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Effect of Different Sowing Time on Seed Vigour Parameters of Wheat (*Triticum aestivum* L.) Varieties

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ABSTRACT

The experiment was conducted at, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad during, 2017-18. For this study different wheat varieties were sown on different time. First sowing was done as early sowing on 15 November and second sowing on 30 November for evaluating whether sowing affect seed vigor parameters. In this study twelve wheat varieties after harvesting were studied under laboratory condition. Seed quality parameters such as test weight (g), seed moisture content (%), germination percent (%), root length (cm), shoot length (cm), seedling length (cm), seedling fresh weight (g), seedling dry weight (g), vigour index I & II were considered for evaluating seed vigor. Study showed that varieties sown early performed better than medium sown wheat varieties in terms of Test weight, germination per cent, Seedling fresh weight, seedling length and vigor indices I & II. On the basis of 12 early sown wheat varieties, Super-252 showed maximum vigour index-I (2427.95), where as Super-303 showed high vigour index-II (17.80). In medium sown wheat varieties Lokman showed high vigour index-I (2280.70) and vigour index-II(19.36).

Key word: *Wheat varieties, Seed quality, Seed vigour*

INTRODUCTION

Wheat is a cereal grass of the Graminae (Poaceae) family and of the genus Triticum, is the world's largest cereal crop. It has been described as the "King of Cereals" because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. According to the earliest historic records, wheat was an important cultivated cereal in South-western Asia, Syria, Northern Israel, Iraq and Eastern Turkey. Wheat was cultivated in ancient Greece and Egypt in pre-historic times. The central Asia, Near East, Mediterranean and Ethiopian regions are the world's most important centers of diversity of wheat and its related species[11,13].

Wheat (*Triticum aestivum* L.) is an important cereal grown as food grain in the world.

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Wheat has good nutrition profile with 12.1 percent protein, 1.8 percent lipids, 1.8 percent ash, 2.0 percent reducing sugars, 6.7 percent pentose's, 59.2 percent starch, 70 percent total carbohydrates and provides 314 Cal/100 g of food. It is also a good source of minerals and vitamins *viz.,* calcium (37 mg/100g), iron (4.1mg/100g), thiamine (0.45mg/100g), riboflavin (0.13mg/100g), and nicotinic acid (5.4mg/100g)[26].

Wheat is grown in world on an area of about 222 million hectares with a production of 730 million tones and productivity of 32.9 quintal/hectare. Wheat is grown in India on an area of about 302.27 lakh hectares with a production of 93.50 million tones and productivity of 30.93 quintal/hectare, In Uttar Pradesh wheat is grown on an area of about 9.65 million hectares with production of 26.87 million tones and productivity of 27.86 quintal/hectare (Directorate of Economics and Statics, Department of Agriculture, Cooperation & Farmers Welfare, 2015-16).

Seed vigour is the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of environments, a vigorous seed lot is one that is potentially able to perform well under environmental conditions which are not optimal for the species[8]. Seed vigour might be considered as a potential for seedling establishment in the field and the same idea was supported by various seed technologists[14]. Those new approaches and the comments from[24] constituted the foundation for the current concepts of seed vigour. Seed vigour determines the potential for rapid, uniform emergence, and development of normal seedlings under a wide range of field conditions[3]. Seed vigour, an important component of seed quality, depends on genetic and environmental factors, such as maternal plant nutrition, seed maturity, reserve and seed moisture content1[7,22].

MATERIAL AND METHODS

The laboratory experiment for the present investigation entitled with "Effect of different sowing time on seed vigour parameters of wheat (*Triticum aestivum* L.) varieties" was conducted during 2017-18 at Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, (U.P.). The laboratory experimental setup was laid out in complete randomized design (CRD) with 4 replications during the 2017-18. Seed vigour parameters of twelve wheat (*Triticum aestivum* L.) varieties were studied.

Test weight (g),[8]

The 1000 grains was counted randomly from the seed yield of each treatment in four replication and weight by adopting the procedure given by ISTA, 2001. The average weight was recorded in grams.

Seed moisture content (%)

The moisture content as a percentage by weight (fresh weight basis) is calculated to one decimal place, by using of the formula-

$$\% \text{ of seed moisture content (mc)} = \frac{M2-M3}{M2-M1} \times 100$$

Where

M1 = Weight of the weighing bottle/container with cover in g

M2 = Weight of the weighing bottle/container with cover and seeds before drying

M3 = Weight of the weighing bottle/container with cover and seeds after drying

Germination per cent (%),[8]

It refers to the proportion by number of seeds which have produced seedlings classified as normal under the conditions and within the period specified that is the percentage of normal seedlings.

The equation to calculate germination percent is:

$$GP = \frac{\text{No. of seeds germinated x 100}}{\text{Total no. of seeds}}$$

Root length (cm)

Five seedlings were selected randomly from each variety on 8th day from germination test. The root length was measured from the tip of the primary root to base of hypocotyls with the help of a scale and mean root length was expressed in centimetre.

Shoot length (cm)

Five normal seedlings used for root length measurement, was also used for the measurement of shoot length. The shoot length was measured from the tip of the primary leaf to the base of the hypocotyls and mean shoot length was expressed in centimetre.

Seedling length (cm)

Length of five normal seedlings grown on moist blotting paper kept at optimum temperature was measured in centimetre on the day of final count and maximum seedling length is considered vigorous.

Seedling fresh weight (g)

Measured on a sensitive electronic weighing balance immediately after removal from test tubes and wiped dry with paper towel.

Seedling dry weight (g)

For taking the observation of seedling dry weight, ten seedlings were dried in hot air oven at 100º C temperature for 24 hours. The dried seedlings were weighed with the help of electronic balance in gram.

Vigour index –

Vigour index I weas calculated by the multiplication of germination percentage with seedling length on the day of final count.

Vigour index I = Germination (%) x Seedling length (cm)

Vigour index II in terms of mass was determined by the multiplication of germination percentage with seedling dry weight on the day of final count.

Vigour index II = Germination (%) x Seedling dry weight

Table 1: Mean performance of early sown wheat (*Triticum aestivum* L.) varieties on seed quality characters

Varieties		Test weight (g)	Seed moisture content (%)	Germination per cent (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Fresh weight of seedling (g)	Dry weight of seedling (g)	Vigour index-I	Vigour index-II
PBW-154		45.6	11.56	86.00	12.21	16.39	28.80	0.86	0.20	2,364.60	16.35
PBW-343		38.4	13.57	89.25	10.74	14.96	25.70	0.82	0.19	2,175.95	16.56
PBW-502		40.4	12.06	87.00	10.99	11.6	22.92	0.90	0.16	1,913.67	13.98
PBW-550		41.8	13.46	87.75	10.96	12.22	23.93	0.96	0.20	2,021.08	17.10
HUW-234		36.1	13.88	84.75	10.45	12.00	22.33	0.91	0.16	1,881.46	13.71
HD-2967		35.6	14.03	85.75	10.87	10.57	21.44	0.89	0.18	1,794.56	15.53
Super-252		47	11.71	87.25	12.22	15.84	28.15	0.91	0.19	2,427.95	17.08
Super-303		42.4	12.79	79.25	11.85	12.24	24.07	0.96	0.16	2,040.94	17.80
HD-3086		48.2	14.32	89.50	12.15	11.17	23.33	1.04	0.21	2,047.90	14.32
Kuber		43.2	12	88.50	10.84	11.17	21.73	0.90	0.18	1,920.65	15.95
M.D.Vijeta		37.4	11.79	86.50	11.35	10.14	21.58	0.84	0.16	1,867.69	14.07
Lokman		48.8	12.09	87.50	10.54	13.74	24.36	0.93	0.19	2,147.73	17.19
Grand Mean		**42.07**	**12.77**	**86.58**	**11.26**	**12.67**	**24.03**	**0.91**	**0.18**	**2,050.35**	**15.80**
CD 5%		21.51	1.04	NS	0.80	0.79	1.40	NS	0.02	184.21	2.42
S E		1.33	0.29	1.32	0.28	0.27	0.48	0.04	0.00	63.96	0.84
CV		11.02	7.98	3.06	4.96	4.33	4.05	10.59	8.03	6.24	10.65
Range	**Max**	48.8	14.32	89.5	12.22	16.39	28.80	1.04	0.21	2,427.95	17.80
	Min	35.6	11.56	79.25	10.45	10.14	21.44	0.82	0.16	1,794.56	13.71

RESULTS AND DISCUSSION

Test weight in early sown 12 wheat varieties ranged from 35.6 to 48.8g with mean value of 42.07 g. Variety HD-3086 exhibited highest test weight (48.8 g), whereas variety HD-2967 exhibited low test weight (35.6). Test weight in medium sown varieties ranged from 32.6 to 43.5 g with mean value of 38.40 g. The variety Lokman exhibited highest test weight (43.5 g), whereas variety PBW-343 exhibited low test weight (32.6). These results are in accordance with Protic *et al*. (2007) who concluded that test weight of winter wheat decreased with later sowing, as a consequence of compensatory effects among yield components[4] similar was observed by Costa *et al*., 2013.

Seed moisture content in early sown varieties ranged between 11.56 to 14.32 percent with mean value of 12.77. Variety HD-3086 exhibited highest seed moisture content (14.32), whereas variety PBW-154 exhibited low seed moisture content (11.56) percent. Seed moisture content in medium

sown varieties was ranged from 11.46 to 14.29 percent with mean value of 12.94. The variety HD-3086 exhibited highest seed moisture content (14.29), whereas variety Lokman exhibited low seed moisture content (11.46) percent.

Germination per cent in early sown varieties ranged from 89.5 to 79.25 percent with mean value of 86.58. The variety HD-3086 exhibited highest germination percentage (89.5), whereas variety Super-303 exhibited low germination percentage (79.25) percent. Germination per cent in medium sown varieties ranged from 81 to 87.75 percent with mean value of 83.68. The variety PBW-154 exhibited highest germination per cent (87.75), whereas variety HD-3086 exhibited low germination per cent (81).

Late sowing reduced germination percentage, poor seedling vigor, reduced radicle and plumule growth of geminated seedlings are major impacts caused by heat stress documented in various cultivated plant species[10], Piramila *et al*., 2012, Toh *et al*.,[25]. Root length in early sown varieties ranged from 10.45 to 12.22 centimeter with mean value of 11.26. The variety Super-252 exhibited maximum root length (12.22), whereas variety HUW-234 exhibited minimum root length (10.45).

Root length in medium sown varieties was ranged from 10.43 to 13.31 centimeter with mean value of 12.05. The variety M.D.Vijeta exhibited maximum root length (13.31), whereas variety PBW-502 exhibited minimum root length (10.43).

Shoot length in early sown varieties was ranged from 10.14 to 16.39 cm with mean value of 12.67. The variety PBW-154 exhibited maximum shoot length (16.39), whereas variety M.D.Vijeta exhibited minimum shoot length (10.14 cm). Shoot length in medium sown varieties ranged from 10.21 to 14.01 centimeter with mean value of 12.34. The variety Kuber exhibited maximum shoot length (14.01), whereas variety HD-3086 exhibited minimum shoot length (10.21 cm). Seedling length in early sown varieties showed higher range mean from 21.44 to 28.80 with mean value of 24.03 cm, variety PBW-154 exhibited maximum seedling length (28.80), whereas variety HD-2967 exhibited minimum seedling length (21.44 cm). Seedling length in medium sown varieties ranged between 20.77 to 26.42 with mean value of 24.33 cm. The variety Lokman exhibited maximum seedling length (26.42), whereas variety PBW-502 exhibited minimum seedling length (20.77 cm). Seeds obtained from plants grown under high temperature conditions produced smaller seedlings with lower dry weight and shorter and fewer roots than those seeds produced at low temperatures[7].

Fresh weight of seedlings in early sown varieties ranged from 0.82 to 1.04 with mean value of 0.91. The variety HD-3086 exhibited maximum seedling fresh weight (1.04 g), whereas variety PBW-343 exhibited minimum seedling length (0.82 g). Fresh weight of seedlings in medium sown varieties ranged from 0.77 to 1.03 with mean value of 0.89. The variety HD-2967 exhibited maximum seedling fresh weight (1.03 g), whereas variety HD-3086 exhibited minimum seedling length (0.77 g).

Seedling dry weight in early sown varieties ranged from 0.16 to 0.21 with mean value of 0.18 g whereas in medium sown varieties it ranged from 0.15 to 0.65 with mean value of 0.22 g. The variety HD-3086 exhibited maximum seedling dry weight (0.21 g), whereas variety Super-303 exhibited minimum seedling dry weight (0.16 g)in early sown variety. The variety PBW-154 exhibited maximum seedling dry weight (0.65 g), whereas variety PBW-550 exhibited minimum seedling dry weight (0.15 g) in medium sown wheat variety.

Seeds obtained from plants grown under high temperature conditions produced smaller seedlings with lower dry weight and shorter and fewer roots than those seeds produced at low temperatures[7]. The same result has also been reported by several workers, Grass and Burris[7] and Sechnyak *et al.*[19] in wheat, by Keigley and Mullen[9] and Egli *et al.*[5] in soybean, by Fussel and Pearson[6]

in pearl millet grain and by Steiner and Opoku-Boateng in mature lettuce seed.

Vigour index-I in early sown varieties ranged from 1794.56 to 2427.95 with mean value of 2050.35. Variety Super-252 exhibited maximum seedling vigour index-I (2427.95), whereas variety HD-2967 exhibited minimum seedling vigour index-I (1794.56). Seedling vigour index-I in medium sown varieties was ranged from 1748.69 to 2280.70 with mean value of 2038.03. The variety Lokman exhibited maximum seedling vigour index-I (2280.70), whereas variety PBW-502 exhibited minimum seedling vigour index-I (1748.69). Seedling vigour index-II in early sown varieties was ranged from 13.71 to 17.80 with mean value of 15.80. The variety Super-303 exhibited maximum seedling vigour index-II (17.80), whereas variety HUW-234 exhibited minimum seedling vigour index-II (13.71). Seedling vigour index-II in medium sown varieties ranged from 12.66 to 19.36 with mean value of 15.59. The variety PBW-502 exhibited maximum seedling vigour index-II (19.36), whereas variety PBW-550 exhibited minimum seedling vigour index-II (12.66).

Seedling length, germination and vigour potential were reduced by high temperature treatments in several cultivars[7]. The seeds obtained from plants grown under high temperature conditions produced smaller seedlings with lower dry weight than those seeds produced at low temperatures.

Vigour potential is affected with a lot of biotic and abiotic factors. The abiotic factors like heat, drought has adverse impact on seed vigour. Grass and Burris[7] reported impaired germination and decline in seed vigour in wheat reflected in reduced shoot and root dry weight and higher seed conductivity due to higher temperature experienced during seed development and maturation. The seed lot showing higher vigour index is considered to be more vigorous[1]. The results are also in line with the findings of Seshu and Dadlani[20] who asserted that high germination percentage and vigour are significant aspects of seed quality. Quality seed with higher germination percentage and vigour index might be contributed to get optimum plant population, growth and development. This was also supported by Parera and Cantliffe[12] who reported that rapid and uniform field emergence is essential to achieve better growth and high yield. Findings of previous works also showed that variation in seed germination and vigour were observed due to variation in sowing date[23,16].

Table 2: Mean performance of medium sown wheat (*Triticum aestivum* L.) varieties on seed quality characters

Varieties		Test weight (g)	Seed moisture content (%)	Germination per cent (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Fresh weight of seedling (g)	Dry weight of seedling (g)	Vigour index-I	Vigour index-II
PBW-154		43	13.13	87.75	11.69	13.36	25.30	0.90	0.65	2221.25	17.52
PBW-343		32.6	13	82.75	12.31	13.43	25.75	0.88	0.15	2129.84	12.71
PBW-502		36.6	12.4	84.25	10.43	10.34	20.77	0.82	0.23	1748.69	19.36
PBW-550		35.8	13.41	82.75	12.35	13.15	25.32	0.86	0.15	2096.62	12.66
HUW-234		40.3	13.78	82.25	11.34	10.70	22.04	0.90	0.16	1812.82	13.40
HD-2967		35.3	12.13	82.75	12.29	13.07	25.36	1.03	0.19	2097.95	16.14
Super-252		39.8	12.94	84.50	10.91	12.71	23.62	1.02	0.17	1996.12	14.83
Super-303		39.7	12.65	81.25	11.84	12.03	23.87	0.84	0.17	1939.60	14.00
HD-3086		39.6	14.29	81.00	12.48	10.21	22.70	0.77	0.22	1838.23	18.41
Kuber		41.3	13.27	84.50	12.36	14.01	26.36	0.98	0.19	2227.64	16.54
M.D.Vijeta		33.4	12.84	84.25	13.31	11.95	24.52	0.77	0.18	2066.82	15.17
Lokman		43.5	11.46	86.25	13.31	13.11	26.42	0.89	0.19	2280.70	16.34
Grand Mean		**38.40**	**12.94**	**83.68**	**12.05**	**12.34**	**24.33**	**0.89**	**0.22**	**2038.03**	**15.59**
CD 5%		12.95	0.55	NS	0.55	0.61	0.90	0.11	0.01	198.18	3.28
S E		1.03	0.21	2.52	0.19	0.21	0.31	0.04	1.28	68.81	1.14
CV		9.37	5.76	6.03	3.18	3.45	2.57	9.21	460.69	6.75	14.63
Range	**Max**	43.5	14.29	87.75	13.31	14.01	26.42	1.03	0.65	2280.70	19.36
	Min	32.6	11.46	81	10.43	10.21	20.77	0.77	0.15	1748.69	12.66

CONCLUSION

From the above study it found that variety sown earlier showed higher seed vigor parameters in terms test weight (g), seed moisture content (%), germination (%), vigour index I & II than medium sown varieties .

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REFERENCES

1. Abdul-Baki, A. A. and Anderson, J. D., Physiological and biochemical deterioration of seed. In: Kozlowski, T. T., (2nd Ed.) Seed Biology. *Academic Press, New York*, London. 283-315 (1973).
2. Anonymous, Annual report of Directorate of Economics & Statistics, *Department of Agriculture*, Cooperation & Farmers Welfare (2017).
3. Baalbaki, R., Elias, S., Marcos, F. and Mcdonald, J. M. B., Seed vigor testing handbook. Association of Official Seed Analysts (Contribution to the Handbook on Seed Testing, 32) (2009).
4. Borghi, B. M., Corbellini, M., Ciaffi, E., Lafiandra, E., Stefanis, D., Sgrulletta, G., Boggini, and Fonzo, N., Effect of heat shock during grain filling on grain quality of bread and durum wheats. *Aust. J. Agric. Res*. **46:** 1365-1380 (1995).
5. Egli, D. B., Tekrony, D. M., Heitholt, J. J. and Rupe, J., Air temperature during seed filling and soybean seed germination and vigor. *Crop Sci*. **45:** 1329-1335 (2005).
6. Fussel, L. K. and Pearson, C. J., Effects of grain development and thermal history on grain maturation and seed vigor of *Pennesetum americanum*. *J. Exp. Bot.* **121:** 635-643 (1980).
7. Grass, L. and Burris J. S., Effect of heat stress during seed development and maturation on wheat seed quality. I. Seed germination and seedling vigor. *Can. J. Plant Sci.* **75:** 821-829 (1995a).
8. ISTA, Seed Vigour Testing. International Rules for Seed Testing (2014).
9. Keigley, P. J. and Mullen, R. E., Changes in soybean quality from high temperature during seed filling and maturation. *Crop Sci.* **26:** 1212-1216 (1986).
10. Kumar, S., Kaur, R., Kaur, N., Bhandhari, K., Kaushal, N., Gupta, K., Bains, T. S. and Nayyar, H., Heat-stress induced inhibition in growth and chlorosis in mungbean (*Phaseolus aureus* Roxb.) is partly mitigated by ascorbic acid application and is related to reduction in oxidative stress. *Acta Physiol. Plant.* **33:** 2091-2101 (2011).
11. Kundu, S. and Nagarajan, S., Distinguishing characters of Indian wheat varieties, Research Bulletin No. **4:** *Directorate of Wheat Research, Karnal, India* (1996).
12. Parera, C. A. and Cantliffe, D. J., Pre-sowing seed priming. *Horticulture,* **6:** 109-141 (1994).
13. Perrino, P. and Porcedu, E., Wheat genetic resources in Ethiopia and the Mediterranean region. In: Wheat Genetic Resources, Meeting Diversity Needs, *International Center for Agricultural Research in the Dry Areas*, 161-178 (1990).
14. Pollock, B. M. and Roos, E. E., Seed and seedling vigor. *Seed biology*, **1:** 314-388 (1972).
15. Protic, R., Miric, M., Protic, N., Jovanovic, Ž. and Jovin, P., The test weight of several winter wheat genotypes under various sowing dates and nitrogen fertilizer rates. *Rom. Agric. Res*. **24:** 43-36 (2007).
16. Rahman, M. M., Hampton, J. G. and Hill, M. J., Soybean seed yield as affected by time of sowing in a cool temperature

environment. *Seed Science and Technology*, **7:** 1-15 (2005).

17. Ramamoorthy, R. and Natarjan, N., Seed invigoration by hydration and dehydration for improvement of seed quality in safflower (Carthamus tinctorius L.). *Journal of Agronomy and Crop Science*, **178:** 125-128 (1997).
18. Costa, R., Pinheiro, N. Almeida, A. S., Gomes, C. O., Coutinho, J., Coco, J. O., Costa, A. and Maçã s, B., Effect of sowing date and seeding rate on bread wheat yield and test weight under Mediterranean conditions. *Emir. J. Food Agric*. **25(12):** 951-961 (2013).
19. Sechnyak, L. K., Kindruk, N. A. and Slyusarenko, O. K., New experimental approach to problem of seed ecology. In Bulletin Problems of Crop Breeding and Genetics. *Sofia. pp* 254-269 (1985).
20. Seshu, D. V. and Dadlani, M., Role of woman in seed management with special reference to rice. *IRTP Technical Bulletin*, **5:** 24 (1989).
21. Steiner, J. J. and Opoku-Boateng, K., Natural season long and diurnal temperature effects on lettuce seed production and quality. *J. Amer. Soc. Hort. Sci.* **116:** 396-400 (1991).
22. Taylor, J. C., Prapport, L. and Lockwood, G. B., Octacosanol in human health. *Nutrition*, **19:** 192–195 (2003).
23. TeKrony, D. M., Egli, D. B., Ellis, R. H., Black, M., Murdoch, A. J. and Hong, T. D., Accumulation of seed vigour during development and maturation. *Plant Sci. Biotech. Agric.* **30:** 369-384 (1997).
24. Tekrony, D. M., Precision is an essential component in seed vigor testing. *Seed Science and Technology*, **31:** 435-477 (2003).
25. Toh, S., Imamura, A., Watanabe, A., Okamot, M., Jikumaru, Y., Hanada, A., Aso, Y., Ishiyama, K., Tamura, N. and Iuchi, S., High temperature-induced abscisic acid biosynthesis and its role inthe inhibition of gibberellin action in *Arabidopsis* seeds. *Plant Physiol.***146:** 1368-1385 (2008).
26. Vaughan, D. A., Morishima, H. and Kadowaki, K., Diversity in the Triticum genus. *Current Openion in Plant Biology*, **6:** 139-146 (2003).