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Influence of seed reserves on seedling vigour, seed cotton productivity and fiber properties of upland cotton (*Gossypium hirsutum*)

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ABSTRACT : An experiment was undertaken to examine the effect of seed weight on seedling establishment, seed productivity, and fiber quality aspects of cotton. Two sets of experiments were conducted using the graded seeds of upland cotton genotypes. In experiment I, an investigation was carried out on the effect of seed size with reference to seedling parameters, seed cotton productivity, and fiber properties. Cotton genotypes were selected on the basis of the seed index of those genotypes having very low (CPD 428), low (LRA 5166), medium (MCU 9), high (Sumangala) and very high seed weight (VC 31). Further, in each genotype, bulk seeds were graded based on seed weight into small (G1) and large (G2). The graded seeds were evaluated under the laboratory to ascertain the seedling quality and forwarded to a field experiment for determination of field emergence and seed productivity. It was observed that the performance of large size seeds was significantly superior over small ones in all the genotypes in all the parameters studied. In experiment II, bulk seeds of varieties Anjali (V1), Sumangala (V2) and LRA 5166 (V3) were graded into G1 (Very large), G2 (Large), G3 (Medium), G4 (Small), G5 (Very small) and they were compared with the (G0) bulk seeds of each variety for seedling performance, seed cotton productivity, and seed oil content. The cotton *cv.* Sumangala with large size seeds possessed a more significant positive association with seedling characters, seed cotton productivity, and fiber properties than Anjali and LRA5166. It was evident that the high seed index and seed volume play a vital role in determining the growth performance and productivity.

Key words: *Gossypium,* seed cotton productivity, seed index, seed size, seed vigour, seed yield

Cotton (*Gossypium* sp.) is the "King of Fiber" crops and commercially most important. It play vital role in the Indian economy through employment opportunities and foreign exchange. In India, cotton cultivation is sprawling over eleven states under the variegated soil and climatic conditions. Cotton is predominantly propagated through seeds and in commercial cultivation; the seeds of varieties/hybrids needs to be replaced in every season of planting. Indian farmers are more dependent rather market seed than the farm saved seeds due to its value additions inculcated for seed quality enhancement treatments. Cotton seeds are produced in larger quantities for commercial cultivation, although they are genetically pure, the physical and physiological quality of seed gains greater importance in terms of field emergence, seedling vigour, filed uniformity and plant stand. Since the cost of planting seeds keeps on rising, adoption of low seed rate is advocated with high quality seed using precision planting system. Despite all physiological qualities, the physical parameter such as seed volume and seed weight decides the seedling performance. Hence, use of physically bold, physiologically sound, and biologically more active seed ensures the cotton grower with less risk in the maintenance of optimum plant population, reduced pest and disease incidence, ultimately lead to higher productivity.

In cotton, the existence of variability for seed size, weight, seed shape, colour, seed oil content, and seed-borne pathogen due to production environment and cultivation practices is a common feature that exists among and within seed lot (Seemi and Shaukat,2010). These variations cause poor seed germination and seedling establishment and persist when stored over a period. Oil bearing seeds like cotton tend to absorb the atmospheric moisture and thereby lose its viability very quickly. In recent times, besides modern seed processing approaches, several seed quality enhancement treatments are suggested as pre-storage and pre-sowing application (Afzal *et al.*, 2016).

For planting seed requirements, Indian cotton farmers solely depended on private and public agencies as they produce and market in larger quantities. The unsold carry over bulk seeds needs to be stored under ambient without loss of viability and vigour for future planting (Yadav *et al.*, 2014). From the time of physiological maturity and more during storage desiccation of seeds has frequently been related to oxidative injury. Free radicals of O2 and its derivatives have been suggested to play an important role in declining seed viability, mostly by lipid peroxidation, protein, and nucleic acid damage (Chaitanya and Naithani, 1994). Lipid peroxidation and free radical production are believed to be the basic cause of seed deterioration.Seed viability and vigor is interlinked with factors that happen to occur during seed production and that of with seed storage environment. In cottonseed, deterioration takes place rapidly under ambient storage conditions and cause phenomenal monetary loss. Therefore protecting the seed under ambient conditions has assumed commercial importance of formidable dimensions (Narayanan *et al.*, 2012).

Though several approaches have been proposed for the prevention of loss of seed deterioration and improvement for planting quality, an attempt has been made in this study to explore and quantify the role of seed index and seed volume as a vital physical parameter in determining the seedling emergence, field performance, and subsequently seed and seed cotton productivity of upland cotton genotypes.

MATERIALS AND METHODS

Field experiments were conducted to elucidate information on the role of planting seed size on seed quality, seed cotton productivity, and fiber properties. In the first experiment, five genotypes were selected in such a manner that their seed index are very low (CPD 428), Low (LRA 5166), Medium (MCU 9), High (Sumangala), and Very high (VC 31). From selected genotypes, bulk seeds were graded in to small and large based on seed volume (Table 1). The graded seeds were assessed for the seed quality under laboratory condition as to trace the influence of seed reserves on seed germination and seedling vigor. The graded seeds were subjected to the standard germination test (ISTA 1999). From this ten normal seedlings were selected for the measurement of seedling root (RL) and shoot (SL) length of individual seedlings. Root length was measured from the collar region to the tip of the primary root and shoot length from the collar region to the tip of the plumule. vigor index (VI) (Abdul Baki and Anderson 1972) was computed by multiplying the seedling length with germination percent. Dry matter of seedlings (DMS) was estimated using the seedlings used for growth measurements, they were dried in a hot-air oven at 85°C for 24 h and cooled in a desiccator, weighed and expressed in (g /5seedling). The graded seeds were sown in the field adopting the FRBD. Normal package of practices were followed throughout the crop growth. Observations on field emergence, plant stand, bolls /plant, boll weight (g/boll), ginning (%), seed cotton yield (kg/ha), seed yield (kg/ha) were taken at appropriate stages. The harvested seeds were estimated for oil content (%) and free fatty acid (%). Bolls/plant was recorded on five randomly selected plants in each replication. In each plot 10 randomly selected bolls were collected weighed and the average was expressed as boll weight/(g). The harvested sample bolls were ginned and ginning (%) was arrived adopting the formula lint weight/*kapas* weight x100. Seed cotton was harvested plot-wise in three pickings and they were pooled and expressed as seed cotton yield (kg/ha). Seed yield (kg/ha) from each lot was computed using the seed recovery values obtained in the ginning process. The seed oil (%) content and free fatty acid (%) of resultant seeds were estimated by adopting the procedures of A.O.A.C., (1960) and Karon and Altschul, (1944), respectively. The fiber parameters such as fiber length (FL), fiber strength (FS), fiber fineness (FF), fiber uniformity (FU), and fiber maturity (FM) were measured in High Volume Instrument (Premier) under ICC mode.

In another set of three genotypes Anjali, Sumangala, LRA 5166, delinted, cleaned bulk seeds were size graded based on their 100 seed weight into very large (G1), large (G2), medium (G3), small (G4) and very small (G5). The graded seeds were compared with bulk seeds (G0) to serve as control. Quality of the graded seed lot was estimated by adopting the procedure explained above. After evaluation the graded seeds were sown in the field in factorial randomized block design (FRBD). The experimental plots were maintained with normal package of practices of cotton seed crop. Biometric observations in each plot on agronomic traits were recorded on five plants selected randomly adopting the above procedure. Fiber properties were measured in High Volume Instrument (Premier) under ICC mode. The data thus generated were statistically analyzed as per the procedure of Panse and Sukhatme, (1967).

RESULTS AND DISCUSSION

The present study was conducted to explicate information on the role of stored seed reserves, measured in terms of seed size/ weight that can manifest on cotton seedling parameters, seed germination and seed cotton productivity and is there any influence on fiber properties. Based on the mean seed index, the cotton genotypes were classified into very low, low, medium, high, and very high with mean weights in g/100-seed of 5.5, 6.47, 7.95, 8.78, and 9.1, respectively. Genotypes representing the above

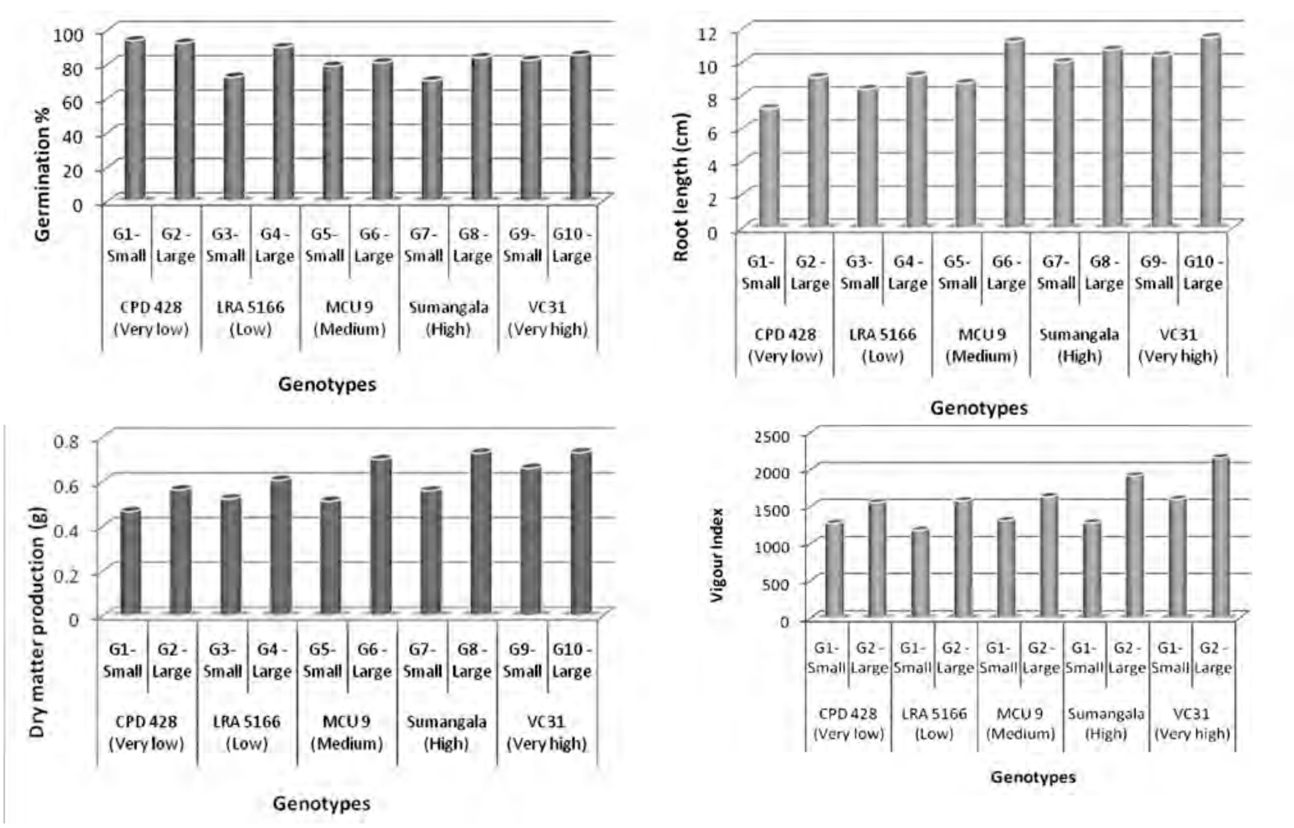

Fig. 1: Effect of seed size on seedling characters of upland cotton genotypes

Table 1. Classification of upland cotton genotypes (*G.hirsutum* L.)and grading of seed lots based on seed index.

Variety	Genotype seed index (g)	Category	Grade	Grade seed index (g)
CPD 428	5.5	Very low	Small (G1)	4.74
			Large (G2)	6.26
LRA 5166	6.47	Low	Small (G3)	5.28
			Large (G4)	7.66
MCU 9	7.95	Medium	Small (G5)	6.4
			Large (G6)	9.5
Sumangala	8.78	High	Small (G7)	7.69
			Large (G8)	9.87
VC31	9.1	Very high	Small (G9)	7.9
			Large (G10)	10.26

Table 2. Influence of seed index on seed germination and seedling parameters of upland cotton genotypes

Variety (seed index group)	Grade	Germination (%)	Root length	Shoot length	Dry matter (g /5seedling)	Vigour index
CPD 428 (Very low)	Small (G1)	82.50	7.20	8.25	0.47	1275
	Large (G2)	86.00	9.10	9.00	0.56	1557
Mean		**84.25**	**8.15**	**7.6**	**0.51**	**1330**
LRA 5166 (Low)	Small (G1)	72.50	8.37	7.95	0.52	1183
	Large (G2)	90.00	9.18	8.40	0.61	1582
Mean		**81.25**	**8.77**	**8.17**	**0.57**	**1383**
MCU 9 (Medium)	Small (G1)	79.00	8.73	7.90	0.51	1314
	Large (G2)	81.00	11.25	8.95	0.70	1636
Mean		**80.00**	**9.99**	**8.42**	**0.61**	**1475**
Sumangala (High)	Small (G1)	70.50	10.00	8.20	0.56	1283
	Large (G2)	84.00	10.75	12.10	0.73	1919
Mean		**77.25**	**10.37**	**10.15**	**0.64**	**1601**
VC 31 (Very high)	Small(G1)	82.50	10.40	9.00	0.66	1601
	Large(G2)	90.50	11.50	12.40	0.73	2164
Mean		**86.5**	**10.95**	**10.70**	**0.69**	**1882**
Mean (G1)		**79.70**	**8.94**	**8.26**	**0.54**	**1177**
Mean (G2)		**86.60**	**10.35**	**10.17**	**0.67**	**1598**
CD (p = 0.05)	V	7.78	0.48	0.52	0.07	124
	G	4.92	0.30	0.33	0.04	78
	V x G	NS	0.69	0.74	0.10	176

category are CPD 428 (very low), LRA 5166 (Low), MCU 9 (Medium), Sumangala (High), and VC 31 (Very high) (Table 1).

It was observed in terms of germination percentage, seedling vigour, root and shoot length of seedling and dry matter production in seedling that the large size seeds performed well when compared to small seeds. The very high seed index genotype (VC 31) out performed for its seed quality than the rest of the category. Irrespective of seed index category of genotypes, large size (G2) seeds with more food reserves have shown significantly higher germination and seed vigour than small (G1) seeds (Table 2 and Fig. 1). These findings were supported by the fact that larger size seeds, in turn, produced larger embryos and have a high respiration rate that results in greater field emergence than the small size seeds. The high germination rate and faster growth of the seedling may be attributed to greater food reserves available to the growing seedling. This indicates that large size seeds have

Table 3. Effect of seed index on seed and seed cotton productivity in upland cotton genotypes

Variety (seed index group)	Grade	Plant stand (%)	Bolls/ plant	Boll weight (g/boll)	Ginning (%)	Seed cotton yield (kg/ha)	Seed yield (kg/ha)	Seed oil content (%)	Free fatty acid (%)
CPD 428	Small(G1)	92.2	47	3.58	33.5	2021.5	909.7	24.68	36.77
(Very low)	Large(G2)	94.1	50	3.85	33.7	2054.5	924.5	28.23	31.26
Mean		**93.2**	**48**	**3.72**	**33.6**	**2038.0**	**917.1**	**26.45**	**34.01**
LRA 5166	Small(G1)	93.5	49	3.64	34.9	2140.8	963.3	42.62	30.15
(Low)	Large(G2)	96.1	54	4.08	34.2	2168.4	975.8	12.80	39.71
Mean		**94.8**	**52**	**3.86**	**34.5**	**2154.6**	**969.6**	**27.71**	**34.93**
MCU 9	Small(G1)	93.5	51	4.32	35.8	2258.4	1016.3	14.41	75.36
(Medium)	Large(G2)	96.1	56	4.59	35.2	2283.3	1027.5	21.64	39.55
Mean		**94.8**	**54**	**4.45**	**35.5**	**2270.9**	**1021.8**	**18.02**	**57.46**
Sumangala	Small(G1)	92.8	53	4.43	37.9	2259.4	1016.7	25.02	49.28
(High)	Large(G2)	96.7	57	4.66	38.9	2283.3	1044.4	25.58	38.66
Mean		**94.8**	**55**	**4.54**	**38.4**	**2290.2**	**1030.6**	**25.30**	**43.97**
VC 31	Small(G1)	93.5	53	5.07	38.1	2283.1	1027.4	23.52	36.03
(Very high)	Large(G2)	96.1	57	5.66	39.7	2342.2	1054.0	21.78	47.84
Mean		**94.8**	**56**	**5.36**	**38.9**	**2312.7**	**1040.7**	**22.65**	**41.93**
Mean (G1)		**93.1**	**51**	**4.21**	**36.1**	**2192.7**	**986.7**	**26.05**	**45.52**
Mean (G2)		**95.8**	**55**	**4.57**	**36.3**	**2233.9**	**1005.3**	**22.00**	**39.40**
CD (p = 0.05)	V	NS	1.58	0.112	1.730	72.378	32.576	NS	NS
	G	1.45	1.00	0.071	NS	NS	NS	NS	NS
	V x G	NS	NS	0.159	NS	NS	NS	NS	NS

Table 4. Effect of planting seed index onthe resultant fiber properties of upland *G.hirsutum* cotton genotypes

Variety (seed index group)	Grade	2.5 per cent length (mm)	Maturity ratio	Uniformity ratio (%)	Micro-naire (µg.inch)	Fibre strength(g/tex)	Elongation (%)
CPD 428	Small(G1)	22.06	0.83	49.03	4.83	20.83	5.73
(Very low)	Large(G2)	21.93	0.81	48.06	4.63	21.73	6.16
Mean		**22.00**	**0.81**	**48.55**	**4.73**	**21.28**	**5.95**
LRA 5166	Small(G1)	25.06	0.74	46.43	3.83	21.73	5.90
(Low)	Large(G2)	25.90	0.74	45.46	3.83	19.96	6.20
Mean		**25.48**	**0.74**	**45.95**	**3.83**	**20.85**	**6.05**
MCU 9	Small(G1)	30.50	0.67	43.66	3.16	22.63	6.20
(Medium)	Large(G2)	30.10	0.69	44.13	3.43	21.63	6.00
Mean		**30.20**	**0.68**	**43.90**	**3.30**	**22.13**	**6.10**
Sumangala	Small(G1)	26.10	0.77	46.10	4.10	20.30	6.50
(High)	Large(G2)	27.13	0.80	46.26	4.46	19.56	6.20
Mean		**26.61**	**0.78**	**46.18**	**4.28**	**19.93**	**6.35**
VC 31	Small(G1)	27.23	0.78	47.26	4.10	20.56	6.13
(Very high)	Large(G2)	26.43	0.77	47.03	3.96	20.60	6.20
Mean		**26.83**	**0.77**	**47.15**	**4.03**	**20.58**	**6.16**
Mean (G1)		**26.19**	**0.76**	**46.50**	**4.00**	**21.21**	**6.09**
Mean (G2)		**26.30**	**0.76**	**46.19**	**4.06**	**20.70**	**6.15**
CD (p = 0.05)	V	1.53	0.03	0.91	0.28	NS	NS
	G	NS	NS	NS	NS	NS	NS
	V x G	NS	NS	NS	NS	NS	NS

Table 5. Grading of cotton seeds based on seed weight in upland *G.hirsutum* cotton genotypes

Variety	100 seed weight (g)					
	Bulk (G0)	Very large (G1)	Large (G2)	Medium (G3)	Small (G4)	Very small (G5)
Anjali (V1)	8.00	9.87	7.87	6.89	5.46	4.66
Sumangala (V2)	9.60	12.11	10.49	9.91	8.60	7.58
LRA 5166 (V3)	7.77	10.25	8.19	7.61	6.72	5.62

Table 6. Effect of seed grades (seed weight) on seed and seedling quality of *G.hirsutum* cotton genotypes

Variety	Grade	Germination (%)	Root length (cm)	Shoot length (cm)	Vigour index	Dry matter production (g/5 seedlings)
Anjali (V1)	G0	88	8.8	14.3	2028	0.38
	G1	93	9.3	14.4	2204	0.40
	G2	89	9.2	14.2	2082	0.35
	G3	87	8.5	13.8	1936	0.35
	G4	85	8.6	14.2	1933	0.31
	G5	81	7.3	13.5	1685	0.31
	Mean	**87**	**8.6**	**14.1**	**1978**	**0.35**
Sumangala V2)	G0	87	9.5	14.4	2071	0.43
	G1	91	9.8	14.5	2202	0.44
	G2	89	9.1	14.4	2089	0.43
	G3	87	9.3	14.2	2040	0.40
	G4	87	8.6	14.1	1970	0.37
	G5	85	7.2	14.1	1806	0.33
	Mean	**87**	**8.9**	**14.3**	**2029**	**0.39**
LRA 5166 (V3)	G0	89	8.9	15.5	2167	0.44
	G1	89	8.9	16.9	2292	0.45
	G2	86	8.5	14.8	2006	0.42
	G3	82	8.8	16.5	1906	0.41
	G4	81	8.1	14.1	1798	0.33
	G5	80	8.1	13.5	1726	0.32
	Mean	**84**	**8.5**	**14.9**	**1982**	**0.39**
Mean	**G0**	**88**	**9.0**	**14.7**	**2088**	**0.42**
	G1	**91**	**9.3**	**15.3**	**2232**	**0.43**
	G2	**88**	**8.9**	**14.5**	**2059**	**0.39**
	G3	**85**	**8.8**	**14.2**	**1960**	**0.39**
	G4	**84**	**8.4**	**14.1**	**1900**	**0.33**
	G5	**82**	**7.5**	**13.7**	**1739**	**0.32**
SEd	V	0.663	0.367	0.244	45.46	0.012
	G	0.938	0.519	0.345	64.29	0.017
	V x G	1.624	0.899	0.598	11.35	0.030
CD(P = 0.05)	V	1.399	NS	0.515	NS	0.026
	G	1.979	1.096	0.728	135.64	0.037
	V x G	NS	NS	NS	NS	NS

a greater influence on seedling characters which ultimately contribute for higher yield and productivity. Ries and Everson, (1973) have reported in wheat that, seed size is positively correlated with seed vigor, larger seeds tend to produce more vigorous seedlings. Similarly, the germination rate and seedling vigor index increased with the increase of seed size in rice (Roy *et al.*, 1996).

Nagaraju (2001) observed that in sunflower, higher germination percentage, seedling length, seedling vigor index, dry

Table 7. Effect of seed grades (seed weight) on growth and yield attributing traits of upland *G.hirsutum* cotton genotypes

Variety	Grade	Field emergence (%)	Plant height (cm)	Sympodia/ plant	Monopodia/ plant	Leaves/ plant	Bolls/ plant	Boll weight g)	Seed weight (g/boll)	Lint weight (g/boll)
Anjali (V1)	G0	90.9	87.2	17.8	0.5	94.6	34.0	4.5	2.75	1.74
	G1	98.5	87.3	20.0	0.2	99.8	37.0	4.7	2.83	1.87
	G2	95.5	78.6	18.6	0.7	92.3	34.9	4.7	2.77	1.92
	G3	93.9	76.7	16.9	0.8	90.7	34.1	4.4	2.75	1.65
	G4	89.4	74.5	16.7	0.8	86.5	33.0	4.2	2.65	1.55
	G5	75.8	75.2	16.3	0.2	83.0	29.0	3.9	2.64	1.25
	Mean	**90.7**	**79.9**	**17.7**	**0.5**	**91.1**	**33.7**	**4.4**	**2.73**	**1.66**
Sumangala(V2)	G0	97.0	119.3	19.9	0.1	122.5	42.8	4.5	2.89	1.60
	G1	98.5	118.8	21.3	0.5	126.0	43.3	4.7	2.99	1.71
	G2	96.9	117.6	19.7	0.1	119.0	39.9	4.6	2.84	1.66
	G3	93.9	114.1	18.2	0.3	119.5	36.6	4.5	2.77	1.73
	G4	93.9	115.5	17.6	0.0	118.5	33.2	3.8	2.74	1.05
	G5	81.8	112.5	17.1	0.1	117.3	33.1	3.7	2.67	1.03
	Mean	**93.7**	**116.3**	**18.9**	**0.2**	**120.4**	**38.2**	**4.3**	**2.81**	**1.46**
LRA5166(V3)	G0	96.9	97.8	18.9	0.5	115.2	36.4	4.3	2.77	1.53
	G1	97.0	100.2	19.2	0.5	122.0	40.3	4.8	2.84	1.91
	G2	92.4	93.9	18.5	0.3	114.3	37.5	4.2	2.77	1.42
	G3	87.9	95.3	17.9	0.0	114.7	36.2	4.0	2.76	1.25
	G4	84.8	93.7	16.8	0.5	113.2	35.5	3.9	2.62	1.32
	G5	77.3	89.1	16.5	0.2	112.9	33.5	3.8	2.63	1.16
	Mean	**89.4**	**94.9**	**17.9**	**0.3**	**115.4**	**36.6**	**4.2**	**2.73**	**1.43**
Mean	**G0**	**94.9**	**101.4**	**18.9**	**0.4**	**110.8**	**37.7**	**4.4**	**2.80**	**1.62**
	G1	**98.0**	**102.1**	**20.2**	**0.4**	**115.9**	**40.2**	**4.7**	**2.88**	**1.83**
	G2	**94.9**	**96.7**	**18.9**	**0.4**	**108.5**	**37.4**	**4.5**	**2.79**	**1.67**
	G3	**91.9**	**95.4**	**17.7**	**0.4**	**108.3**	**35.6**	**4.3**	**2.76**	**1.53**
	G4	**89.4**	**94.6**	**17.0**	**0.4**	**105.8**	**33.9**	**3.9**	**2.67**	**1.31**
	G5	**78.3**	**92.3**	**16.6**	**0.2**	**104.4**	**31.8**	**3.8**	**2.65**	**1.15**
SEd	V	1.305	0.785	0.209	0.112	1.034	0.593	0.073	0.022	0.062
	G	1.846	1.110	0.295	0.158	1.463	0.839	0.104	0.032	0.088
	V x G	3.198	1.923	0.512	0.274	2.534	1.454	0.180	0.055	0.152
CD (p = 0.05)	V	2.754	1.656	0.441	0.236	2.182	1.252	0.155	0.047	0.131
	G	3.896	2.342	0.624	NS	3.086	1.771	0.219	0.067	0.185
	V x G	NS	4.057	NS	NS	NS	3.068	NS	NS	NS

weight, and field emergence in large size seeds compared to small seeds respectively. Nerson (2002) reported that smaller muskmelon seeds had the lowest germination percentage, emergence, and seedling growth demonstrating that there is an association between seed physical parameters and seed quality. Sulochanamma and Reddy (2007) reported in groundnut, seedling vigor in the shriveled and small seeds were less than bold seeds. Gunaga *et al.*, (2011) reported that the higher and quick germination in bigger sized seeds could be due to the presence of the higher amount of carbohydrates and other nutrients than the medium and small-sized seeds. Effect of seed size (less than 1.95, 1.95-2.35 and more than 2.35 mm) on germination characteristics of six oat (*Avena sativa* L.) cultivars under water stress condition showed that germination was increased with increasing seed size (Mathur *et al.*, 1982).

The crop growth and productivity

parameters observed in cotton seed crop revealed that the performance of large size seeds was significantly superior over small ones in all the genotypes for all the growth and productivity parameters (Table 3). In all the genotypes having seeds index categories such as very low (CPD 428), Low (LRA 5166), Medium (MCU 9), High (Sumangala), and Very high (VC 31), the contribution for yield and yield attributing traits was found more due to large size (G2) seeds than small (G1) size seeds. In very high seed index variety (VC 31), this effect was much more apparent. Nagaraju (2001) reported significantly higher yield and yield parameters in sunflower with large size seeds than small size seeds. The observation on the fiber properties revealed non-significant result, indicating that they are more of genetically controlled rather influenced by other factors as evidenced by the expression of non significant differences in 2.5 per cent span length (mm), maturity ratio, uniformity ratio (%) and micronaire among the genotypes (Table 4).

The seeds of three varieties Anjali, Sumangala, and LRA 5166 were graded in to very large, large, medium, small, and very small and compared with the bulk seeds based on 100 seed weight (Table 5). The mean germination percentage recorded for seeds grades revealed that very large (G1) have contributed significantly than other grades. Among the verities, the increase in germination due to very large size seeds was 5 and 4 per cent in Anjali and Sumangala, respectively when compared to other grades, however, seed grades have shown no influence in LRA5166. (Table 6). A similar observation was reported in wheat (Nik *et al.*, 2011) that plants grown from large seeds were more vigorous and produces greater dry matter than those grown from small seeds. Hojjat (2011) reported that the germination parameters related by seed weight and large seeds germinated early and showed better germination than small seeds of lentil genotypes.

Under field condition, the genotype Sumangala registered significantly higher field emergence percentage of 97.0, 98.5, 96.9, 93.9, 93.9 and 81.8 per cent in seed grades G0, G1, G2, G3, G4, and G5, respectively compared to Anjali and LRA 5166. Similarly, Sumangala excelled for other morphometric traits such as plant height (cm), sympodia/plant, monopodia/ plant, leaves /plant, bolls /plant, boll weight (g), seed weight (g/boll), lint weight (g/boll), seeds/boll, 100 seed weight (g), ginning (%), lint index, good seed recovery (%), seed cotton yield (kg/ha), seed yield (kg/ha) and seed oil content (%) (Table 7, 8).

Among the seed size grades, very large seeds (G1) recorded the highest field emergence of 98.5, 98.5 and 97 per cent, respectively in Anjali, Sumangala and LRA 5166 which was on par with large grade (G2) and bulk (G0) seeds. The lowest field emergence of 75.8 per cent, 81.8 per cent and 77.3 per cent, respectively in Anjali, Sumangala and LRA 5166 was recorded with very small (G5) seeds. Similarly, higher values for biometric observations, yield, and productivity parameters were recorded in all the varieties due to very large (G1) and large size (G2) seeds.

Among the three varieties, Sumangala recorded higher values for yield and yield attributing traits. The large sized planting seeds produced higher seeds and seed cotton when compared to other size grades irrespective of varieties. Seed size is an important parameter for plant growth and yield. Seed size affected the proportion of seed germination and seedling growth. It has an advantage of seedling establishment under moisture deficit situations due to deeper root systems (Leishman and Westoby, 1994). Zareian, *et al.,* 2013 observed in wheat that, seed size not only influences emergence and establishment but also affected yield components and ultimately grain yield.

Table 8. Effect of seed grades (seed weight) on seed and seed cotton productivity in *G.hirsutum* cotton genotypes

Variety	Grade	Seeds/ boll	100 seed weight (g)	Ginning (%)	Lint index	Good seed (%)	Poor seed (%)	Seed cotton yield (kg/ha)	Seed yield (kg/ha)	Seed content oil (%)	Free fatty acid (%)
Anjali (V1)	G0	27.0	9.75	38.75	6.2	98.2	1.85	2321	1392	24.55	40.95
	G1	28.4	10.10	39.75	6.7	98.8	1.25	2617	1570	31.24	31.96
	G2	27.6	9.95	40.95	6.9	97.3	2.75	2326	1395	32.90	31.55
	G3	26.9	10.05	37.40	6.1	97.3	2.75	2197	1318	24.91	42.62
	G4	25.4	9.75	36.95	5.7	95.7	4.35	1827	1096	24.31	40.44
	G5	25.1	9.75	32.15	4.7	94.5	5.55	1136	681	21.74	46.84
	Mean	**26.7**	**9.89**	**37.65**	**6.0**	**96.9**	**3.08**	**2070**	**1242**	**26.61**	**39.06**
Sumangala (V2)	G0	26.4	11.10	35.65	6.2	98.5	1.50	3125	1845	23.11	35.39
	G1	26.6	12.10	36.35	6.9	98.8	1.15	3185	1911	18.02	54.68
	G2	26.2	11.05	36.45	6.4	98.1	1.90	3037	1822	40.89	30.27
	G3	25.1	10.95	38.45	6.8	96.8	3.20	2962	1777	22.78	33.11
	G4	25.1	10.80	27.55	4.2	96.0	4.00	2656	1594	42.95	25.77
	G5	24.5	10.50	27.80	4.1	95.9	4.10	2459	1475	11.81	72.29
	Mean	**24.7**	**11.08**	**33.70**	**5.7**	**97.4**	**2.64**	**2914**	**1748**	**26.59**	**41.92**
LRA 5166 (V3)	G0	28.2	9.85	35.55	5.5	99.1	0.90	2553	1532	23.58	70.16
	G1	28.9	10.80	40.20	7.3	99.3	0.70	2741	1644	27.37	32.99
	G2	28.5	9.95	33.95	5.2	98.3	1.75	2642	1585	26.90	67.58
	G3	27.9	10.00	30.70	4.5	97.9	2.15	2493	1496	38.70	59.19
	G4	27.2	9.75	33.50	4.9	94.5	5.50	2257	1354	15.32	78.99
	G5	26.7	9.65	30.70	4.3	94.9	5.05	2104	1262	22.62	45.56
	Mean	**27.9**	**10.00**	**34.10**	**5.3**	**97.3**	**2.67**	**2465**	**1478**	**25.75**	**59.08**
Mean	**G0**	**27.2**	**10.23**	**36.65**	**5.9**	**98.6**	**1.41**	**2686**	**1612**	**23.75**	**48.83**
	G1	**27.9**	**11.0**	**38.76**	**6.9**	**98.9**	**1.03**	**2847**	**1708**	**25.54**	**39.87**
	G2	**27.4**	**10.31**	**37.11**	**6.1**	**97.9**	**2.13**	**2668**	**1600**	**33.56**	**43.13**
	G3	**26.7**	**10.33**	**35.51**	**5.8**	**97.3**	**2.70**	**2551**	**1503**	**28.80**	**44.97**
	G4	**25.9**	**10.10**	**32.66**	**4.9**	**95.4**	**4.61**	**2246**	**1348**	**27.53**	**48.40**
	G5	**25.4**	**9.96**	**30.21**	**4.3**	**95.1**	**4.90**	**1899**	**1139**	**18.72**	**54.90**
SEd	V	0.081	0.107	0.958	0.257	0.261	0.261	97.58	58.56	4.30	4.34
	G	0.114	0.151	1.355	0.364	0.369	0.369	138.00	82.82	6.07	6.13
	V x G	0.198	0.262	2.347	0.630	0.640	0.640	239.03	143.46	10.52	10.62
CD (p = 0.05)	V	0.171	0.226	2.022	0.543	NS	NS	205.89	123.57	NS	9.15
	G	0.242	0.319	2.859	0.768	0.780	0.780	291.17	174.55	NS	NS
	V x G	0.419	NS	4.953	NS	NS	NS	NS	NS	NS	22.42

CONCLUSION

In both the experiments, seed weight plays a crucial role in field emergence, seedling establishment followed by plant stand and seed cotton productivity. Existence of genetic variation and factors that influence the seed crop environment is the causes for occurrence of seed size variation with in a seed lot and between varieties. Based on the size and volume, the seeds are graded and compared for its performance and productivity. This variation is attributed to the flow of nutrients into the seed during the developmental process at mother plant (Ambika *et al.*, 2014). From this experiment, the drawn inference is that large size either by weight or volume with well-developed embryo and high amount of food reserve has contributed for the production of elite seedling. Hence, grading of seed lot based on seed index or seed volume is advocated for the achievement of higher productivity and this practice may be customized depending up on the genotype and species.

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