International Journal of Agricultural Research

ISSN 1816-4897

Academic Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 8 (1): 26-33, 2013
ISSN 1816-4897 / DOI: 10.3923/ijar.2013.26.33

Influence of Different Seed Size Fractions on Seed Germination, Seedling Emergence and Seed Yield Characters in Tropical Soybean (*Glycine max* L. Merrill)

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ABSTRACT

Seed size is a component of seed quality which has impact on the performance of crop and variations exist in seed sizes among varieties. Seed size is a key factor in crop improvement. However, scarce information is available on relationship between seed size, seed quality and yield characters in elite tropical soybean. Therefore, the study was initiated to determine the influence of seed size on the seed quality traits, seed yield and yield components of five tropical soybean varieties. Seeds of each variety were graded into large (S1), medium (S2) and small (S3). The graded seeds were tested in the laboratory for seed germination and 100 seed weight and the same seed lots was then grown on the field and evaluated for seedling emergence, seed yield and yield characters. Variety TGx1485-ID consistently displayed superior 100- seed weight of between 12.18 and 16.64 g before sowing at each of the three seed sizes. M-351 variety with large seed size had maximum seed germination (100%) in all the three classes of seed and seedling emergence in large (95%) and medium seeds (93%). Lots with small seed size had maximum seed germination (97%) and emergence (90%) while those with large seed size produced the highest seed per plant (88), pods per plant (54) and seed yield per plant (9.72 g). It is suggested that seed grading could be done to separate small seeds for superior seed quality and large seed size for high seed yields.

Key words: Genetic make up, small- medium- and large- seed size, seed fraction

INTRODUCTION

Yield, being a complex quantitative trait, is influenced by various component traits. For effective improvement, simultaneous improvement of the most important yield component is necessary. Soybean seed yields have been erratic during the past few years in Nigeria. Low yield and failure of the crop are attributed to several causes principally poor seed quality, inadequate breeding efforts and environmental conditions among others (Ojo, 2000; Ellis, 1992; Odiemah, 1991; Adebisi *et al*., 2004a, b). Solutions can be obtained with good seed characteristics and field management practices.

The effect of seed size on crop improvement has attracted the attention of research workers for many years. According to Dhillon and Kler (1976), seed size in cereals and legumes appears to influence the grain yield. Production of more fruits, larger seeds and higher seed yield per plant from plants grown from large seeds was reported by Ahmed and Zuberi (1973) in Brassica. In contrast, high yields from plants grown from small seeds were reported by Dhillon (1973) in soybean and Merchetti (1994) in wheat. Reddy *et al.* (1989) observed that soybean varieties with large seeds flowered and matured earlier and produced large seeds, high yield and high harvest index. This superiority may be attributed to the high seedling vigour resulting from extra food reserves present in large seeds (Burris *et al.*, 1971, 1973; Fortes and Ohlrogg, 1972). Ries (1971) in bean (*Phaseolus* sp.) and Reddy *et al.* (1989) in soybean reported non- significant effect of seed size on yield. Large seeds are considered to be ideal for high yields (Fortes and Ohlrogg, 1972). In contrast, Sato and Kamiyama (1956) could not find any relationship between seed size and yield in soybean crop. However Adejare (2010) reported that large seed size of elite maize had higher seed quality and higher seed yield compared to other medium and small sizes.

Seed quality is a collection of seed properties which are considered to be of importance for the value of seed for sowing purposes (FAO, 1999). Seed size is one of the components of seed quality which affects the performance of crop (Ojo, 2000; Adebisi, 2004; Adebisi *et al.,* 2011). Soybean genotypes differ in their ability to maintain seed quality (Adebisi and Ajala, 2000; Adebisi and Ojo, 2001). Germination of seed indicates its power to reproduce a new plant. It is conditioned by a regular embryo development and the amount of available food reserves. These two components are necessary pre-requisites for the development of a normal embryo, a vigorous seedling and a well- developed plant. Milosevic *et al.* (1992) observed that seed size fraction of sugar beet differed in the dynamics of seed germination. A positive correlation exists between seed size and quality (Snyder and Filban, 1970; Benati *et al.*, 1988) reported that seed of large size germinates more quickly, it is stronger in the first developmental stages, has better root weight and higher yield than small ones. Ayo-Vaughn *et al.* (2010) reported a strong relationship between seed weight and potential longevity in NERICA rice. Adebisi *et al.* (2011) also reported that selection for superior 300-seed weight would result in improved seed longevity in soybean.

If seed size influences seed quality and yield, it would be advantageous to sow seeds that give the best seed quality and highest yield. From the available literature it appears that nothing or not much research has been aimed at resolving this issue in Nigerian soybean varieties. Therefore in the light of the advantages of seed grading, an attempt was made in tropical soybean to estimate the effect of seed size on the seed quality, seed yield and yield characters.

MATERIALS AND METHODS

Seeds of five promiscuous cultivars of soybean; M-351, TGX1485-ID, TGX1019-EN, TGX1649-11F and TGX1831-32E obtained from International Institute of Tropical Agriculture (11TA), Ibadan were used for the study.

Seeds of the five varieties were multiplied to obtain sufficient seeds in 2007 cropping season and tested for effect of seed size in 2008 (first trial) and 2009 (second trial) in both seed laboratory and field. All the recommended cultural practices for the crop were followed.

Two kilogrammes of cleaned seed of each variety were separated into three sizes; large, medium and small. Seeds were graded into large size (SI) by retaining on 16/64" sieve, medium size (S2) by retaining on 15/64"seive and small size (S3) by retaining on 14/64" sieve using an Office Model of National Seed Service (NSS), Ibadan's seed grader.

Laboratory test: Germination tests of graded seeds were carried out in accordance with International Seed Testing Rules (ISTA, 1995) using moisten paper towel as medium. The test was replicated three times in a Completely Randomized Design with 100 seeds under each replication. Percentage germination was determined after 8 days. Weight of 100 seeds of the graded seed fractions was also determined before sowing.

Field test: The field test experiment was carried out at the Teaching and Research Farm of Federal University of Agriculture, Abeokuta. Ogun State, Nigeria.

Field emergence: Field emergence of graded seeds was tested in the field. Fifty seeds of each variety were sown in the field in a Randomized Complete Block Design with three replicates. They were sown in lines with a spacing of 1.5 by 0.1 m. Field emergence was recorded on each day up to 20 days to allow for delayed emergence.

Seed yield and yield characters: These were investigated in the field, which was laid out in a randomized complete block design with three replications. The size of each plot was four rows of 6 m with 75 cm between each row and 5 cm between each plant in the row. Following land preparation, 7.5 kg N, 67.5 kg P and 7.5 kg K per ha were applied in the form of compound fertilizer, N.P.K 15:15 and single super phosphate. Pre emergence herbicides, a mixture of Galex and Gramoxone in a CP3 knapsack sprayer at the rate of 5 and 3 L ha^{-1}, respectively were applied immediately after sowing.

From the two inner rows, ten plants were selected at random from each sub-plot for recording observations on number of seeds per plant, number of pods per plant, number of seeds per pod, 100-seed weight, seed yield per plant.

Data analysis: Data obtained from both tests were subjected to analysis of variance for each character. The significant of treatment means was determined with Duncan Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

From the data presented in Table 1, analysis of variance revealed that variety, seed size and interaction of variety x seed size effects were highly significant ($p \leq 0.01$) on all the characters except

Table 1: Summary of analysis of variance showing mean squares effects on seed quality and seed yield characters of graded seeds in five soybean varieties in two trials

Source of Variation	DF	100- seed weight before sowing (g)	Seed germination (%)	Seedling emergence (%)	Seeds per plant	Pods per plant	Seeds per pod	100 seed weight at harvest (g)	Seed yield/ plant (g)
Trial (T)	1	2.55ns	1.10ns	3.56ns	96.66ns	110.44ns	0.44ns	0.39ns	1.11ns
Variety (V)	4	9.62**	88.86**	137.08**	394.91*	649.31**	0.58ns	13.64**	24.76**
Seed-size (S)	2	59.57**	22.87**	31.67**	789.96*	1850.02**	0.29ns	0.26ns	4.53**
T×V	4	3.22ns	1.56ns	2.22ns	144.29ns	130.42ns	0.60ns	0.54ns	2.11ns
V×S	8	0.81**	38.34**	42.36**	551.76**	420.99**	9.44ns	0.37ns	7.92**
T×S	2	2.90ns	1.00ns	2.09ns	155.11ns	104.60ns	0.80ns	0.49ns	2.88ns
T×V×S	8	2.99ns	1.44ns	1.69ns	122.20ns	97.66ns	0.59ns	0.40ns	1.98ns
Error	17	1.80	0.64	1.09	164.89	101.22	0.22	0.21	0.82

*Significant at p<0.05, **Significant at p<0.01, ns: Not significant

seed per pod. The significant variety effects on 100-seed weight before sowing, seed germination, seedling emergence, seeds per plant, 100-seed weight at harvest and seed yield per plant suggest that differences in varieties were responsible for variation in these characters. The significant effects of the three different seed sizes (large, medium and small) on all the characters except seeds per pod and 100-seed weight at harvest showed that different fractions of seed size influenced these characters. In contrast, Sato and Kamiyama (1956) in soybean, Ries (1971) in bean (*Phaseolus* sp.), Robinson (1974) in sunflower (*Helianthus annus* L.) and Reddy *et al.* (1989) in Indian soybean reported non significant effect of seed size on yield. The non-significant effect of seed size on seeds per pod confirms the dominant effects of genotypes, soil conditions, cultural practices and climatic factors during crop growth over the effect of seed size. The significant variety x seed size interactions observed for 100-seed weight before sowing, seed germination, seedling emergence, seeds per plant; pods per plant and seed yield per plant suggest that the effect of seed size was different in different soybean varieties. Significant seed size×variety interactions for pods per plant, seed per plant and seed yield per plant was earlier observed by Reddy *et al.* (1989) in Indian soybean varieties.

From the results shown in Table 2, it was observed that variety TGX1485-ID (14.02 g) followed by TGX1831-32E (12.20 g) and TGX1019-12EN (12.19 g) had the highest 100 seed weight before sowing while TGX1649-11F recorded the lowest value (11.33 g). Though M-351 was medium in seed weight (11.71 g) it had the highest seed germination (100%) and seedling emergence (93%). This was followed by TGx1649-11F with 97% seed germination and 91% seedling emergence whereas TGx1019-2EN gave the least of these two characters. TGx1831-32E produced the highest seeds per plant and pods per plant of 89 and 59, respectively. A few other varieties had values comparable to those of these two varieties. Variety TGX1449-11F had maximum seed yield of 10.82 g. This was however not significantly difference from that of TGx1019-2EN (10.17 g). Variety M-351 recorded the lowest seed yield per plant (6.55 g).

According to Longden (1996), the factors which significantly affect the quality of seed, are, first of all, its size and emergence capacity. Data presented in Table 2 also showed significant differences in all the character except seeds per pods and 100-seed weight after harvest under the three different seed sizes (large, medium and small. This suggests that seed grading to separate the seeds for the seed quality and high seed yield would be worth considering. Large seed size had highest

Table 2: Main effects of variety and seed size on seed quality and yield characters of soybean across two trials

Variety	100 seed weight before sowing (g)	Seed germination (%)	Seedling emergence (%)	Seeds per plant	Pods per plant	Seed per pod	100-seed weight at harvest	Seed yield/ plant(g)
Variety M-351	11.71^{c}	100^{a}	93^{a}	72^{b}	43^{b}	2^{b}	8.94^{d}	6.55^{b}
TGx1019-2EN	12.19^{b}	92^{e}	84^{e}	75^{b}	40^{b}	3^{b}	11.90^{ab}	10.17^{ab}
TGx1485-1D	14.02^{a}	96^{c}	88^{c}	79^{ab}	39^{b}	2^{b}	11.93^{a}	8.68^{c}
TGx1649-11F	11.33^{d}	97^{b}	91^{b}	81^{ab}	39^{b}	3^{b}	11.29^{b}	10.82^{a}
TGx1831-32E	12.20^{b}	93^{d}	86^{d}	89^{a}	59^{a}	2^{b}	10.74^{c}	9.61^{b}
Mean	12.29	96	88	79	44	3	11.11	9.17
Seed size								
Large size	14.52^{a}	95^{b}	88^{b}	88^{a}	54^{a}	3^{a}	10.81^{a}	9.72^{a}
Medium size	11.67^{b}	94^{b}	87^{b}	77^{b}	47^{b}	3^{a}	11.05^{a}	8.62^{b}
Small size	10.69^{c}	97^{a}	90^{a}	74^{b}	32^{c}	2^{a}	11.07^{a}	9.16^{ab}
Mean	12.29	96	89	80	44	3	11.11	9.17

Means followed by the same letter in superscript along the column are not significantly different from one another at $p<0.05$

values of 100-seed weight within seed grades (14.52 g) which was significantly reduced in the medium (11.67 g) and small fractions (10.69 g). However 100-seed weight of medium graded seed was significantly higher than small graded seed. Regarding the germination potential of the different seed fractions, it was found that the small seed fractions had higher germination and field emergence percentages than the large and medium seed fractions which agrees with data in the literature (Singh *et al.*, 1978). According to Milosevic *et al.* (1992) smaller seeds absorbed large percent amount of water and their germination process started earlier than large seed fractions. A significant difference (at 5%probability level) existed for seeds per plant, pods per plant and seed yield per pant for large seed size. Large seeds had highest values of seeds per plant and pods per plant. Dhillon (1973) and Reddy *et al.* (1989) in soybeans reported more seeds from the plants from large seeds when planted on an equal number of seed basis under competition. Dhillon and Kler, (1976) also found similar results in groundnut (*Arachis hypogea* L.). Interestingly, the weight of 100 seeds before sowing was found to be about 10% higher than seeds subsequently produced. This slight reduction in seed size of all seed grades of all the varieties may be due to fluctuation in the growing conditions prevailing during crop growth.

From the data shown in Table 3, variety TGx1485-ID consistently displayed superior 100- seed weight before sowing at each of the three seed sizes. Variety M-351 with large seed size had maximum seed germination (100%) in all the three classes of seeds and seedling emergence in large and medium seeds. However, TGx1649-11F with large seed size had the least seed germination (92%) and seedling emergence (86%). Seedling emergence of TGX1019-2EN and TGX1831-32E was generally low with each of the three sizes, probably due to genetic make up of the variety. This support findings by Hojjat (2011) in Lentil (*Lens culinaris* Medik) genotypes.

From the results in Table 4, large and small seeds of TGx1649-11F variety were found to have high seed yield per plant with 13.43 and 11.16 g, respectively while medium seeded of variety

Table 3: Effect of seed size on seed quality characters of five soybean varieties across two trials

	100-seed weight before sowing (g)			Seed germination (%)			Seedling emergence (%)		
Variety	S1	S2	S3	S1	S2	S3	S1	S2	S3
M-351	14.10^{bc}	11.22^{b}	9.91^{b}	100^{a}	100^{a}	100^{a}	95^{a}	93^{a}	92^{b}
TG×1019-2EN	15.01^{b}	11.51^{b}	10.05^{b}	96^{b}	88^{c}	93^{c}	88^{c}	79^{d}	85^{d}
TG×1485-1D	16.64^{a}	13.25^{a}	12.18^{a}	96^{b}	96^{b}	96^{b}	90^{b}	88^{b}	86^{d}
TG×1649-11F	13.96^{c}	11.78^{b}	10.79^{b}	92^{c}	100^{a}	100^{a}	86^{d}	93^{a}	95^{a}
TG×1831-32E	13.96^{c}	11.78^{b}	10.86^{b}	96^{b}	88^{b}	95^{b}	88^{c}	81^{c}	88^{c}

Means followed by the same letter in superscript along the column are not significantly different from one another at $p<0.05$, S1: Large seed size, S2: Medium seed size, S3: Small seed size

Table 4: Effect of seed size on seed yield characters of five soybean varieties across two trials

	Seeds per plant			Pods per plant			Seeds per plant (g)		
Variety	S1	S2	S3	S1	S2	S3	S1	S2	S3
M-351	83^{b}	69^{d}	65^{b}	50^{b}	46^{b}	33^{b}	7.40^{c}	5.25^{e}	7.00^{d}
TGX1019-2EN	89^{b}	94^{a}	57^{b}	56^{b}	44^{b}	19^{c}	9.90^{b}	11.52^{a}	9.09^{c}
TGX1485-1D	70^{c}	79^{c}	75^{b}	47^{c}	36^{c}	35^{b}	7.83^{c}	9.69^{b}	8.52^{c}
TGX1649-11F	101^{a}	89^{a}	83^{a}	81^{a}	56^{a}	40^{a}	13.43^{a}	7.87^{d}	11.16^{a}
TGX1831-32E	97^{a}	86^{a}	89^{a}	84^{a}	52^{a}	42^{a}	10.03^{b}	8.76^{c}	10.03^{b}

Means followed by the same letter in superscript along the column are not significantly different from one another at $p<0.05$, S1: Large seed size, S2: Medium seed size, S3: Small seed size

Table 5: Relationship between seed weight (seed size) and seed quality and seed yield characters across two trials

	Seed weight			
Characters	Large seed	Medium seed	Small size	Across seed size
Seed germination (%)	0.258	-0.220	-0.006	0.020
Seedling emergence	0.226	-0.272	0.080	-0.005
Seeds per plant	-0.603**	0.439	0.185	0.268
Pods per plant	0.051	-0.523*	0.628**	0.394
Seeds per pod	-0.101	-0.056	0.170	0.069
100 seed weight after harvest	0.4770	0.334	0.138	0.128
Seed yield per plant (g)	-0.601	0.357	-0.164	0.087
N	15	15	15	45

*Correlation is significant at $p<0.05$, **Correlation is significant at $p<0.01$

TGX1019-EN had more seed yield per plant (11.52 g) than other varieties. Large seeds of TGX1019-2EN and TGX1831-32E had comparable seed yield per plant. Also small seeded TGX1019-2EN and TGX1485-ID were found to have similar seed yield per plant of 9.09 and 8.52 g, respectively. However, large, medium and small graded seeds of the five varieties were found to have comparable 100-seed weight after harvest. The results further revealed that varieties with large seeds produced maximum seed per plant, pods per plant and high seed yield per plant. This superiority may be attributable to the high seedling vigour resulting from extra food reserves present in large seeds (Sexton *et al.,* 1994; Gholami *et al.,* 2009).

Correlation between seed size, germination capacity, vigour and yield has been debated for a long time. As shown in Table 5, the data revealed that significant negative correlations were found between large seed size and seeds per plant ($r = -0.603$) and between medium seed size and pods per plant ($r = -0.523$) whereas small seed size had significant positive association with pods per plant ($r = 0.628$). Interestingly, correlation across the three seed sizes revealed that seed size had strong positive relationship with pods per plant. The three graded seed sizes recorded non-significant association with seed germination, seedling emergence, seeds per pod, 100- seed weight at harvest and seed yield per plant.

CONCLUSION

The following conclusions may be drawn:

- Highly significant differences were observed among varieties, seed sizes and interaction of the two factors for all the characters except seeds per pod and 100-seed weight after harvest
- Variety TGx1485-ID consistently displayed superior 100- seed weight before sowing at each of the three seed sizes. M-351 variety with large seed size had maximum seed germination and seedling emergence and retained this with medium and small seed sizes
- The small seed size had the highest seed germination and field emergence whereas large seed size produced the highest seeds per plant, pods per plant and seed yield per plant
- Small seed size was positively associated with pods per plant. With major contribution from small seed size. Seed size was not associated with seed germination, emergence, seeds per pod, 100- seed weight after harvest and seed yield per plant

ACKNOWLEDGMENT

The authors are highly indebted to the Department of Plant Breeding and Seed Technology for providing material support during and after the experiment and Mrs O.T. Adebisi for her physical support during the field work of the study.

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