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Effect of Seed Size and Embryo Size on Early Seedling Vigour in Wheat

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ABSTRACT: Rapid seedling establishment is an important requirement for successful crop production in dry land farming systems. Seed size, as a characteristic of seed quality, influences seedling growth and establishment. Early vigour has been widely reported to provide improved productivity of wheat in semi-arid environments, and particularly those environments in which rainfall patterns are erratic and crop is to be sown in residual moisture. Hence, in these situations embryo size is an essential parameter which strongly affects seed vigour of crops along with seed size. In lieu of this, the present study was conducted on sixty wheat genotypes, including certain advance wheat lines and released varieties, to study the effect of seed size and embryo size on early seedling vigour. Based on the coleoptile length, the material was categorised into short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile length genotypes. These three coleoptile class genotypes had an average 1000- seed weight of 40.24g 43.04g and 43.78g, respectively and an embryo size of 2.261 mm^2, 2.3895 mm^2 and 2.8395 mm^2, respectively. No correlation was observed between 1000 seed weight and different coleoptile length genotype classes, seed vigour index I and II, and seedling emergence percent and hence was found less effective for selection of genotypes for early seedling vigour. Embryo size of more than 3 mm^2 was found in majority of long coleoptile genotype group. Higher embryo size was also in correlation with the higher SVI I, SVI II, seedling emergence and shoot length. Therefore embryo size can be utilised as more reliable indicator of higher seedling vigour in early stage of wheat; for development of varieties suitable for dryland agriculture.

Keywords: Coleoptile length, Embryo size, Seed size, Seed vigour, Test weight

Wheat (*Triticum aestivum* L.) is the most important food grain crop providing daily nutrients to very large section of world population. India is second largest producer of wheat after China, producing about 98.51 million tonnes from 29.69 m ha in the crop year 2016-2017. Wheat yield in the Indian context remained almost stagnant in the last two decades and sustainability of wheat based cropping production system mainly the rice-wheat cropping system in India is questionable. The total land area of India is 329 million hectares of which 144 million hectares is arable land. Out of this, 94 million hectares fall under dry lands constituting 65% of dryland and rainfed areas which produce 40% of the total food grains that feeds 40% of the total population. The remaining 50 million hectares constituting 35% of irrigated areas, account for 60% of the crop production. Dryland areas contribute significantly to wheat (*Triticum aestivum L.)* production, amounting to thirty three per cent of wheat production.

Enhancing the production of dryland areas seems an attractive way to increase the productivity and production of wheat by introduction of alternate cropping system in rice-wheat areas. In the dryland area, upper soil moisture is depleted very rapidly after the sowing due to higher rate of evaporation. Hence, depth of sowing in these areas becomes an important factor for field emergence in semi dwarf varieties of wheat. Thus, the coleoptile length of the seedling becomes an important feature for the proper field emergence [1]. Similarly, moisture depletion takes place very rapidly with very early sowing of wheat due to presence of high temperature at that time. Thus higher depth of sowing facilitated by longer coleoptile length is of utmost importance for uniform establishment of crop for getting the higher productivity. Seed size, as a characteristic of seed quality, influences seedling growth and establishment. Moreover, the effect of seed size and embryo size is directly correlated by the seedling vigour [2] and higher seedling vigour leads to a uniform and rapid field emergence. Seedling emergence is not only influenced by the endosperm it contains but is also influenced by the interaction of embryo length, embryo width and embryo weight [3]. Moreover, the effect of seed size and embryo size is directly correlated with the seedling vigour and higher seedling vigour leads to a uniform and rapid field emergence. However, their individual effect in deciding the seedling vigour is yet to be studied, because correlation between embryo size and seed size has not been reported. Hence, the present study was conducted to evaluate the effect of seed size and embryo size on early seedling vigour.

MATERIALS AND METHODS

The experimental material for the study comprised of sixty wheat genotypes, including certain advance wheat lines and released varieties and was conducted for two years viz. 2016-17 and 2017-18. The weight of randomly selected 1000 kernels from the bulk produce of each plot was recorded in grams on an electronic machine. For measuring the coleoptile length, 25 seeds were kept on a moist germination paper with germ end down having 1cm markings on either side of the central line, and kept in upright position at 20^{0}C in dark and observation was taken on 10th day. Based on the coleoptile length, the genotypes were divided into three categories; short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) (Table 1). The experiment for emergence percentage was conducted in pots of size 15 cm diameter and 15 cm depth. Pots were filled with soil representing uniform moisture levels (11-12 %) from various locations in the divisional field. Ten seeds for each variety were sown at varying depths of 5 cm, 7.5 cm and 10 cm and were replicated twice; and emergence percentage was recorded. The germination test was conducted and ten normal seedlings were selected randomly for measuring shoot length and expressed in centimetres (cm). Vigour indices were calculated by the procedure as suggested by the Abdul-Baki and Anderson [4]. For the embryo size, ten seeds of each genotype were soaked in water overnight at room temperature and embryo was excised. Length and width was measured by randomly selected ten seeds using Vernier callipers and embryo size was calculated by the formula as suggested by Moore and Rebetzke [3].

Embryo size (mm^2) = Embryo length (mm)* Embryo width (mm)*0.72.

Embryo weight and 1000 grain weight were correlated with different vigour parameters and inferences were drawn for their effect on early seedling vigour.

RESULTS AND DISCUSSION

The coleoptile length of all the 60 genotypes was recorded and categorised as short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) (Table 1).

Table 1. Seed and seedling traits for genotypes categorised under short, medium and long coleoptile length

Genotypes	Coleoptile Length (cm)	Shoot Length (cm)	Seed Vigour Index I	Seed Vigour Index II	1000 seed wt (g)	Embryo size (mm^2)
Short coleoptile length genotypes						
CLY1642	3.64	6.80	2210	41.25	42.31	1.80
CLY1647	3.82	6.60	1964	36.26	40.03	2.21
CLY1648	3.78	7.24	2084	49.86	41.21	2.74
CLY1649	3.80	7.44	1999	38.41	37.32	2.18
CLY1650	3.50	6.58	1851	45.41	34.57	2.34
CLY1652	3.52	6.92	1996	47.09	40.23	2.10
CLY1653	3.44	6.82	2020	42.88	41.85	1.76
CLY1656	3.76	7.26	2024	50.21	48.23	1.90
CLY1659	4.56	7.74	2151	40.79	46.02	2.13
CLY1662	3.56	7.62	2022	37.86	39.08	2.32
CLY1664	3.90	6.82	2046	39.45	43.75	2.23
CLY1670	3.58	7.00	1981	46.07	37.42	2.39
CLY1679	3.54	7.00	2016	35.75	34.41	2.29
CLY1684	3.98	7.30	1988	41.55	38.26	2.11
CLY1686	3.48	7.80	1964	41.76	43.61	2.72
CLY1698	3.80	7.00	2194	43.77	39.01	2.51

Genotypes	Coleoptile Length (cm)	Shoot Length (cm)	Seed Vigour Index I	Seed Vigour Index II	1000 seed wt (g)	Embryo size (mm^2)
CLY1708	3.98	7.04	2119	29.81	44.31	2.30
HD3086	3.60	7.72	2238	43.08	36.87	2.76
HD 3117	4.26	8.24	2113	48.78	34.12	2.17
HD 2967	3.86	7.38	2056	42.63	42.32	2.26
Mean	3.77	7.12	2051.8	42.3	40.24	2.26
Medium coleoptile length genotypes						
CLY1601	5.44	9.08	2404	53.36	35.32	2.44
CLY1610	5.62	9.56	2347	56.12	45.21	2.45
CLY1622	5.60	9.92	2417	50.92	43.24	2.37
CLY1632	5.30	9.16	2097	62.1	39.34	2.73
CLY1634	5.48	9.00	2105	55.18	38.21	2.27
CLY1635	5.66	7.98	2111	48.91	41.09	2.14
CLY1638	5.44	9.44	2344	58.96	47.90	2.31
CLY1651	4.86	7.78	1969	46.80	34.68	1.91
CLY1657	4.96	9.30	2493	48.01	48.91	2.22
CLY1676	5.42	9.26	2216	58.67	43.21	2.92
CLY1677	5.32	9.06	2365	51.81	46.31	2.22
CLY1678	5.26	8.68	2135	66.50	36.32	2.69
CLY1680	5.26	8.40	2049	61.64	38.14	2.52
CLY1681	4.96	8.46	2365	60.45	43.20	2.52
CLY1692	5.26	9.20	2083	64.73	48.16	2.81
CLY1693	5.04	9.36	2335	65.28	42.13	2.26
CLY1695	4.82	8.70	2342	59.63	41.20	2.51
CLY1701	4.82	7.14	1852	45.56	44.32	2.13
CLY1707	5.12	8.78	2101	46.63	49.03	1.88
HD2329	6.10	9.26	2187	50.16	47.31	2.49
Mean	5.29	8.87	2198.1	55.57	43.04	2.39
Long coleoptile length genotypes						
CLY1606	7.90	10.88	2771	69.00	44.24	2.58
CLY1611	8.52	12.64	2566	72.63	46.23	2.81
CLY1612	7.90	12.84	2492	65.86	48.32	3.02
CLY1613	8.46	13.48	2873	73.47	45.31	2.78
CLY1615	8.34	11.62	2496	76.14	48.32	2.80
CLY1617	8.42	12.64	2632	79.20	46.24	2.70
CLY1621	7.40	11.88	2437	68.38	42.18	3.16
CLY1630	8.36	13.24	3059	72.94	39.13	2.60
CLY1636	7.96	12.84	2934	70.17	41.00	2.75
CLY1641	8.22	12.30	2900	77.08	47.12	2.37
CLY1644	8.90	12.72	2966	75.88	42.14	2.99
CLY1661	8.30	12.82	2894	82.43	47.18	2.82
CLY1668	7.82	12.82	2562	68.15	46.12	2.42
CLY1683	7.68	13.02	2589	67.25	44.18	2.50
CLY1700	7.36	11.60	2560	73.98	41.32	3.04
CLY1706	8.52	13.64	2828	74.62	45.14	3.01
NP4	7.66	12.32	2835	79.13	37.12	3.05
NP818	7.96	12.84	2866	72.15	38.12	3.15
C 306	7.96	13.12	2682	70.20	42.13	3.01
HDCSW18	7.42	12.84	2937	67.34	44.16	3.23
Mean	8.05	12.60	2752	72.80	43.78	2.84
CD(p=0.05)	0.137	0.338	45.83	0.80	0.80	0.58

Seed of each genotype was sown in pots under varying sowing depths of 5cm, 7.5 cm, and 10 cm and replicated twice. When short coleoptile length genotypes were sown at depths of 5 cm, 7.5 cm and 10 cm depths, average seedling emergence from 5 cm and 7.5 cm sowing depths was comparable to some extent i.e. 92.25% and 86.25% but the emergence from 10 cm sowing depth was drastically reduced to 58% (Figure 1). For medium coleoptile length genotypes, average seedling emergence from 5 cm and 7.5 cm sowing depths was 97% and 86.75% and the emergence from 10 cm sowing depth was reduced to 70.75 % (Figure 2). For large coleoptile length genotypes, average seedling emergence from 5 cm and 7.5 cm sowing depths was 97.75% and 91%. The emergence from deep sown condition averaged to 83% (Figure 3) which

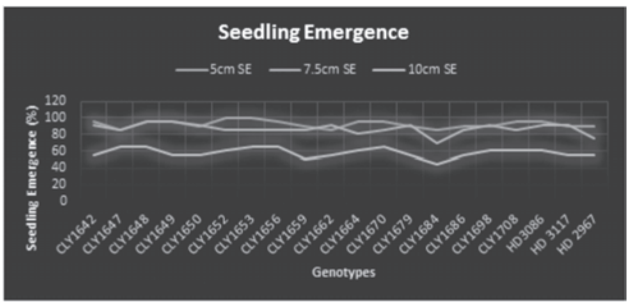

Figure 1. Seedling emergence percentage of short coleoptile length genotypes from various sowing depths

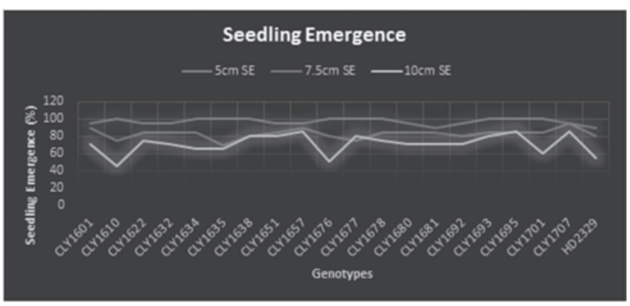

Figure 2. Seedling emergence percentage of medium coleoptile length genotypes from various sowing depths

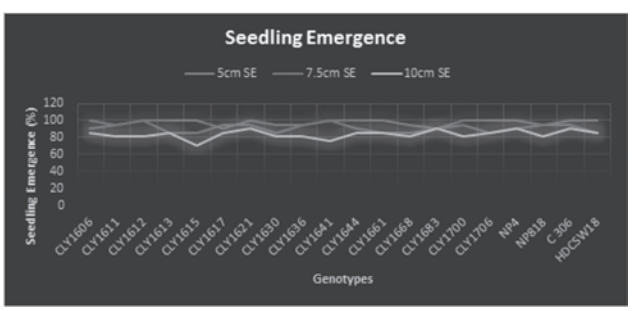

Figure 3. Seedling emergence percentage of long coleoptile length genotypes from various sowing depths

was quite good as compared to short and medium coleoptile genotypes. Although, there was a reduction in seedling emergence but it is sufficient to obtain a good plant stand in field condition.

The coleoptile length was directly proportional to seedling shoot length i.e. short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile classes had on an average 7.12 cm, 8.87 cm, and 12.60 cm shoot lengths respectively (Table 1). This provides the long coleoptile genotypes an added advantage of better photosynthesis and dry matter accumulation over the short and medium coleoptile genotypes during early developmental stages and helps in better field establishment. Similarly, the higher coleoptile length class genotypes had higher seedling vigour Index I and seedling vigour Index II. The short, medium and long coleoptile classes had on an average SV I value of 2051.8, 2198.11 and 2752.33, respectively and SV II values of 42.3, 55.57 and 72.8, respectively (Table 1). Hence, the longer coleoptile genotypes can provide better seedling emergence and ultimately better field establishment.

Seed size represents the stored food reserve in seed which nourishes the seed in early developmental phases. Different coleoptile class genotypes had an average 1000- seed weight i.e. 40.24g, 43.04g, and 43.78g (Table1). Normally it is believed that larger the seed size, higher is the initial seedling vigour but the present study revealed that there was no correlation between 1000 seed weight and seedling emergence percent, coleoptile length, shoot length, SV I and SV II (Table 2). Since thousand seed weight was not correlated with these parameters and was hence, found less effective for selection of genotypes for early seedling vigour. However, no correlation between seed size and seedling vigour parameters as reported in present study was in contrast with the studies of other workers [5-7]. They reported that seed size was directly proportional to the seedling performance in field and smaller seedling had low early seedling vigour and field performance but the larger seeds had high early seedling vigour and field performance which ultimately increases the yield.

Embryo of seed is also called the miniature plant having all essential structures which are required for plant formation. Embryo size represents the number of cells present in embryo and is important for early seedling vigour of wheat. Embryo size of different genotype

Table 2. Correlation table for embryo size and thousand seed weight with emergence from different sowing depths (5cm, 7.5 cm and 10 cm), coleoptile length (CL), shoot length (SL), SVI and SVII

	Correlation coefficient (r)						
	5cm	7.5cm	10cm	CL	SL	SVI I	SVI II
Embryo size	0.202722*	0.342561*	0.223654*	0.362819**	0.377201**	0.247856*	0.408974**
Thousand seed weight	0.203938	0.047083	0.20185	0.325305*	0.344445	0.285993*	0.276953*

* Significance ($p<0.05$) **Significance ($p<0.01$)

classes i.e. short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile length had an average embryo size of 2.261 mm^2, 2.3895 mm^2 and 2.8395 mm^2, respectively (Table 1). Embryo size of more than 3 mm^2 was found in many of long coleoptile genotype group i.e. CLY No.1612, CLY NO.1700, CLY No.1706, NP4, NP818, C306 and HDCSW18. Higher embryo size was also in correlation with the higher SVI I, SVI II, seedling emergence and shoot length (Table 2). Hence, it is clearly evident that embryo size is correlated with most of the seedling vigour parameters. Similar results were found by Nagasawa *et al.* [8] who concluded that proportion of embryo to endosperm varies widely among species; however it is relatively uniform within individual species.

Thus, from the current study it can be concluded that for selection of a good variety and to enhance their performance in dryland areas, selection should be based on the embryo size as a basic parameter and should have a good proportion of seed size and embryo size, so that the living cells of embryo are well nourished by the sufficient amount of stored food. Similar results were earlier reported by other workers [2] that embryo size was dependent on interaction of seed size and genotype; and the early seedling vigour is not only dependent on seed size and embryo size alone but a proper proportion of these two is required for early seedling growth.

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