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Effect of Depth of Sowing on Seedling Emergence, Root Characters and Seed Quality Parameters in Wheat (*Triticum aestivum* L.)

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A B S T R A C T

The present study was conducted to study the effect of depth of sowing on seedling emergence, and correlation with coleoptile length in advance lines of wheat. The experimental material comprised of 60 wheat genotypes including certain advance lines and released varieties; and was carried out for two consecutive season viz. 2016-17 and 2017-18. These genotypes were categorised into three different coleoptile length groups i.e. short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile length on the basis of observation in laboratory. All genotypes were sown at three different depths of 5cm, 7.5cm and 10 cm and replicated twice. The study revealed that the short and medium coleoptile length genotypes had less variation in emergence at all depths whereas the longer coleoptile length genotypes had significantly better field emergence. Coleoptile length was directly proportional to seedling shoot length i.e. short, medium and long coleoptile classes had an average coleoptile length of 7.12 cm, 8.87 cm, and 12.60 cm respectively. Longer coleoptile length class genotypes also had higher SVI I and SVI II i.e. short, medium and long coleoptile classes had an average SV I value of 2051.8, 2198.11 and 2752.33 and SV II value of 42.3, 55.57 and 72.8 respectively. Larger coleoptile length was also in accordance with the higher root surface area, root volume and number of forks which provide genotypes early seedling vigour in stress conditions.

Introduction

The total land area of India is 329 million hectares of which 144 million hectares is arable land. 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. New production methodology like conservation agriculture can provide long term solution to all above raised issues. 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 (Mohan *et al.,* 2013). 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. Hence, higher crop yield is mainly dependent on the rapid and uniform field establishment of crop in the field, which is highly influenced by the sowing depth and the ability of the seedlings to emerge from the soil. Hence, the present study was conducted to study the effect of depth of sowing on seedling emergence, root characters and seed quality parameters in wheat.

Materials and Methods

The present study was undertaken during 2016-17 and 2017-18 at Division of Seed Science and Technology, IARI, New Delhi. The experimental material comprised of 60 wheat genotypes which were divided into three categories based on the coleoptile length of lines. These lines were denoted by code name (CLY Number); and are listed along with their respective pedigree (Table 1). The experiment was conducted in pots of size 15 cm diameter and 15 cm depth. Pot was filled with soil representing uniform moisture levels (11-12 %) from various locations in the divisional field. Ten seeds for each genotypes were sown at varying depths of 5 cm, 7.5 cm and 10 cm and was replicated twice. The germination test was conducted as per ISTA 2015. Speed of germination was calculated by the formula as suggested by the Maguire (1962). For measuring the seedling length, ten normal seedlings were selected randomly for measuring root and shoot length and expressed in centimetres (cm). After taking the final count of germination test, 10 normal seedlings from each replication were removed, washed, weighed and dried overnight at 80 $\pm$ 1^{0}C. Seedling dry weight was expressed in mg/five seedlings. Vigour indices were calculated by the procedure as suggested by the Abdul-Baki and Anderson, 1973. For measuring 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. Roots obtained at 8th day were separated from shoot by cutting and scanned in root scanner by the latest WinRHIZO software for root length, surface area, root volume and number of forks. In the present investigation the laboratory studies were analyzed by using completely randomized design (CRD). Star Nebula software obtained from website of IRRI was used for the data analysis and correlation between all the important parameters was calculated.

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). Seed of each genotype was sown in pots under varying sowing depths of 5cm, 7.5 cm, and 10cm and replicated twice. When short coleoptile length genotypes were sown at depths of 5cm, 7.5cm and 10cm depths, average seedling emergence from 5cm and 7.5 cm sowing depths was comparable to some extent i.e. 92.25% and 86.25% but the emergence from 10cm sowing depth was drastically reduced to 58% (Fig. 1). For medium coleoptile length genotypes, average seedling emergence from 5cm and 7.5 cm sowing depths was 97% and 86.75% and the emergence from 10cm sowing depth was reduced to 70.75 % (Fig. 2). For large coleoptile length genotypes, average seedling emergence from 5cm and 7.5 cm sowing depths was 97.75% and 91%. The emergence from deep sown condition averaged to 83% (Fig. 3) which 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. No definite relation could be established between speed of germination and genotypes of three different classes i.e. short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile length genotypes. For each class, the speed of germination was 38.70, 38.20 and 39.60 respectively (Table 1). The speed of emergence is mainly dependent on the radical appearance which is a part of root initials, and no effect of GAR *Rht* genes on root length has been reported till date. Hence this explains the possible cause for non-existence of any definite relation. 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. Root biomass study is an efficient and rapid technique for assessment of the crop performance mainly for the initial growth stages which determines the early seedling vigour of crop. Surface area is main root biomass parameter which determines the early seedling vigour in wheat and results of the present study revealed that root surface area of different genotype classes i.e. short, medium and long coleoptile length had an average surface area of 6.23 cm^2, 7.52 cm^2 and 8.55 cm^2 respectively, where longer coleoptile length class genotypes had distinctly larger surface area; which leads to better seedling vigour and seedling establishment (Table 2). Similarly, longer coleoptile length genotypes had distinctly larger root volume than that of short and medium coleoptile length genotypes (Table 2). Root volume is also a major root biomass parameter responsible for early seedling vigour of wheat and from this study it is clearly evident that root volume of different genotype 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 root volume of 0.089 cm^3, 0.110 cm^3 and 0.131 cm^3 respectively (Table 2). Number of forks is an important parameter of root biomass in crops like wheat having fibrous root structure, more is the number of forks more is the absorptive surface and more nutrient uptake results in good seedling establishment. From the study of number of forks, it is clearly evident that number of forks of different genotype classes i.e. short (2.5-4.5 cm), medium (4.6-6.5 cm) and long (6.6-9 cm) coleoptile lengths had an average 37.6, 42.8 and 56.5 number of forks respectively. Higher number of forks in genotypes of long coleoptile length class gives an advantage over other genotype classes and provides an early growth advantage also (Table 2).

Table.1 Seed quality parameters for genotypes categorised under short, medium and long coleoptile length

Genotypes	Pedigree	Coleoptile Length(cm)	Speed of Germination	Shoot Length (cm)	Seed Vigour Index I	Seed Vigour Index II
Short coleoptile length genotypes						
CLY1642	7 EBWYT 504	3.64	38.75	6.80	2210	41.25
CLY1647	HD2874/HD2967//43rd IBWSN 1148	3.82	38.17	6.60	1964	36.26
CLY1648	HD2874/HD2967//43rd IBWSN 1148	3.78	40.17	7.24	2084	49.86
CLY1649	HD2874/HD2967//43rd IBWSN 1087	3.80	41.00	7.44	1999	38.41333
CLY1650	HD2874/HD2967//43rd IBWSN 1087	3.50	37.33	6.58	1851	45.41333
CLY1652	10 SBWON-27//PBW 343/DW571	3.52	37.67	6.92	1996	47.09
CLY1653	31ESWYT-113//DW1272/HP1731	3.44	39.83	6.82	2020	42.88
CLY1656	31ESWYT-113//DW1272/HP1731	3.76	38.60	7.26	2024	50.21333
CLY1659	31ESWYT-147/3/HW5028//HD2432/DW1309	4.56	38.25	7.74	2151	40.78667
CLY1662	18 HRWYT 214/18HRWYT-229	3.56	38.42	7.62	2022	37.85667
CLY1664	18 HRWYT 214/18HRWYT-229	3.90	36.42	6.82	2046	39.45
CLY1670	HD 2824/VL804//PBW532/UP2425	3.58	40.75	7.00	1981	46.07
CLY1679	EBWYT 60	3.54	36.42	7.00	2016	35.75
CLY1684	Recombinant inbred line (RILs)	3.98	37.50	7.30	1988	41.55
CLY1686	CL1449/PBW343//WL412/Vei/Koel/3/Pes/Mc-II	3.48	39.08	7.80	1964	41.76
CLY1698	31 ESWYT 138/CSW23	3.80	39.90	7.00	2194	43.77333
CLY1708	PBW343/CL1538//HD2932/HD2189	3.98	39.42	7.04	2119	29.80667
HD3086		3.60	38.17	7.72	2238	43.08333
HD 3117		4.26	38.58	8.24	2113	48.78
HD 2967		3.86	39.67	7.38	2056	42.63
Mean		**3.77**	**38.70**	**7.12**	**2051.8**	**42.3**
Medium coleoptile length genotypes						
CLY1601	CL2596/K9451/CL882//HD2009	5.44	37.75	9.08	2404	53.36
CLY1610	CL2596/K9451//CL882//HD2009	5.62	40.00	9.56	2347	56.12
CLY1622	C-32 SAWSN 327	5.60	38.00	9.92	2417	50.92
CLY1632	HD2953/HS365	5.30	40.08	9.16	2097	62.1
CLY1634	SAWSN 3094	5.48	37.08	9.00	2105	55.18
CLY1635	SAWSN 3097	5.66	35.17	7.98	2111	48.90667
CLY1638	18 HRWYT 214	5.44	38.00	9.44	2344	58.96
CLY1651	HD2874/HD2967//43rd IBWSN 1087	4.86	39.92	7.78	1969	46.8
CLY1657	31ESWYT-147/3/HW5028//HD2432/DW1309	4.96	36.00	9.30	2493	48.01333
CLY1676	SAWSN 3194	5.42	38.58	9.26	2216	58.66667
CLY1677	CSISA-HT-EM-37	5.32	38.17	9.06	2365	51.81333
CLY1678	SRRSN 6083	5.26	34.25	8.68	2135	66.50333
CLY1680	EBWYT 98	5.26	38.67	8.40	2049	61.64
CLY1681	EBWYT 81	4.96	38.08	8.46	2365	60.45
CLY1692	31 ESWYT 135/CSW23	5.26	38.75	9.20	2083	64.72667
CLY1693	31 ESWYT 135/CSW23	5.04	39.17	9.36	2335	65.28
CLY1695	31 ESWYT 135//HD2329/WR544/PBW343/NW3041	4.82	39.00	8.70	2342	59.63
CLY1701	31 ESWYT 138//PBW343/PH137/MC-II	4.82	40.42	7.14	1852	45.56

CLY1707	31 ESWYT 138/CSW30	5.12	38.90	8.78	2101	46.62667
HD2329		6.10	38.18	9.26	2187	50.16
Mean		**5.29**	**38.20**	**8.87**	**2198.11**	**55.57**
Long coleoptile length genotypes						
CLY1606	CL1633/ CNo. 601// CL1633/ CNo. 601	7.90	40.42	10.88	2771	69
CLY1611	HD2967/NIVT-1A(3A)	8.52	40.17	12.64	2566	72.63
CLY1612	SAWYT-319(06-07)	7.90	36.33	12.84	2492	65.86
CLY1613	CP264//HD2839/ HD2329	8.46	39.00	13.48	2873	73.47
CLY1615	HD2329/HDK-10//CBW38/WR541	8.34	39.58	11.62	2496	76.14
CLY1617	IBWSN70//IBWSN 1053	8.42	40.83	12.64	2632	79.2
CLY1621	C-32 SAWSN 179	7.40	40.17	11.88	2437	68.38
CLY1630	HD 2878/HD29	8.36	38.42	13.24	3059	72.94333
CLY1636	EBWYT 21	7.96	38.83	12.84	2934	70.17333
CLY1641	28 SAWSN 3157	8.22	40.25	12.30	2900	77.08
CLY1644	VL 616 (2) Inqulab/Kundan	8.90	37.83	12.72	2966	75.88
CLY1661	18 HRWYT 214/18HRWYT-229	8.30	40.34	12.82	2894	82.42667
CLY1668	18 HRWYT 222//VL849/UP2571	7.82	39.83	12.82	2562	68.14667
CLY1683	SAWYT-331	7.68	41.58	13.02	2589	67.25
CLY1700	31 ESWYT 138//PBW343/PH137/MC-II	7.36	41.58	11.60	2560	73.98
CLY1706	31 ESWYT 138/CSW30	8.52	38.25	13.64	2828	74.62
NP4		7.66	42.75	12.32	2835	79.12667
NP818		7.96	39.92	12.84	2866	72.15333
C 306		7.96	39.33	13.12	2682	70.2
HDCSW18		7.42	36.58	12.84	2937	67.34
Mean		**8.05**	**39.60**	**12.60**	**2752.33**	**72.8**
C.D. at 5%		**0.136847**	**0.798616**	**0.337539**	**45.8302**	**0.798616**

Table.2 Root characters for genotypes categorised under short, medium and long coleoptile length

Genotypes	**Surface area (cm^2)**	**Root volume (cm^3)**	**Number of forks**
Short coleoptile length genotypes			
CLY1642	6.604	0.0822	34
CLY1647	6.814	0.0837	45
CLY1648	6.686	0.0992	42
CLY1649	6.218	0.0776	31
CLY1650	5.076	0.0896	37
CLY1652	5.224	0.0783	44
CLY1653	5.726	0.1032	40
CLY1656	3.78	0.1024	32
CLY1659	5.682	0.0678	37
CLY1662	7.14	0.1148	35
CLY1664	5.65	0.0876	41
CLY1670	6.326	0.1058	40
CLY1679	6.34	0.0982	33
CLY1684	7.476	0.0762	36
CLY1686	6.886	0.108	43
CLY1698	7.126	0.0854	32
CLY1708	7.026	0.1056	36

HD3086	5.876	0.0916	42
HD 3117	5.868	0.0712	38
HD 2967	6.544	0.0534	34
Mean	**6.23**	**0.089**	**37.6**
Medium coleoptile length genotypes			
CLY1601	7.246	0.112	43
CLY1610	7.654	0.114	47
CLY1622	7.95	0.108	38
CLY1632	6.38	0.0991	41
CLY1634	7.273	0.1028	45
CLY1635	7.158	0.1074	38
CLY1638	8.152	0.1268	48
CLY1651	7.478	0.1162	50
CLY1657	7.132	0.0874	42
CLY1676	7.761	0.128	46
CLY1677	7.864	0.119	46
CLY1678	7.886	0.1056	36
CLY1680	7.486	0.1224	39
CLY1681	7.784	0.0982	43
CLY1692	7.662	0.119	46
CLY1693	7.26	0.124	42
CLY1695	7.378	0.1064	38
CLY1701	8.206	0.1023	42
CLY1707	7.508	0.1096	42
HD2329	7.356	0.0983	44
Mean	**7.52**	**0.110**	**42.8**
Long coleoptile length genotypes			
CLY1606	8.068	0.1196	47
CLY1611	8.824	0.1308	53
CLY1612	8.816	0.137	46
CLY1613	8.903	0.1134	49
CLY1615	8.982	0.1334	57
CLY1617	8.21	0.1098	63
CLY1621	8.81	0.1384	54
CLY1630	8.212	0.1564	76
CLY1636	7.412	0.1384	53
CLY1641	9.424	0.1426	62
CLY1644	8.418	0.1254	59
CLY1661	8.134	0.1342	58
CLY1668	8.208	0.1234	60
CLY1683	9.208	0.1566	48
CLY1700	8.778	0.1346	61
CLY1706	8.444	0.1376	55
NP4	8.312	0.1128	56
NP818	8.618	0.1172	47
C 306	8.414	0.1314	59
HDCSW18	8.89	0.133	67
Mean	**8.55**	**0.131**	**56.5**
C.D. at 5%	**0.321917**	**0.445196**	**0.679235**

Fig.1 Seedling emergence of short (2.5-4.5 cm) coleoptile length genotypes from different sowing depths

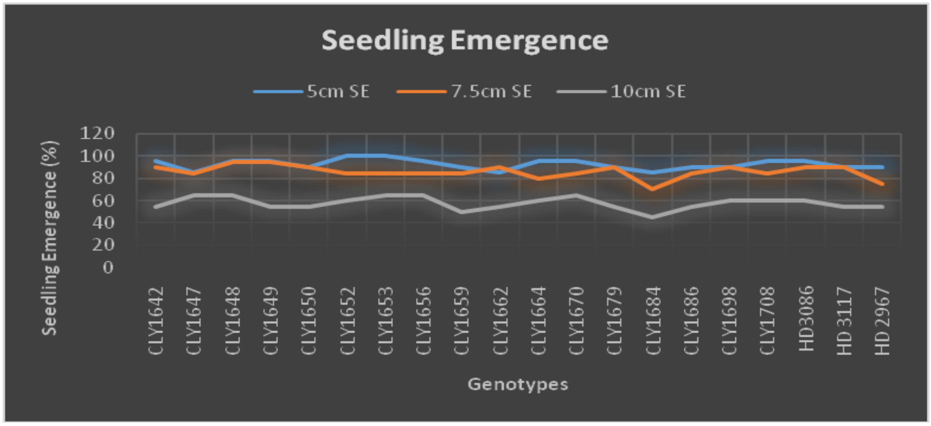


Fig.2 Seedling emergence of medium (4.6-6.5 cm) coleoptile length genotypes from different sowing depths

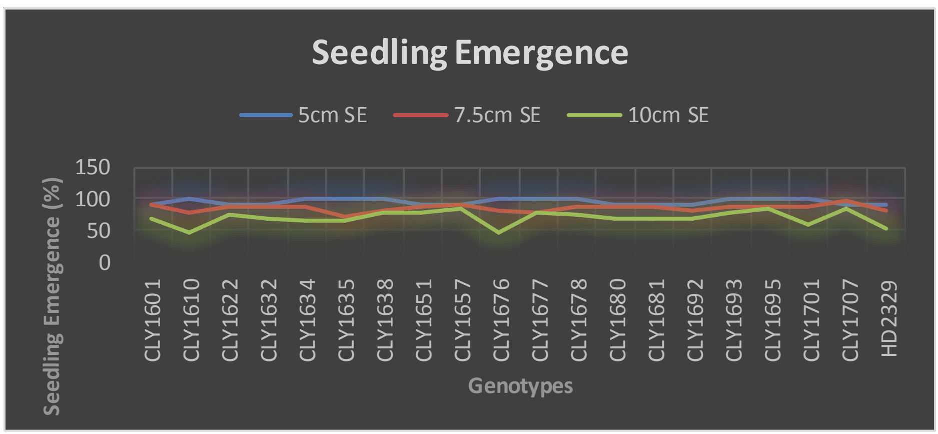
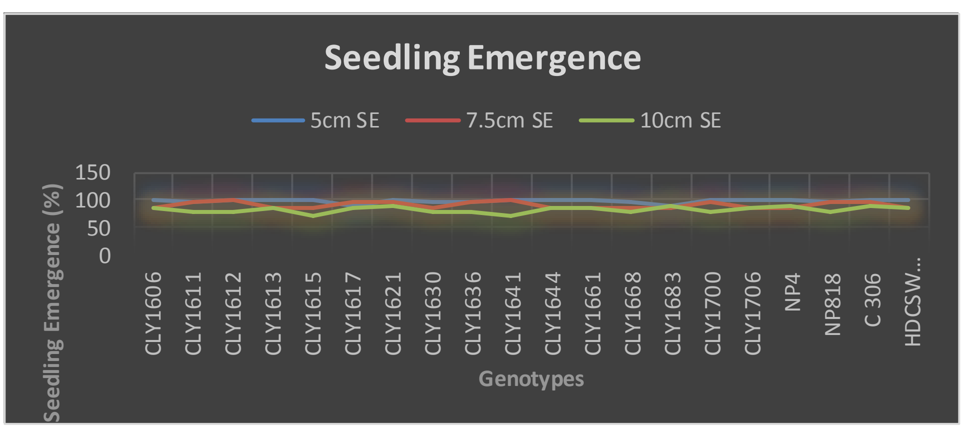


Fig.3 Seedling emergence of long (6.6-9 cm) coleoptile length genotypes from different sowing depths



Hence from above observations it is concluded that longer coleoptile length class had longer emergence and early seedling vigour as compared to short and medium coleoptile length classes.

The study revealed that the short and medium coleoptile length genotypes had less variation in emergence from 5cm and 7.5 cm depths of sowing.

On the other hand emergence from 10 cm depth was drastically reduced by 34.25% and 28.25% in short coleoptile length genotypes and by 26.25% and 16% in medium coleoptile genotypes respectively from the emergence from 5 cm and 7.5 cm sowing depths. Similar results were found by Amram *et al.,* (2015); Chen *et al.,* (2013); Rebetzke *et al.,* (2005). The study of seedling vigour index and its relationship with the coleoptile length provides conclusive evidence that genotypes with longer coleoptile had greater early seedling vigour in field than short and medium coleoptile length class of genotypes. Similar results were also repeated by Rosyara *et al.,* (2009).

The longer coleoptile length class of genotypes consistently had greater root surface area, root dry weight, root volume and number of forks per seedling which enhanced their capacity to absorb water from deeper soil profile and increasing number of forks also enhance the capacity to increase specific surface area and hence had capacity to perform well in dryland areas and similar findings were repeated by Rosyara *et al.,* (2009).

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