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Relation of Seed Vigour to Yield Performance in Different Seed Lots of Cotton (*Gossypium Hirsutum* L.)

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ABSTRACT

Seed is the basic input of agriculture and which have valuable role in Indian economy. The quality seed is presumed to possess a high magnitude of genetic purity, seed vigour, germination per cent along with free from seed borne diseases supplemented with high yielding ability. Seed encloses a mysterious source of life of a plant, mysterious time and place mechanism which signals next growth stage. Seed vigour is the property of a seed indicating the sum of seed properties that determine the ability of viable seeds to germinate with speed, uniform, and produce healthy seedlings with rapid emergence, despite of optimal favorable conditions. Seed Vigour is one of the key factors that determining the success or failure of a crop based on performance of seed. The present investigation includes two sets of experiments. *i.e.,* laboratory and field experiment which were undertaken at Seed Technology Research Unit (STRU), Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola during 2021-2022 to evaluate vigour traits and to correlate them with yield contributing traits in five seed lots of *G. hirsutum* cotton *viz.,* PKV-Rajat (ARS-Achalpur, CRS-Mission School Block and CRS-Nimbi), AKH-09-5 (CRS-Shivar Block) and AKH-081 (ARS-Achalpur). Observations were recorded for six seed vigour traits in laboratory *viz.,* germination per cent, shoot and root length, seedling dry weight, seed vigour index-I and seed vigour index-II along with fourteen yield and its attributing traits in field. The both experiments i.e. laboratory experiment and field experiment were laid down separately using completely randomized design and randomized block design, respectively for proper handling and analysis of data. ANOVA revealed significant differences among the seed lots for all the six vigour traits under laboratory condition along with all fourteen yield and its contributing traits in *G. hirsutum* in field experiment indicating substantial degree of variation among seed lots. Although yield is complex quantitative trait, in present investigation seed cotton yield was found to be positively and significantly associated with all six seed vigour parameters in seed lots *viz.,* germination per cent (r=0.904*), shoot length (r=0.941*), root length (r=0.954*), seedling dry weight (r=0.959*), seed vigour index-I (r=0.944*), seed vigour index-II (r=0.951*) and germination per cent (r=0.958*), shoot length (r=0.965**), root length (r=0.947*), seedling dry weight (r=0.961**), seed vigour index-I (r=0.972**), seed vigour index-II (r=0.987**) respectively. The prediction of quality and potential of seed lots may be done at seedling stage in laboratory for successful crop stand. Also, the seed vigour traits may be useful for deciding the worth of seed lots in respect of its planting values. On the basis of present investigation the seed lots of same genotypes having same genetic constitution may vary in potential due to variation in conditions where they are grown.

Keywords: Cotton, *G.hirsutum* L., Seed Vigour Traits, Seed Lots, Correlation and Field Parameters

INTRODUCTION

Cotton as predominantly self-pollinated and often cross-pollinated one of cash crop. The word cotton reported to be derived from Arabic word *'KUTON'* or *'QUTON'*, belonging to genus *Gossypium* and family Malvaceae. It consists of nearly forty-five diploid and five allotetraploid species those are found naturally throughout the semiarid and arid region of Africa, Australia, Central and South Africa, Indian subcontinent, Arabia, Galapagos and Hawaii. During the course of evolution and domestication humans have selected four species of cotton for its cultivation having seed fibres were characteristically long and spinnable. In cultivated species of cotton viz., *Gossypium arboreum, G. herbaceum* are diploid (2n=2x=26) and are native to old world, also known as Asiatic cottons because they are predominantly grown in Asia. While the *G. hirsutum* and *G. barbadense* species are tetraploid (2n=4x=52) and are also referred to as New World Cottons. *G. hirsutum* is also known as American cotton or upland cotton and *G. barbadense* as Egyptian or Sea Island cotton or Tanguish Cotton or quality cotton. *G. hirsutum* is the predominant species which alone contributes about 90 per cent to the global production whereas eight per cent is under G. barbadense and about two per cent is under *G. arboreum* and *G. herbaceum* (Simpson, 1954).

Seed is a basic input in agriculture and which have valuable role in Indian Economy. Seed Vigour is one of the major factors that determining the worth of seed in respect of success or failure of a crop stand. Seed vigour referred as the ability of the seed to germinate and get established under less-than-optimal conditions, or to survive in a series of environmental stresses during germination (Abdul-Baki, 1980). Moreover,

Seed vigour determines the potential for rapid and uniform emergence of plants under a wide range of field conditions for weather factors. The quality of seed is a matter of concern in agriculture throughout the globe, the rapid and uniform emergence of vigourous seedlings of the cultivar is key event to ensure high plant performance that affects uniformity of growth, yield and quality of the harvested product. These factors highlight the importance of selecting high quality seed lots.

Evaluation of germination and the screening of seed lots with superior performance is a crucial initial step for achieving successful crop production through healthy plant stand. The performance of the sown seeds indicates whether the potential identified by appropriate laboratory tests was achieved and how adequate were the techniques, used for its vigour evaluation. The availability of quality seed is a prerequisite for the satisfactory production of a good quality crop and is also essential for economy. Whereas, the cotton quality has different meanings for farmers and industry as a source of fibre, as for cotton cultivating farmers high cotton quality means more income and for the industry, it means fewer losses. Cotton growers are more interested in predicting field emergence i.e. plant stands so that crop production schedule can be precisely matched to meet market demand. The thumb rule for maximum yield is that it can be achieved by use of high-quality seed, and seed quality test that can help them to predict the performance of seed. The standard germination test is commonly used to evaluate seed quality and guide farmers to determine the quantity of seed to be sown through manipulating the seed rate. When field conditions are optimum, the standard germination test may predict relative emergence of the seed lot in the field, however, under sub-optimal field conditions, standard germination test results, generally overestimate field emergence. In such circumstances, the vigour tests provide additional information on the relative performance of seed in the fields under wide range of environments. Since, the cost of seed is rising day-by-day , seed producing agencies and farmers are becoming more interested in laboratory-based vigour techniques.

MATERIAL AND METHODS

The research work comprised both laboratory and field evaluations of cotton seed lots to investigate the relationship existing between seed vigour traits and yield and its contributing traits in *G. hirsutum* cotton seed lots (Table 1) was carried out during *Kharif-2021* at Seed Technology Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Table 1. Details of *Gossypium hirsutum L.* seed lots

Seed Lot	Variety	Source of seed losts
1	PKV-Rajat	ARS-Achalpur
2	PKV-Rajat	CRS-Nimbi
3	AKH-09-5	CRS-Shivar Block
4	AKH-081	ARS-Achalpur
5	PKV-Rajat	CRS- Mission School Block

Field observations were recorded for six seed vigour traits *viz.,* germination per cent, shoot length (cm), root length (cm), seedling dry weight (mg), seed vigour index-I and seed vigour index-II along with fourteen yield and yield contributing traits in field experiment *viz.,* field emergence per cent, days to first flowering, days to 50 per cent flowering, days to 50 per cent boll bursting, plant height, number of monopodia per plant, number of sympodia per plant, number of boll per plant, number of seed per boll, boll weight, seed index, ginning per cent, lint index, and seed cotton yield per plant. The laboratory experiment and field experiment were laid down separately using completely randomized design and randomized block design, respectively and analysis was carried out as per standard statistical procedures (Panse and Sukhatme, 1967). Whereas, correlation coefficient (r) i.e. estimates of mutual association among seed vigour traits and yield and its contributing traits were estimated with the help technique given by Pearson (1920).

RESULT AND DISCUSSION

Analysis of variance: The data was subjected to analysis of variance to study the variation for seed vigour traits *viz.,* germination per cent, shoot length, root length, seedling dry weight, seed vigour index-I and seed vigour index-II among the five seed lots of *G. hirsutum* cotton in completely randomized design as presented in Table 2 revealed that the variations among seed lots was found highly significant for all six seed vigour traits indicating substantial degree of variation among material for seed vigour traits and highlighted the differences among seed lots for initial seedling vigour under controlled laboratory conditions. The analysis of variance of fourteen yield contributing traits revealed highly significant differences among the all seed lots for morphological traits recorded from field experiment conducted in randomized block design with four replications indicated substantial degree of variations among the experimental material for yield and its contributing traits under the study (Table 3).

Table 2: Analysis of variance of seed vigour traits of *G. hirsutum* seed lots

Sources of variation	DF.	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry wt. (mg)	Seed vigour index-I	Seed vigour index-II

Treatment	4	18.33**	3.00**	3.42**	35.17**	125680.83**	34.66**
Error	15	3.23	0.21	0.16	4.61	2440.79	3.41

,= significant at 5% and 1% level of significance*

Table 3: Analysis of variance of fourteen yield contributing traits of *G. hirsutum* seed lots

Sr. No.	Characters	Mean Sum of Squares		
		Replications *(df-3)*	Genotypes *(df-4)*	Error *(df-12)*
1	Field emergence per cent	3.60	10.20**	2.93
2	Days to first flowering	2.03	27.08**	2.24
3	Days to 50% flowering	1.93	6.83*	2.06
4	Days to 50% boll bursting	7.73	14.83**	1.86
5	Plant height (cm)	7.10	44.95**	4.41
6	No. of monopodia per plant	0.04	0.92**	0.02
7	No. of sympodia per plant	2.03	8.61*	2.49
8	No. of boll per plant	2.10	9.12*	1.97
9	No. of seed per boll	0.53	8.88**	1.58
10	Boll wt. (g)	0.04	0.09*	0.02
11	Seed index (g)	0.13	1.01**	0.04
12	Ginning per cent	13.12	5.34	8.71
13	Lint index	0.65	0.8	0.30
14	Seed cotton yield per plant	72.21	141.79*	39.98

,= significant at 5% and 1% level of significance*

Association among seed vigour traits and yield contributing traits: The correlation coefficient (r) is known for the linear relationship between two variables, wherein, the significant positive correlation suggests that selection for one character could be used to indirectly select for another character but this can cause difficulties during selection if the association is between desirable and undesirable traits (Adebisi et al., 2004). The vigour is an important aspect of seed quality which controls its field stand establishment abilities and therefore, seed vigour tests are required to obtain reliable assessments of field performance in field crops (Delouche 1967, Jadhav and Ujjainkar 2023). The analysis of correlation coefficient has been undertaken to estimate the degree of relationship among seed vigour traits and fourteen yield contributing traits (Table 4) discussed under following headings.

Table 4: Correlation among yield contributing traits and seed vigour traits of *G. hirsutum*

Yield contributing traits	Correlation coefficient (r) with different seed vigour traits					
	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (mg)	Seed vigour index-I	Seed vigour index-II
Field emergence per cent	0.945*	0.906*	0.977**	0.846	0.955*	0.904*
Days to first flowering	0.987**	0.950*	0.943*	0.832	0.970**	0.885*
Days to 50% flowering	0.927*	0.897*	0.945*	0.886*	0.938*	0.935*
Days to 50% boll bursting	0.856	0.947*	0.908*	0.958*	0.914*	0.938*
Plant height (cm)	0.970**	0.975**	0.943*	0.880*	0.972**	0.909*
No. of monopodia per	0.959**	0.892*	0.931*	0.815	0.940*	0.884*

plant						
No. of sympodia per plant	0.922*	0.915*	0.990**	0.888*	0.954*	0.930*
No. of boll per plant	0.907*	0.937*	0.989**	0.934*	0.956*	0.954*
No. of seed per boll	0.964**	0.935*	0.943*	0.907*	0.962**	0.953*
Boll wt. (g)	0.970**	0.954*	0.958*	0.929*	0.976**	0.969**
Seed index (g)	0.990**	0.958*	0.979**	0.883*	0.988**	0.934*
Ginning per cent	0.646	0.672	0.832	0.665	0.722	0.690
Lint index	0.885*	0.871	0.972**	0.819	0.918*	0.866
Seed cotton yield per plant	0.958*	0.965**	0.947*	0.961**	0.972**	0.987**

,= significant at 5% and 1% level of significance*

Germination per cent: In field, the germination is the first stage of plant growth, which is one of the important stages of the life cycle sensitive plants and is designated as a key process in the emergence of seedlings. The seed germination is the active resumption of growth of embryo and development of normal plant. Seed germination depends upon degree of seed filling because of bold seed have more germination percentage due to maximum chemical energy provided for seed germination. As per table 4, the vigourous seed influence rapid seed germination, seedling emergence and plant field performance due to increasing seed cotton yield. In cotton seed lots germination per cent showed positive correlation with all fourteen yield and yield contributing morphological traits, indicating the importance of germination value of seed for success of crop stand. In present investigation, all the morphological traits shown statistically significant positive correlation except days to 50 per cent boll bursting (r=0.856) and ginning per cent (r=0.646), in positive direction but were non-significant. The character of seed index exhibited the highest and positive degree of correlation (r=0.990**), followed by phenological attribute i.e. days to first flowering (r=0.987**), plant height (r=0.970**), boll weight (r=0.970**), number of seed per boll (r=0.964**), number of monopodial branches per plant (r=0.959**), seed cotton yield (r=0.958*), field emergence per cent (r=0.945*), days to 50 per cent flowering (r=0.927*), number of sympodia per plant (r=0.922*), number of boll per plant (r=0.907*) and lint index (r=0.885*). The germination is a one of the complex physiological process in seed bearing plants which depends on several environmental factors viz., light, temperature and storage duration (Koornneff et.al. 2002). Even the environmental conditions prevailed during seed formation and maturation have viable impact on seed germination and dormancy. Germination testing remains the principle, and internationally accepted criterion for seed viability. The results obtained in investigation revealed that there is a major role of germination potential for even crop stand and subsequent growth and development. Also the rapid germination is an important component of the seed vigour concept since it corresponds to more rapid seedling emergence in field. Among the yield and important yield contributing traits viz., seed index (g), days to first flowering, plant height (cm), boll weight (g), number of seed per boll, number of monopodia per plant, seed cotton yield per plant (g), field emergence per cent, days to 50 per cent flowering, number of sympodia per plant, number of boll per plant and lint index exhibited highly significant and positive relationship with germination. Sympodial branches are responsible for deciding the plant geometry of genotype. The boll attributes viz., number of boll per plant, boll weight, number of seeds per boll and seed index which showed positive correlation with germination value of seed lots. These boll attributes play important role in contributing towards yield. Significant positive relationship (r=0.81*) was observed germination per cent with days to first flowering and days to 50 per cent flowering Douglous *et al.,* (1974). Significant (r=0.86**) correlation of germination per cent was observed with field emergence after fifteen days of sowing in cotton (Zade *et al.,* 1994). Similar results were obtained in cotton experiments reported by Lal *et al.,* (2017), Ujjainkar et al (2023). The values of correlation coeffecients indicated that for a number of sympodia per plant, there would be a proportional germination per cent. However, the results are fully supported by Mattioni *et al.,* (2012) who conducted experiments in cotton to find out the correlation of germination per cent with various plant characters and found that significant associations between number of sympodia per plant (r=0.930**) and seed yield per plant (r=970**).

Shoot length: Generally, the poor crop establishment is often resulted due to the poor seed quality. Whereas, the seed awarded with the high-quality results in rapid germination and emergence and rapid root and shoot growth during the early stages of seedling development. In present study, revealed that shoot length has highly significant and positively associated with yield and its fourteen yield contributing traits, highlighted the importance of development of plant height and vegetative growth due to increase in photosynthetic efficiency. The *G. hirsutum* seed lots for shoot length showed positive correlation with all fourteen yield and its contributing characters which indicating importance of germination value of seed for success of crop. All the morphological traits shown statistically significant positive correlation except lint index (r=0.871) and ginning per cent (r=0.672) in positive direction but were fail to attempt the statistical significance. The character of plant height (cm) exhibited the highest and positive degree of correlation (r=0.975**) followed by seed cotton yield per plant (r=0.965**), seed index (r=0.958*), boll weight (r=0.954*), days to first flowering (r=0.950*), days to 50 per cent boll bursting (r=0.947*), number of boll per plant (r=0.937*), number of seed per boll (r=0.935*), number of sympodia per plant (r=0.915*), field emergence per cent (r=0.906*), days to 50 per cent flowering (r=0.897*) and number of monopodia per plant (r=0.892*). The shoot length of cotton seedling of important characteristics for deciding the morph-physiological characteristics viz., number of monopodia and number of sympodia these are the major contributor of seed cotton yield as these are actual boll bearing structures in cotton plants. The poor seed lot exhibited poor seedling growth due to shorter plants, less in number of vegetative and boll bearing branches of plants, affecting canopy characteristics, physiological and biochemical processes and subsequently resulting in to lower yield. Significant correlation showed that the increase in shoot length

there would be a proportional number of sympodia per plant in cotton. The findings obtained in present research work are in agreement to the results found by Douglous et al., (1974), Bishnoi et al., (1980), Shridhar and Nagaraja (2004), (Pahlavani et al., 2008) and Mattioni et al., (2012).

Root length: Root length of cotton seedlings has direct influence on the vigourous and rapid growth of plant and vegetative development in the field. In present investigation seedling root length showed positive correlation with all yield contributing traits, ensuring the rapid nutrient absorption which is the decisive factors for healthy and uniform plant stand. Root length also responsible for rapid establishment of seedling in field condition. All the morphological traits shown statistically significance correlation in positive direction except ginning per cent (r=0.832) in positive direction but were non-significant (Table 4). The character of number of sympodia per plant (g) exhibited the highest and positive degree of correlation (r=0.990**) followed by number of boll per plant (r=0.989**), seed index (r=0.979**), field emergence per cent (r=0.977**), lint index (r=0.972**), boll weight (r=0.958*), seed cotton yield per plant (g) (r=0.947*), days to 50 per cent flowering (r=0.945*), days to first flowering (r=0.943*), plant height (r=0.943*), number of seed per boll (r=0.943*), number of monopodia per plant (r=0.931*), and days to 50 per cent boll bursting (r=0.908*). Its revealed that healthy root systems ensure the proper nourishment, uptake of nutrients and subsequent yield increase. The healthy root system responsible for high sensibility stresses of plant during the growth period. The traits of root length are highly significant and positively correlated with many yield contributing characters including number of sympodia per plant, number of bolls per plant, boll weight and number of seed per boll. These are all the yield contributing traits which reflect the yield. Similar results were attributed by Lather et al., (1992) and Sandhu et al., (1992), Lal Mohan et al., (2017) and Vanashri Hulke et al., (2019) in cotton.

Seedling Dry-weight: The seedling dry weight may be more precisely depict the seed quality as comparison to seedling length as the change in root: shoot ratio during plants lifecycle is part of an intrinsic ontogeny, but the growth rates of roots and shoots continually adjust to resource availability with photo assimilate. Seedling dry weight is an important seed vigour trait which can be used as index of efficiency for conversion of seed food reservoir, as the effect of lower seed vigour on speed of seed germination due to poor growth of seedling and accumulation of seedling dry weight. In present investigation, all yield contributing traits shown statistically significant positive correlation field emergence per cent (r=0.846), days to first flowering (r=0.832), lint index (r=0.819), number of monopodia per plant (r=0.815) and ginning per cent (r=0.665) in positive direction but were non-significant (Table 4). The character of seed cotton yield per plant (g) exhibited the highest and positive degree of correlation (r=0.961**), followed by days to 50 per cent boll bursting (r=0.958*), number of boll per plant (r=0.934*), boll weight (r=0.929*),number of seed per boll (r=0.907*), number of sympodia per plant (r=0.888*), days to 50 per cent flowering (r=0.886*), seed index (r=0.883*) and plant height (r=0.880*). Many cotton researchers also highlighted the similar kind of reports viz., Mattioni et al., (2012) and Devi et al., (2019). While, the contrasting results were reported by Douglous et al., (1974) and which reported positive correlation for days to 50 per cent boll bursting.

Seed Vigour Index – I: As per the definition of Perry, 1970, the seed vigour defined as the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence. The evaluation of vigour tests for predicting seed planting value is important in providing better results for ranking the quality of seed, as the successful crop production start with a good plant stand and the seed vigour is an important component of seed quality and satisfactory levels are necessary in addition to essentialities of moisture purity, germination and seed health etc. In present study, the seed lots of *G. hirsutum* for seed vigour index-I showed positive correlation with all fourteen yield and its contributing characters which indicating importance of germination value of seed for success of crop. All the morphological traits shown statistically significant positive correlation except ginning per cent (r=0.722) in positive direction but were non-significant (Table 4). The character of number of seed index (g) exhibited the highest and positive degree of correlation (r=0.988**) followed by boll weight (r=0.976**), plant height (r=0.972**), seed cotton yield per plant (r=0.972**), days to first flowering (r=0.970**), number of seed per boll (r=0.962**), number of boll per plant (r=0.956*), field emergence per cent (r=0.955*), number of sympodia per plant (r=0.954*), number of monopodia per plant (r=0.940*), days to 50 per cent flowering (r=0.938*), lint index (r=0.918*) and days to 50 per cent boll bursting (r=0.914*). The results of the analysis of correlations showed that seed vigour index-I in light of present studies, was positively and significantly associated with field emergence per cent. This information suggested that a vigourous lot have maximum field emergence per cent, which in turn increased optimum plant population it leads to maximum seed cotton yield. Similar results were reported by Snider et al., (2014), Douglous et al., (1974) Lather et al., (1992), Sandhu et al., (1992), Lal et al., (2017) and Devi et al., (2019).

Seed Vigour Index – II: Generally the estimation of vigour of seed or seed lot, depending on seedling length i.e., shoot and root length would not be sufficient to draw valid conclusions for seed lots, as the conversion of seed reservoir in to the structural unit of plant more reliable provide estimates of vigour (Ujjainkar and Marawar, 2021). In present investigation, the seed lots for seed vigour index-I showed positive correlation with all fourteen yield and its contributing characters which indicating importance of germination value of seed for success of crop. All the morphological traits shown statistically significant positive correlation except that of lint index (r=0.866) and ginning per cent (r=0.690), which was in positive direction but were non-significant (Table 4). The character of seed cotton yield per plant (g) exhibited the highest and positive degree of correlation (r=0.987**),followed by boll weight (r=0.969**), number of boll per plant (r=0.954*), number of seed per boll (r=0.953*), days to 50 per cent boll bursting (r=0.938*), days to 50 per cent flowering (r=0.935*), seed index (r=0.934*), number of sympodia per plant (r=0.930*), plant height (r=0.909*), field emergence per cent (r=0.904*), days to first flowering (r=0.885*) and number of monopodia per plant (r=0.884*), highlighted the importance of these characters in respect of seed cotton yield in upland cotton. Similar kind of findings were also reported in cotton research reported by Sandhu et al., (1992), Zade et al., (1994), Adebisi et al., (2010), (Keshavulu et al., 2012), Liu et al., (2014), Li et al., (2023) Ujjainkar et al (2023) and Holladay et al (2024) in range of crops.

CONCLUSION

It can be concluded that based on study on American cotton seed lots, the prediction of quality and potential of seed lots may be done at seedling stage in laboratory for successful crop stand. Also, the seed vigour traits may be useful for deciding the faith of seed lots. Based on the present investigation the seed lots of same genotypes having same genetic constitution may vary in potential due to variation in conditions where they are grown. Further, the vigour traits were including seed germination, root length, shoot length, seedling dry weight, seed vigour index- I, and seed vigour index -II shown positive association with yield contributing characters and may be used to determine planting value of cotton seed lots.

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