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Variability for Seed Reserve Traits and Their Interrelationship among Hybrids and Varieties of Cotton

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ABSTRACT: Investigation was carried out to examine the influence of seed weight and seed reserve factors on the development of superior seedling mass in cotton. The objectives included study on variability with respect to seed reserve utilization traits such as initial seed weight, seed reserve content and seed reserve depletion, seed reserve depletion rate, seed reserve respiration and seed reserve utilization efficiency as well as their interrelationships in cotton. The genotypes included seeds of hybrids, varieties of *hirsutum* species and *arboreum* species which varied widely in their initial seed weight. The comparison of traits among genotypes showed initial seed weight, seedling dry weight and seed reserve content significantly higher for hybrids followed by *G. hirsutum* and *G. arboreum* varieties respectively. However, the Seed Reserve Utilization Efficiency (SRUE) showed no variation irrespective of the seeds being hybrids or varieties. Correlation study revealed seed weight having significant positive correlation with seed reserve content measured as seed reserve depletion in seeds of all genotypes. However, the conversion efficiency of seed reserve into seedling tissue (SRUE) showed negative correlation with all the studied traits *viz.* initial seed weight, seed reserve content and seed reserve depletion rate and, was the same across species or type of seeds. This indicated that higher seed weight or higher seed reserve in the seed are not the only factors responsible for superior seedling emergence and growth. These findings could be of use for development of improved germplasm with a high conversion rate of seed storage reserves.

Keywords: Cotton, *G. hirsutum, G. arboreum*, Seed weight, Seedling growth, Seed reserve depletion, Seed reserve utilization efficiency

INTRODUCTION

High seed quality enabling stronger seedlings at the initial stage of crop growth can resist adversity and plays an important role in realizing increased crop yields under changing climate conditions. Stress tolerance is one of the major parameters measured along with seedling growth and germination to determine seed vigor [1]. Seed vigour is the sum of those properties that determine the germination activity and performance of seed lots in a wide range of environments [2]. Seed reserve mobilization is one such trait which is considered favoring the development of vigorous seedlings and, its three components include, initial seed weight, fraction of seed reserves which are mobilized or depleted and the conversion efficiency of mobilized seed reserves to seedling tissues. A variety with better seed weight and size is understood to have better seed reserves [3]. Earlier, study on influence of seed reserve parameters on seedling growth was reported in seeds of cotton, wheat and sorghum [4], [5], [6]. In India, cotton hybrids are more popular and widely grown, the seeds of which are bold and heavy producing healthy and strong seedlings. It was imperative to understand if superior reserve utilization and conversion of reserves also played a role in making the hybrid seed produce superior seedlings compared to straight varieties. The hypotheses tested here were (i) the ability of the seed to remove nutrients from reserve tissues and transform them into seedlings (Seed Reserve Utilization efficiency) is determined by the seed weight which in turn is determined by the seed reserve content; (ii) the seed reserve utilization ability is higher for hybrids than varieties. The objective of the study therefore was thus to determine the variability with respect to four seed reserve utilization traits as well as their interrelation ships among cotton genotypes *viz.* hybrids and straight varieties which vary widely in their seed weight.

MATERIAL AND METHODS

The seed materials for present study included six each of cotton hybrids, *G. hirsutum* and *G. arboreum* varieties which varied in their seed weight/mass. While the seeds of *hirsutum* and *arboreum* varieties were produced at

ICAR-Central Institute for Cotton Research, Nagpur, the seeds of hybrids were outsourced. Acid delinted fresh untreated seeds were tested for seed moisture and initial germination (%). The seed moisture content was in the range of 6-8% and all the genotypes showed more than 70% germination (IMSCS). Thereafter, the seeds were used for the experiment in which following parameters were recorded.

Seed weight (g)

Dry weight of 100 seeds were measured in three replications which were subsequently subjected to germination test.

Standard germination test: One hundred seeds in three replicates were placed on moisture saturated paper towels rolled and kept upright. The rolled towels were kept in controlled conditions (25±1°C), 70% relative humidity. Data were recorded after 12 days to calculate the germination (%) [2].

Seed quality evaluation

The physiological status of the cultivars was defined by germination test and shoot length. The seed weight (g) for germinated number of seeds were recalculated as shown below:

Re-calculated seed weight (X) = [No: of seeds germinated (Y) X 100 seed weight] / 100

The obtained value was then considered as the initial seed weight (ISW in g) in the study that followed. During the observation on germination, the respective seed hulls of each germinated seedling was collected separately and kept for drying and weighing to get the seed hull weight (g). Only the normal seedlings as per ISTA 2019 were taken for further observations. The shoot length (cm) as well as seedling length (cm) (shoot length + root length) were measured. All the germinated seedlings after measurement in each replication were kept inside heated oven at 80^0C for 24 hours for drying and weighed to determine seedling dry weight (SDW in g)

Evaluation of seed reserve traits

The seed reserve traits were estimated based on seed and seedling dry weights, seed reserve utilized or depleted, rate of seed reserve utilization or depletion, and use efficiency of seed reserves [4].

The difference between the initial seed weight and the dried seed hull weight gave the value for seed reserve depletion (SRD) *i.e.* ISW - SHW. Seed Reserve Depletion ratio or rate (SRDR) was calculated by dividing SRD with initial seed weight (SRD /ISW), amount of seed reserve respired (SRR) was obtained by reducing the total of SDW and SHW from the initial seed weight (ISW - (SDW + SHW). Seed Reserve Utilization Efficiency (SRUE) was arrived at by dividing seedling dry weight by seed reserve depletion (seedling dry weight / Seed Reserve Depletion).

Statistical analysis

The generated data was utilized for comparative analysis of each parameter among the species. Correlation co-efficient between the traits were also worked out separately for hybrids, *G. hirsutum* and *G. arboreum* varieties using SAS statistical software version 9.4 (SAS Institute Inc. 2016. SAS® 9.4 Language Reference: Concepts, Sixth Edition. Cary, NC: SAS Institute Inc.)

RESULTS AND DISCUSSION

Comparison of traits among hybrids and varieties

The seed, seed reserve and seedling parameters considered as physiological traits were evaluated among the studied genotypes of cotton which included hybrids, *G. hirsutum* and *G. arboreum* varieties. The traits including shoot length, initial seed weight, seed reserve content or seed reserve depleted and seedling dry weight were significantly higher for hybrids, followed by *G. hirsutum* and *G. arboreum* varieties respectively (Table 1). Using cultivars that are contrasting in seed size and type (hybrids or varieties) but with similar quality would provide a good study material to understand the role of seed reserves in seedling growth. Hybrid seeds being bolder and bigger in size are known to produce superior seedlings with longer shoots and higher seedling dry weight in field conditions. With regard to the varieties, the seeds of *G. hirsutum* are bigger than seeds of *G. arboreum* varieties and showed higher values for the mentioned traits among both species. The seed reserve depletion (SRD), seed reserve depletion rate (SRDR) and seed reserve respiration (SRR) were higher for hybrids followed by *G. hirsutum* and *G. arboreum* varieties respectively. Germination and initial growth are dependent on seed nutritive reserve until photosynthesis begins [7] and hence can be assumed that bigger sized seeds contain higher seed reserve which is shown as higher seed reserve depleted (SRD). However, bigger seeds compared to smaller seeds need not necessarily exhibit higher germination% per se [16], provided, seeds

Table 1. Comparative analysis for the seed physiological parameters among the species

Species	Shoot Length (cm)	Initial Seed Weight (g)	SRD	Seedling Dry Weight (g)	SRDR	SRUE	SRR	Dry weight/ Hull	Germination (%)
Hybrids	14.57^{a}	2.06^{a}	1.31^{a}	0.99^{a}	0.86^{a}	0.80^{a}	0.33^{a}	0.035^{a}	83.55^{a}
hirsutum genotypes	12.14^{b}	1.51^{b}	0.89^{b}	0.67^{b}	0.63^{ab}	0.79^{a}	0.23^{ab}	0.034^{a}	74.89^{a}
arboreum genotypes	10.46^{c}	1.13^{c}	0.61^{c}	0.45^{c}	0.52^{b}	0.78^{a}	0.16^{b}	0.026^{b}	78.67^{a}

#Different (small) letters in each column indicate significant difference ($p<0.05$)

of all genotypes are of high quality. Accordingly, germination (%) was at par for all genotypes irrespective of hybrids or pure line genotypes. It is pertinent to mention that Seed Reserve Utilization Efficiency (SRUE), that is, the seedling matter developed from one unit of seed reserve, showed no significant variation among hybrids or varieties (Table 1).

Correlation analysis of seed reserve traits within varieties and hybrids

The correlation coefficient among the studied traits in *G. hirsutum* varieties is presented in Table 2. It was significant and positive for seed reserve depletion (SRD) or the content of seed reserve with initial seed weight (ISW), seedling dry weight (SDW) and seed reserve respiration (SRR). The mobilized/depleted seed reserves are mainly used for respiration during seedling growth and hence found positively related in wheat seed [6]. The SRD showed a significant negative association with seed reserve utilization efficiency (SRUE), the quantity of plant tissue developed per unit of seed reserve depleted, indicating that, higher reserve need not play a role in efficient seedling growth. SRUE exhibited significant negative correlation with ISW, SDW and Seed reserve respiration (SRR) (Table 2). In maize, it was found that the reserve conversion rate of seeds with lesser weight was higher than that of large seeds which are heavier [8].

The correlation analysis in *G. arboreum* varieties also showed significant and positive association for seed reserve depletion (SRD) with initial seed weight (ISW) and seedling dry weight (SDW). But, unlike *hirsutum* varieties, it was significant and positive for SRD with both SRDR and SRR (Table 3). This indicates that there is higher rate of utilization/depletion of available seed reserve in *G. arboreum* compared to *G. hirsutum* and was found in total agreement with earlier report on a similar study on *arboreum* varieties of cotton [9]. The authors reported this trait as a reason for early emergence and seedling growth usually observed in *arboreum* cotton varieties [4]. The SRUE, as in *G. hirsutum* varieties, exhibited significant negative correlation with traits including ISW, SRD, SRDR and SRR and is again in agreement with the study mentioned above in *arboreum* varieties [9]. It has been reported that seeds mobilizing a greater amount of their reserves tend to effectively utilize a smaller proportion of their reserves and is not always necessary that high seed reserve depletion will be linked to building any useful plant part [10].

Table 2. Correlation coefficient among seed physiological parameters in Hirsutum genotypes

Parameters	Shoot Length (cm)	Initial Seed Weight (g)	SRD	Seedling Dry Weight (g)	SRDR	SRUE	SRR
Shoot Length (cm)	1.00	0.52*	0.43	0.53*	0.07	-0.34	0.33
Initial seed Weight (g)	0.51*	1.00	0.99*	0.97**	0.18	-0.71**	0.91**
SRD	0.43	0.99*	1.00	0.96**	0.17	-0.73**	0.94**
Seedling Dry Weight (g)	0.53*	0.97*	0.96**	1.00	0.06	-0.56*	0.82**
SRDR	0.07	0.18	0.16	0.06	1.00	-0.35	0.32
SRUE	-0.34	-0.71**	-0.73**	-0.56*	-0.35	1.00	-0.87**
SRR	0.33	0.91**	0.94**	0.82**	0.32	-0.87**	1.00
Dry Weight/Hull	0.18	0.03	-0.04	-0.04	0.16	0.09	-0.06

*Significant at $p<0.05$; **Significant at $p<0.01$

Table 3. Correlation coefficient among seed physiological parameters in Arboreum genotypes

Parameters	Shoot Length (cm)	Initial Seed Weight (g)	SRD	Seedling Dry Weight (g)	SRDR	SRUE	SRR
Shoot Length (cm)	1.00	0.51*	0.52*	0.08	0.21	-0.72**	0.63**
Initial seed Weight (g)	0.51*	1.00	0.95**	0.64**	0.67**	-0.67**	0.80**
SRD	0.52*	0.95**	1.00	0.65**	0.77**	-0.74**	0.86**
Seedling Dry Weight (g)	0.08	0.64**	0.65**	1.00	0.56*	-0.01	0.18
SRDR	0.21	0.67**	0.77**	0.56*	1.00	-0.52*	0.63**
SRUE	-0.72**	-0.67**	-0.74**	-0.01	-0.52*	1.00	-0.96**
SRR	0.63**	0.80**	0.86**	0.18	0.63**	-0.96**	1.00
Dry Weight/Hull	-0.15	-0.04	-0.27	-0.20	-0.05	0.25	-0.23

*Significant at $p<0.05$; **Significant at $p<0.01$

Table 4. Correlation coefficient among seed physiological parameters in hybrids

Parameters	Shoot Length (cm)	Initial Seed Weight (g)	SRD	Seedling Dry Weight (g)	SRDR	SRUE	SRR
Shoot Length (cm)	1.00	-0.02	0.06	0.03	0.24	0.02	0.04
Initial Seed Weight (g)	-0.02	1.00	0.96**	0.86**	0.29	-0.03	0.38
SRD	0.05	0.96**	1.00	0.73**	0.55*	-0.25	0.60**
Seedling Dry Weight (g)	0.03	0.86**	0.73**	1.00	-0.04	0.46	-0.11
SRDR	0.24	0.29	0.55*	-0.04	1.00	-0.72**	0.85**
SRUE	0.02	-0.03	-0.25	0.46	-0.72**	1.00	-0.90**
SRR	0.04	0.38	0.60**	-0.11	0.85**	-0.90**	1.00
Dry Weight/Hull	-0.22	0.60**	0.40	0.67*	-0.43	0.43	-0.21

*Significant at $p<0.05$; **Significant at $p<0.01$

In the hybrids too, the SRD showed significant positive correlation with ISW, SDW, SRDR and SRR and was in complete accordance with *G. arboreum* and *G. hirsutum* varieties (Table 4). The low or significantly negative association for SRUE with all the studied traits in hybrids similar to *G. hirsutum* and *G. arboreum* varieties further strengthened the understanding that SRUE is a trait which does not depend upon ISW or SRD. A study in chickpea showed that conversion efficiency of seed reserves into plant tissue (SRUE) was the same regardless of seed size [11] and in maize, it was found that smaller seeds showed higher reserve mobilization efficiency than large seeds [10].

The seed material used in the present study maintained similar correlation among seed reserve traits irrespective of them being hybrid or straight varieties of *desi* or *G. hirsutum*. This could be because the study was under controlled conditions and not under field condition where the developing seedlings might face various stress situations affecting the SRUE as observed in wheat [5]. There is also a contradictory report in wheat which suggested that increased stress in the environment, decreased the SRD and SRDR while there was no effect on SRUE [9] indicating its complete genetic control. However, the PEG priming lead to improvement of the seed reserve depletion and total seedling dry weight (SLDW) of sorghum seedlings under water stress conditions [6] supporting the role of external factors in SRUE.

CONCLUSIONS

Seed reserve and its utilization patterns under controlled conditions were studied in hybrids and varieties of cotton which belonged to different species and varied widely in their seed weights. While the germination (%) did not vary among hybrids or varieties, the initial seed weight as well as seed reserve was significantly higher in hybrids followed by pureline varieties of *hirsutum* and *arboreum* spp. respectively. However, the conversion rate of reserves into seedling tissues, measured as seed reserve utilization efficiency, was not influenced by any of the above traits and showed negative association with these, consistently in seeds of hybrids, *G. hirsutum* varieties and *G. arboreum* varieties. It is thus concluded that seed size or weight with higher seed reserves are not the determining factors for higher seedling growth in cotton.

REFERENCES

1. SANTHY V AND R K DESHMUKH (2008). Methanol stress test to evaluate initial seed vigor in cotton. *Seed Research* **36**(1).

2. ISTA (2015). *International rules for seed testing* Basserdorf, Switzerland International Seed Testing Association

3. AMBIKA S, V MANONMAN AND G SOMASUNDARAM (2014). Review on effect of seed size on seedling vigor and seed yield. *Research Journal of Seed Science,* **7**(2): 31-38.

4. SANTHY V, K RATHINAVEL, SM PALVE AND A VISHWANATHAN (2009). Interrelationships of seed reserve utilization components in desi cotton (Gossypium arboreum). *Indian Journal of Genetics and Plant Breeding*, **69**(1): 69-71.

5. HASAN MA AND JU AHMED (2012). Evaluation of seed reserve utilization efficiency during germination in relation to heat tolerance of wheat. *Thai Journal of Agricultural Science 2012*, **45**(1): 29-36.

6. TOUNEKTI TM, ZA MAHADI AND H KHEMIRA (2020). Priming improves utilization, growth, antioxidant responses and membrane stability at early seedling stage of Saudi sorghum varieties under drought stres**s**. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, **48**(2), 938–953.

7. BAREKE T (2018). Biology of seed development and germination physiology. *Adv. Plants Agric. Res*, **8**(4): 336-46.

8. ANDRADE GCD, CMM COELHO and MS PAADIHA (2019). Seed reserves reduction rate and reserves mobilization to the seedling explain the vigour of maize seeds. *Journal of Seed Science*, **41**: 488-497.

9. SOLTANI AM, GHOLIPOORB AND E ZEINALI (2006). Seed reserve utilization and seedling growth of wheat as affected by drought and salinity. *Environmental and Experimental Botany*, **55:** 195–200.

10. MIN L, W DA-XING, S QING-QING, W CHENG-LAI, L YAN AND Z CHUN-QING (2022). Factors influencing seed reserve utilization during seedling establishment in maize inbred lines *Journal of Integrative Agriculture* **21**(3): 677–684A.

11. SOLTANI AS, E GALESHI, N ZEINALI, I LATIF (2002). Gemination, seed reserve utilization and seedling growth of chickpea as affected by salinity and seed size. *Seed Science and Technology,* **30**(1):51-60.