International Journal of

Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 6 (3): 299-305, 2011
ISSN 1816-4897 / DOI: 10.3923/ijar.2011.299.305

Seed Size and Seed Cut-length Effects on Germination Behavior and Seedling Growth of Avocado (*Persea americana* Merr.)

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ABSTRACT

The objective was to determine the combined effect of seed sizes and seed cutting lengths on avocado seed germination behavior and seedling growth. The experimental treatments were a factorial combination of three seed sizes and three seed cut-lengths in a randomized complete block design with three replications. Cutting of avocado seeds hastened seedling emergence such that seeds with cut-length of 1.5 cm resulted in the earliest emergence of seedlings in 18 days. Medium seed with seed cut-length of 1.5 cm resulted in the shortest time to 50% germination whereas small-sized seed without seed cut delayed the period to 50% germination. Seedling height, leaf area and canopy size were controlled by similar factors along the growth path. In the early stages of seedling growth (WASG) variation in seedling height, leaf area and canopy size were determined by the seed cut-length. However, in the advanced stages of seedling growth (6 to 8 WASG), seed size was the determining factor in variation in seedling height, leaf area and canopy size. There were positive and highly significant correlations among leaf area and canopy size of seedlings ($r = 0.87$; $p = 0.002$), leaf area and seedling girth ($r = 0.99$; $p = 0.000$), canopy size and seedling girth ($r = 0.99$; $p = 0.000$) and number of leaves and seedling girth ($r = 0.99$; $p = 0.000$). The study concluded that mass propagation of avocado seedlings with assured uniformity was possible with medium to large-sized seeds with 1.5 cm cut-length at the distal end.

Key words: Avocado, germination, seedling growth, seed size, seed cut-length

INTRODUCTION

Avocado (*Persea americana* Merr.) is an important subtropical and tropical woody crop cultivated by its nutritious fruits (Toerien, 1999). Its world production is estimated to reach 4.7 million tonnes by 2012 (Market Research Analyst, 2008) with an accompanying consumption rate of 5% (GEPC, 2009). It is a nutrient-dense food (Rainey *et al*., 1994) and in Ghana, it commands a high price in the lean seasons of September to January of the following year. Its cultivation is predominantly found in the forest regions where the climate, soils and vegetation are optimal for its production. Over the years, nurseries have experienced problems with avocado propagation due to a variable germination period of rootstock seeds, which frequently force the nurseries to extend the propagation period as they wait for late-germinating seedlings to achieve graftable size (Sauls and Campbell, 1980). However considering the demand for avocado in both local and international markets, it is paramount importance to explore measures that can enhance the rate of germination of avocado seeds and thus increase seedling uniformity to facilitate mass propagation. In earlier studies, Eggers (1942) and Kadman (1963) reported that early germination was increased by seed coat removal although the practice was difficult and time consuming on many types of avocados. Subsequent research showed that increased germination rate was also facilitated by treatment of seeds with gibberellic acid (Duarte *et al.*, 1974; Leah *et al.*, 1976) a hot water (49-50°C) (Zentmyer and Ohr, 1978) and fungicides (Erwin and Ribeiro, 1996; Adjei *et al.*, 2010). In another study, Sauls and Campbell (1980) rather recorded a reduction in total germination through cutting of both apical and basal ends of the seeds and attributed it to embryo damage due to seed separation during cutting and planting. Although cutting of seeds is a more practical approach to the mass propagation of avocado seedlings, there is no information on the seed germination behavior of avocado if only one end of the seed is cut as well as relating it to seed size considering the fact that there is variation in seed sizes in avocado. This study was therefore undertaken to determine the combined effect of three seed sizes and three seed cutting lengths on avocado seed germination behavior and seedling growth.

MATERIALS AND METHODS

The experiment was conducted at the Department of Horticulture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, (KNUST), Kumasi Ghana from September to December, 2009. Avocado seeds were extracted from non-diseased fruits. The seeds were treated with Contizeb '5' fungicide with Mancozeb as the active ingredient at the rate of 1.3 g L^{-1} of water for 30 min. The seeds were air-dried and the seed coats removed. The experimental treatments were a factorial combination of three seed sizes and three seed cut lengths in a randomized complete block design with three replications. The seed sizes comprised small (≥3.0 cm); medium (3.1-4.0 cm) and large (>4.0 cm). The seed cut lengths also comprised 0 cm (no cut), 1.0 cm cut length and 1.5cm cut length. The seed were cut at the distal end. Polyethylene bags of 14×18 cm sizes with sandy-loam soil which was sieved and pasteurized was used for potting the seeds. Each treatment had ten experimental units. There were 270 experimental units for the entire experiment. Data collected included number of days to emergence, number of days to 50% germination, number of germinated seeds, seedling height, seedling girth, leaf area estimate of seedling and the canopy spread of the seedling.

Statistical analysis: Collected data was analysed by using one-way analysis of Varience and mean was compared by Lsd at 0.05 level of Significance.

RESULTS

Number of days to emergence and 50% germination: Cutting part of avocado seeds hastened seedling emergence such that seeds with cut length of 1.5 cm resulted in the earliest emergence of seedlings, significantly different from the 1 cm cut length (Table 1). Seeds without cut took the longest time to seedling emergence.

On the other hand, there was significant seed size×seed cut length interaction for number of days to 50% germination. Medium seed with seed cut length of 1.5 cm resulted in the shortest time (22 days) to 50% germination whereas small-sized seed without seed cut delayed the period (37 days) to 50% germination (Table 2). Generally, seeds with cut length of 1.5 cm hastened germination as compared to seeds without cut.

Table 1: Effect of length of seed cut on time to seedling emergence

Seed cut length	Number of days to seedling emergence
No cut (0 cm)	22.7
1 cm cut length	20.3
1.5 cm cut length	18.0
LSD (0.05)	1.91

Table 2: Time to 50% germination (days) as influenced by the combined effect of seed size and seed length cut

	Seed size			
Seed cut length	Small	Medium	Large	Mean
No cut (0 cm)	37.0	28.0	34.0	33.0
1 cm cut length	30.0	27.0	28.0	28.3
1.5 cm cut length	25.0	22.0	25.0	24.0
Mean	30.7	25.7	29.0	29.0
LCD (0.05)	Cut length = 3.25	Seed size = 3.25	Cutlenght×Seed size = 5.63	

Table 3: Effect of length of seed cut on seedling height at one and two weeks after seed germination

	Seedling height (cm)	
Seed cut length	1 WASG	2 WASG
No cut (0 cm)	10.3	14.5
1 cm cut length	14.1	15.6
1.5 cm cut length	15.9	17.4
LSD (0.05)	3.46	2.53

Table 4: Effect of seed size on seedling height at six, seven and eight weeks after seed germination

	Seedling height (cm)		
Seed size	6 WASG	7 WASG	8 WASG
Small (≤3.0 cm)	34.3	36.1	37.3
Medium (3.1-4.0 cm)	39	41.4	43.2
Large (>4.0 cm)	37.5	39.8	41.6
LSD (0.05)	4.41	4.18	4.42

Plant height of seedlings: There were no significant interactions between cotyledon cut-length and seed size for seedling height. In the early stages of seedling growth (1 and 2 weeks after seed germination), variation in seedling height was determined by the length of seed cut. Cutting of seed to 1.5 cm in length produced significantly taller seedlings than the uncut seed which produced the shortest seedlings (Table 3). However, during the advanced stages of seedling growth (6 to 8 weeks after seed germination), seed size became the determining factor in seedling height variation such that medium-sized seeds produced significantly taller seedlings than the small-sized seeds, the difference being 14.7% (Table 4).

Seedling girth: There was significant variation in seedling girth due to differences in seed size. In general, the medium and large sized seeds produced seedlings with significantly bigger girths than the small seed (Table 5).

Seedling leaf area: There were no significant interactions between seed cut-length and seed size for seedling leaf area. Similar to the seedling height, in the early stages of seedling growth

Table 5: Effect of seed size on seedling girth at three, four, five, six and seven eight weeks after seed germination

	Girth (cm)					
Seed size	3 WASG	4 WASG	5 WASG	6 WASG	7 WASG	8 WASG
Small (≤3.0 cm)	0.4	0.5	0.5	0.6	0.6	0.6
Medium (3.1-4.0 cm)	0.5	0.6	0.6	0.6	0.6	0.7
Large (>4.0 cm)	0.5	0.6	0.6	0.6	0.7	0.7
LSD (0.05)	0.05	0.05	0.04	0.04	0.04	0.04

Table 6: Effect of length of seed cut on seedling leaf area at one, two and three weeks after seed germination

	Leaf area (cm^2)		
Cotyledon cut length	1 WASG	2 WASG	3 WASG
No cut (0 cm)	2.54	30.28	51.33
1 cm cut length	7.36	38.10	64.65
1.5 cm cut length	10.19	55.30	75.68
LSD (0.05)	3.90	13.05	16.36

Table 7: Effect of seed size on seedling leaf area at four, five, six and seven eight weeks after seed germination

	Leaf area (cm^2)				
Seed size	4 WASG	5 WASG	6 WASG	7 WASG	8 WASG
Small (≤3.0 cm)	95.42	101.48	103.87	110.03	114.44
Medium (3.1-4.0 cm)	109.29	114.79	116.93	119.75	124.74
Large (>4.0 cm)	124.64	129.5	131.26	134.22	136.19
LSD (0.05)	13.84	12.71	14.00	13.74	14.04

Table 8: Effect of length of seed cut on seedling canopy size at one, two and three weeks after seed germination

	Canopy size (cm)		
Seed cut length	1 WASG	2 WASG	3 WASG
No cut (0 cm)	3.10	11.10	19.40
1 cm cut length	8.30	14.70	21.90
1.5 cm cut length	8.60	18.10	25.90
LSD (0.05)	2.68	3.44	3.76

(1 to 3 weeks after seed sowing), variation in seedling leaf area was determined by the length of seed cut. Cutting of seed to 1.5 cm in length produced seedlings with significantly larger leaves than the uncut seed which produced seedlings with the smallest-sized leaves (Table 6). In the advanced stages of seedling growth (4 to 8 weeks after seed sowing), seed size became the determining factor in seedling height variation such that the large-sized seeds produced seedlings with significantly larger leaves than the medium and small-sized seeds (Table 7).

Canopy size: Cutting of seeds (1 or 1.5 cm) resulted in significantly bigger canopy size of seedlings than the uncut seeds during the early growth periods (Table 8). On the contrary, during the later stages of growth, bigger canopy sized seedlings were produced by larger-sized seeds, significantly different from those of small sized seeds, although similar to those of the medium sized seeds (Table 9).

Table 9: Effect of seed size on seedling canopy size at six and seven eight weeks after seed germination

	Canopy size (cm)		
Seed size	6 WASG	7 WASG	8 WASG
Small (≤3.0 cm)	31.1	31.3	32.4
Medium (3.1-4.0 cm)	32.8	33.5	34.2
Large (>4.0 cm)	34.2	34.6	35.7
LSD (0.05)	2.12	1.99	2.66

Table 10: Correlations among selected plant growth parameters

Parameters	Leaf area	Canopy size	No. of leaves	Plant girth
Leaf area	-	r = 0.87 (p = 0.002)	r = 0.25 (p= 0.517)	r = 0.99 (p = 0.000)
Canopy size	r = 0.87 (p = 0.002)	-	r = 0.46 (p= 0.213)	r = 0.99 (p = 0.000)
No. of leaves	r = 0.25 (p= 0.517)	r = 0.46 (p = 0.213)	-	r = 0.99 (p = 0.000)
Plant girth	r = 0.99 (p=0.000)	r = 0.99 (p = 0.000)	r = 0.99 (p = 0.000)	-

Relationships among growth parameters: There was positive and highly significant correlation between leaf area and canopy size of seedlings. Similarly, correlations between plant girth and canopy size, leaf area and number of leaves were positive and highly significant. However correlations between number of leaves and leaf area and canopy size were low and not significant yet positive (Table 10).

DISCUSSION

Avocado seeds undergo physiological dormancy that prevents embryo growth and seed germination until chemical changes occur (Fenner and Thompson, 2005). The Avocado seed is also known to exhibit an embryo-related dormancy caused by the cotyledons (Sanchez-Romero *et al.*, 2007) and which require removal before seed emergence could take place. In this present study, the cutting of the seeds might have facilitated the chemical changes that needed to occur as well as the removal of the embryo dormancy, for embryo growth and subsequent seedling emergence to take place. The shortest period to seedling emergence exhibited by seeds with 1.5 cm cut length implied that a bigger cutting was better in removing the inhibiting factors than a smaller cutting. On the other hand, the delayed period to seedling emergence from the uncut seeds could be attributed to the longer presence of the inhibiting factors in the seed.

Rate of seed germination was influenced by the size of seed in combination with the longest cut length of 1.5 cm. In seed size, the medium and large germinated faster than the small and could be attributed to their proportional food reserves. Similar findings on seed size have been reported for *Zea mays* (Khan *et al.*, 2005) and *Castanea sativa* (Cicek and Tilki, 2007). The dependence of seedling height, in the early stages, on the seed cut length was primarily due to the earliness in emergence but as growth progressed, the seed size became the dominant factor in determining seedling height, a reflection of the differential food reserve capacity of the various seed sizes. Similarly the bigger seedling girth from both medium and large seeds as compared to the small seeds could also be explained by the large food reserves in the medium to large seeds which led to enhanced seedling expansion. Similar observations were made in seedling growth of *Glycine max* (Singh *et al.*, 1972), *Ipomea batatas* (Thakur and Upadhya, 1994) and *Quercus* spp. (Bonfil, 1998). These food reserves in seeds have been found to be mainly carbohydrates and soluble proteins (Thakur, 1987). Seedling leaf area and canopy size also followed the trend of having seed cutting length and seed size dominating the early and advanced growth stages, respectively. Canopy size of seedling correlated highly and positively with seedling leaf area which suggested that good seedling canopy could be obtained from maintenance of a large leaf area of the seedlings. Plant girth also correlated highly and positively with leaf area and canopy size. The large leaf area enhances photosynthesis, with subsequent implications for increased dry matter accumulation which promotes canopy development. Furthermore, the increased dry matter accumulation results in plant girth expansion. Consequently, it is of paramount importance to maintain a large leaf area and canopy size of the seedling if the required girth for seedling grafting could be obtained within a reasonable time period. Accordingly, nursery practices such as moisture conservation and pests and diseases control that would enhance the development of the leaf area as well as the canopy size should be encouraged.

CONCLUSION

Avocado seed emergence, germination and seedling growth are largely determined by seed cut length and seed size. Medium to large-sized seeds with 1.5 cm cut are necessary for enhanced avocado seed germination and seedling growth particularly of plant girth development, an important pre-requisite to good grafting.

ACKNOWLEDGMENT

The authors are very grateful to the Department of Horticulture for the provision of Technicians and other appropriate tools in the execution of the study.

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