environment during seed development and maturation. Adverse weather conditions have a strong relation with seed quality aspects. In mustard seeds for example, there is accumulation of soluble sugars through starch synthase activity and Late Embryogenesis Abundance (LEA) proteins when approaching maturity. The

solutes, enzymes and proteins contribute to grain development, followed by storage longevity and dessication tolerance (Maity and Chakrabarty, 2013).

Crops grown under open-field conditions are usually exposed to abiotic and biotic stress factors which deter productivity and quality. The growth, development and post-harvest quality of any crop depends on the interaction between plant genetics and the environmental conditions in which they are grown. Environment is the overall of all the external conditions that influence the growth and development of plants. The crops have to be adapted to the region in which they are produced so as to be profitable. The environmental factors, such as temperature, light intensity and relative humidity influence crop growth and development. Temperature is the main regulator of crop development processes. Higher temperatures have more influence on the net photosynthesis than lower temperatures. Relative humidity reduces evaporation loss from plants hence maximum nutrient utilization. It also causes the maintenance of cell turgidity which helps in enzyme activity, leading to a higher yield. Cucumber and cluster bean had higher yields in open-field than in the shadenet because these crops required more light-intensity and high temperature for better growth and development (Rajasekar et al., 2013).

REFERENCES

- Acacio F.N., Almeida F.A.C, Vieira J.F and Maraisa F. da Silva (2015). *Physiological Maturity of Pumpkin Seeds*. African Journal of Agricultural Research Vol. 10(27), pp.2662-2667.
- Baxter G.G., Murphy K. and Paech A. (2012). The potential to produce Pumpkin seed for Processing in North East Victoria. Rural Industries Research and Development Corporation, Canberra.
- Chukwudi U.P. and Agbo C.U. (2014). *Influence of fruit characteristics on seeds and seedling emergence of fluted pumpkin (Telfairia occidentalis Hook F.)*. The Journal of Animal and Plant Sciences, 24(2): 2014, Pg: 600-605 ISSN: 1018-7081.
- Costa CJ, Carmona R, Nascimento WM. (2006). *Idade e tempo de armazenamento de frutos e qualidade fisiológica de sementes de abóbora híbrida*. Rev. Bras. Sementes 28 (1):127-132.
- Hamisy, W.C., Makundi, A.H., Marandu, D. & Nkya, M.J. (2002). *Evaluation of five accessions of Curcubita maxima collected from different ecological zones in Tanzania*. The Second International Workshop on Plant Genetic Resources and Biotechnology Report, Arusha, Tanzania, p. 6-10.
- Indira G. Krishi (2004). *Results of Kharif 2003 and proposed programme of Kharif 2004*. Indira Gandhi Krishi Vishwaridyalaya, Raipur. 293p. en Technical Report.
- International Seed Testing Association .(1999). *International Rules for Seed Testing*. International Seed Testing Association, Zurich, Switzerland.
- Kole, S. & Gupta, K. (2002). *The timing of physiological maturity of seeds of sunflower: evaluation through multiple tests*. Seed Sci. & Tech. 10: 457-467.
- Laercio, J.S., Denise F.S.D., Carla C.M & Luiz Antonio S.D. (2012). *Relationship between fruit maturation stage and physiological quality of Physic nut (Jatropha curcas L.) seeds*. Agricultural Sciences vol.36 no.1 pp.1413-7054.
- Maity A. and Chakrabarty S.K. (2013). *Effect of environmental factors on hybrid seed quality of Indian Mustard (Brassica juncea)*. Seed Technology Division, Indian Grassland and Fodder Research Institute, Jhansi, up-284003.
- Muendo, K.M. & Tschirley, D. (2004). *Improving Kenya's Domestic Horticultural Production and Marketing System: Current Competitiveness, Forces of Change, and Challenges for the Future*. Vol. I: Horticultural Production. Working Paper No. 08A/2004
- Napier Tony (2009). *Pumpkin Production*. Primefacts. District Horticulturist Vegetables, Riverina, Yanco.

- Oswell, F. N., Rufaro, M.M., K. Susan, K. & Arnold, B.M. 2007. *Indigenous knowledge of the traditional vegetable pumpkin (Cucurbita maxima/moschata) from Zimbabwe*. African Journal of Agricultural Research, 2(12):649-655.
- Rahman M.A., Miaruddin M., Khan M.H.H., Masud M.A.T and Begum M.M. (2013). Effect of storage periods on postharvest quality of pumpkin. Bangladesh J.Agril.Res.38(2):247-255.
- Rajasekar M., Arumugam T. and Kumar R.S. (2013). *Influence of weather and growing environment on vegetable growth and yield*. Department of Horticulture, Agricultural College and Research Institute, TNAU, Madurai-625104, Tamil Nadu.
- Robinson, R.W. & Decker-Walters, D.S. (1997). *Cucurbits*, p. 226. CAB International University Press, Cambridge
- SAS Institute Inc. (2012).SAS/STAT 9.3 User,s Guide, 2nd ed. SAS Institute Inc, Cary, NC.
- Singh, A. R. & Lachanna, A. (2005). *Effect of dates of harvesting, drying and storage on seed quality of sorghum parental lines*. Seed Res. 13: 180-185.
- Vidigal, D.S., Dias, D.C.F.S., Von Pinho, E.R.V. & Dias, L.A.S. (2009). *Sweet pepper seed quality and LEA-protein activity in relation to fruit maturation and post-harvest storage*. Seed science and Technology: 37,192-201.
- Virchow, D. (2003). *Financing the Conservation of Crop Genetic Resources*, p. 21-54. In: Virchow, D. (ed.). Efficient Conservation of Crop Genetic Diversity. Theor Approaches and Emp Studies.
- Yao K.B., Konan A. J., Koffi, K. K. & Baudoin J.P. (2012). *Effect of fruit age, pre-storage and seed fermentation durations on seed germination and seedling vigour in Legenaria siceraria*. Journal of Applied Biosciences 49: 3339-3351.