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Effect of seed dropping heights on mechanical damage resistance and seed quality in soybean [*Glycine max* (L.) Merril] varieties

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SUMMARY

The influence of four height of dropping *viz*., D_0: 0 feet (No dropping), D_1: 3 feet dropping, D_2: 6 feet dropping, D_3: 9 feet dropping on varieties *viz*., V_1: JS956, V_2: JS335, V_3: JS9305, V_4: PK1029, V_5: Dsb-1 and V_6: NRC-7 were studied for both seed quantitative parameters and seed qualitative parameters. The variety NRC-7 recorded significantly highest hundred seed weight (15.03g) and dehusks seed weight (11.24g). Whereas, the highest seed density (1.37g/cc) was in JS9560; seed mechanical damage (93.50%) and seedling vigour index (2804) in JS-335 variety. The significantly maximum hundred seed weight (13.90g), seed germination (68.00%) and seedling vigour index (2215) were recorded in the seeds without dropping against those dropped from nine feet height which recorded minimum values.

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Key words : Seed dropping, Mechanical damage, Seed quality, Soybean

Soybean [*Glycine max* (L.) Merril] is called as the miracle crop of the 20th century. For centuries, Chinese used to call soybean as the yellow jewel or great treasure. Now-a-days, this prodigious bean is being seen worldwide as a weapon to fight against human hunger as its rich in both high quality seed protein (40-43%) and oil (19-21%) contents. Apart from protein and oil, it is also rich in vitamins, iron, mineral salts and other essential amino acids. It can augment the supply of vegetable protein for the developing country like India, where majority of its population are purely vegetarians.

In India, soybean has witnessed a phenomenal growth both in area and production during last two decades, wherein, it is presently grown in about 9.67 million hectares area contributing to 9.73 million tonnes production annually (Anonymous, 2009).

Soybean seed is regarded as a poor storer, generally it losses its viability and vigour readily since it is easily susceptible to mechanical injuries caused during harvest and post harvest operations. Soon after harvest, soybean seed is subjected to several post harvest operations like threshing, drying, grading, transportation and other handling operations. During these operations, soybean is subjected to the mechanical damages /injuries due to susceptibility and breakage of the seed coat and it losses its viability and vigour at a faster rate due to looses of membrane permeability of seeds. In soybean, there are several improved varieties available for commercial cultivation but they are likely to loose viability and vigour more due to differential mode of mechanical forces causing damages and injuries to the seeds. Some varieties are known to loose viability and vigour more rapidly. While, some varieties retain their quality for longer time, the research work on the response of various soybean varieties on mechanical damage and seed quality are very scanty and hence, it has been investigated.

MATERIALS AND METHODS

An experiment was conducted at College of agriculture, Dharwad, Karnataka, india during 2009-2010

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with three replications. The Design of the experiment adopted was the Completely Randomized Block Design with factorial concept and it was conducted in the laboratory of the department of Seed Science and Technology. Six varieties *viz*., V_1: JS956, V_2: JS335, V_3: JS9305, V_4: PK1029, V_5: Dsb-1 and V_6: NRC-7 and the four height of dropping *viz*., D_0: 0 feet (No dropping), D_1: 3 feet dropping, D_2: 6 feet dropping, D_3: 9 feet dropping were used for the experiment.

The observations on the seed quantitative parameters *viz*., seed length (cm), seed width (cm), seed density (g/cc), seed width (cm), hundred seed weight (g), husk weight (g), dehusk seed weight (g), embryo weight (g), seed mechanical damage (%), seed moisture (%), and seed qualitative parameters *viz*., seed germination, shoot length (cm), root length (cm), seedling dry weight (g), seedling vigour index, field emergence (%), and electrical conductivity (dSm^{-1}) were recorded. The germination test was conducted as per ISTA procedure by adopting rolled towel method. Seedling dry weight was calculated based upon the ten normal seedlings which were selected at 75^0 for 24 hours. The vigour index was calculated by adopting the methods suggested by Abdul-Baki and Anderson and expressed in whole numbers for each treatment by using the following formula. Vigour index = Germination (%) x Seedling length (cm).

RESULTS AND DISCUSSION

The experimental findings obtained from the present investigation have been presented in the following heads:

Seed quantitative parameters:

Significant variations observed due to varieties except seed dropping heights and interaction effects. The seeds of six test soybean varieties subjected to four dropping heights were analysed for different seed quality attributes. The results of the various seed quality parameters as influenced by different varieties and seed dropping heights are discussed hereunder.

Influence of varieties on seed quantitative parameters:

Among the six varieties, the NRC-7 variety recorded significantly the highest hundred seed weight (15.03 g), seedling length (1.21 cm), seed width (0.81 cm), husk weight (1.83 g) and dehusk seed weight (11.24 g) while JS-9560 variety recorded the highest seed density (1.37 g/cc) and embryo weight (1.09 g) and JS-335 variety with maximum seed mechanical damage (93.5%) and seed moisture content (14.21%). On the other hand, it was minimum in JS-9305 variety for seed length (1.00 cm), embryo weight (0.81 g) and seed mechanical damage (89.00%); PK1029 for seed width (0.70 cm), husk weight (1.48 g) and seed moisture content (11.81%); DSb-1 for hundred seed weight (12.40 g) (Table 1 and 2). The significant variations on seed quantitative parameters noticed in different varieties may be perhaps attributed to their genotypic differences. Similar genotypic variations on seed quantitative parameters were also confirmed by Henshaw (2008) and Stoilova and Berova (2009) in cowpea, Gnyandev (2009) in chickpea, Sharma *et al.* (1991).

Effect seed dropping heights on seed quantitative parameters:

All seed quantitative parameters exhibited non-significant variation except seed mechanical damage due to seed dropping heights. Over the varieties, seed mechanical damage was significantly the highest (94.67%) in the seed dropped from nine feet height (D3) and lowest (87.67%) in the seeds not dropped (D0). These results indicated a sharp rise in mechanical damage with increasing in the height of seed dropping from zero to nine feet and the increase in dropping height might have caused more mechanical damage to the seeds in view of more susceptibility of soybean seeds (Table 2). Similar results were also confirmed by Agasanal (1996) and Carbonell *et al.* (1992) in soybean.

Interaction (VxD) effect:

The interaction between varieties and seed dropping height (VxD) was found non-significant for all the seed quantitative parameters studied. On an average, seed length (1.20 cm) was numerically more in interactions of NRC-7 seeds dropped from three feet (V6D1) and six feet heights (V6D2). While, seed width (0.84 cm) and dehusk seed weight (11.50 g), in interaction of NRC-7 seeds not dropped (V6D0); seed density (1.37 g/cc) in interactions of JS-959 seeds dropped from three and nine feet heights (V1D1 and V1D3); husk weight (1.91 g) and embryo weight (1.14 g) in interaction of JS-9560 seeds not dropped (V1D0); seed mechanical damage (96.00%) and seed moisture content (14.53%) in interaction of JS-335 seeds dropped from nine feet height (V2D3). On the other hand, all these respective parameters were less in interactions of NRC-7 seeds dropped from six and nine feet heights (V6D1 and V6D2), PK1029 seeds dropped from three feet height (V4D1), Dsb-1 seeds dropped from six feet height (V5D2), NRC-7 seeds dropped from six feet height (V6D2), PK1029 and seeds not dropped (V4D0), JS-9305 seeds not dropped and nine feet height dropped (V3D0 and V3D3), JS-9560 and seeds not

Table 1 : Effect of seed dropping heights on seed quality parameters in different soybean varieties

Treatments	Seed length (cm)	Seed width (cm)	Seed density (g/cc)	Hundred seed weight (g)	Husk weight (g)
Varieties (V)					
V_1-JS9560	1.12	0.72	1.37	14.58	1.57
V_2-JS335	1.05	0.74	1.12	14.11	1.59
V_3-JS9305	1.00	0.72	1.17	12.47	1.49
V_4-PK1029	1.01	0.70	1.10	13.89	1.48
V_5-Dsb-1	1.15	0.73	1.10	12.40	1.55
V_6-NRC-7	1.21	0.81	1.03	15.03	1.83
Mean	1.09	0.74	1.15	13.75	1.59
S.E.±	0.01	0.01	0.02	0.08	0.02
C.D. (P=0.01)	0.03	0.03	0.06	0.32	0.08
Seed dropping (D)					
D_0- 0 feet	1.11	0.75	1.16	13.90	1.66
D_1- 3 feet	1.09	0.74	1.15	13.76	1.58
D_2- 6 feet	1.09	0.73	1.14	13.61	1.55
D_3- 9 feet	1.08	0.73	1.14	13.72	1.55
Mean	1.09	0.74	1.15	13.75	1.59
S.E.±	0.01	0.01	0.01	0.07	0.02
C.D. (P=0.01)	NS	NS	NS	NS	NS
Interaction (VXD)					
V_1D_0	1.13	0.74	1.38	14.70	1.91
V_1D_1	1.10	0.73	1.37	14.60	1.47
V_1D_2	1.14	0.70	1.36	14.47	1.46
V_1D_3	1.11	0.72	1.37	14.57	1.46
V_2D_0	1.06	0.75	1.12	14.15	1.64
V_2D_1	1.05	0.73	1.12	14.14	1.61
V_2D_2	1.05	0.77	1.12	14.10	1.57
V_2D_3	1.03	0.72	1.11	14.07	1.55
V_3D_0	1.00	0.72	1.20	12.83	1.52
V_3D_1	0.99	0.72	1.18	12.50	1.48
V_3D_2	1.01	0.71	1.15	12.20	1.48
V_3D_3	0.98	0.73	1.16	12.33	1.49
V_4D_0	1.01	0.71	1.10	13.86	1.44
V_4D_1	1.04	0.68	1.11	14.07	1.50
V_4D_2	0.98	0.70	1.09	13.74	1.45
V_4D_3	1.01	0.69	1.10	13.91	1.51
V_5D_0	1.19	0.75	1.12	12.67	1.61
V_5D_1	1.14	0.72	1.10	12.40	1.59
V_5D_2	1.14	0.72	1.09	12.30	1.52
V_5D_3	1.13	0.72	1.08	12.23	1.47
V_6D_0	1.25	0.84	1.04	15.20	1.86
V_6D_1	1.20	0.83	1.02	14.87	1.82
V_6D_2	1.20	0.80	1.01	14.87	1.83
V_6D_3	1.19	0.79	1.04	15.20	1.80
S.E.±	0.02	0.02	0.03	0.17	0.04
C.D. (P=0.01)	NS	NS	NS	NS	NS

NS=Non-significant

Table 2 : Effect of seed dropping heights on seed quality parameters in different soybean varieties

Treatments	Dehusk seed weight (g)	Embryo weight (g)	Seed mechanical damage	Seed moisture content (%)	Seed germination (%)
Varieties (V)					
V_1-JS9560	10.79	1.09	90.00	11.97	52.50 (46.43)*
V_2-JS335	10.88	0.95	93.50	14.21	75.67 (60.68)
V_3-JS9305	10.16	0.81	89.00	13.73	76.33 (61.14)
V_4-PK1029	10.33	0.85	92.50	11.81	55.50 (48.16)
V_5-Dsb-1	9.24	1.00	90.50	12.85	56.33 (48.65)
V_6-NRC-7	11.24	1.02	93.00	12.95	49.83 (44.89)
Mean	10.44	0.95	91.42	12.92	61.03 (51.66)
S.E.±	0.12	0.03	1.31	0.06	0.77
C.D. (P=0.01)	0.45	0.10	4.98	0.21	2.92
Seed dropping (D)					
D_0- 0 feet	10.41	0.96	87.67	12.69	68.00 (55.93)
D_1- 3 feet	10.53	0.96	90.67	12.85	64.89 (54.02)
D_2- 6 feet	10.44	0.97	92.67	12.97	59.33 (50.55)
D_3- 9 feet	10.37	0.94	94.67	13.16	51.89 (46.13)
Mean	10.44	0.95	91.42	12.92	61.03 (51.66)
S.E.±	0.10	0.02	1.07	0.05	0.63
C.D. (P=0.01)	NS	NS	4.06	NS	2.39
Interaction (VXD)					
V_1D_0	10.82	1.14	86.00	11.70	62.00 (51.94)
V_1D_1	10.90	1.07	88.00	11.90	54.67 (47.67)
V_1D_2	10.60	1.07	92.00	12.00	50.67 (45.37)
V_1D_3	10.83	1.07	94.00	12.27	42.67 (40.76)
V_2D_0	10.93	0.92	90.00	13.87	82.67 (65.43)
V_2D_1	10.53	0.92	94.00	14.13	80.00 (63.48)
V_2D_2	11.10	0.95	94.00	14.30	71.33 (57.84)
V_2D_3	10.93	1.00	96.00	14.53	68.67 (55.97)
V_3D_0	10.07	0.79	86.00	13.60	83.33 (65.91)
V_3D_1	10.10	0.82	88.00	13.67	82.00 (64.96)
V_3D_2	10.32	0.86	90.00	13.80	74.00 (59.36)
V_3D_3	10.17	0.79	92.00	13.87	66.00 (54.33)
V_4D_0	9.83	0.80	88.00	11.53	62.00 (51.94)
V_4D_1	10.93	0.86	92.00	11.73	58.67 (49.98)
V_4D_2	10.63	0.89	94.00	11.87	55.33 (48.05)
V_4D_3	9.93	0.84	96.00	12.10	46.00 (42.68)
V_5D_0	9.32	1.00	86.00	12.70	62.00 (51.94)
V_5D_1	9.40	1.04	90.00	12.80	60.00 (50.76)
V_5D_2	9.10	1.05	92.00	12.87	57.33 (49.20)
V_5D_3	9.13	0.93	94.00	13.03	46.00 (42.68)
V_6D_0	11.50	1.09	90.00	12.77	56.00 (48.44)
V_6D_1	11.33	1.02	92.00	12.87	54.00 (47.28)
V_6D_2	10.90	0.98	94.00	13.00	47.33 (43.45)
V_6D_3	11.23	0.99	96.00	13.17	42.00 (40.37)
S.E±	0.24	0.05	2.62	0.11	1.54
C.D. (P=0.01)	NS	NS	NS	NS	NS

NS= Non-significant * Figures in the parenthesis are arcsine transformed values

Table 3 : Effect of seed dropping heights on seed quality parameters in different soybean varieties

Treatments	Shoot length (cm)	Root length (cm)	Seedling dry weight (g)	Seedling vigour index	Field emergence (%)		Electrical conductivity (dSm^{-1})
Varieties (V)							
V_1-JS9560	12.13	17.85	1.15	1583	45.13	(42.19)*	2.98
V_2-JS335	16.91	20.03	1.04	2804	38.56	(38.37)	2.04
V_3-JS9305	14.26	20.73	1.08	2677	36.02	(36.87)	2.25
V_4-PK1029	13.76	19.42	1.01	1852	45.75	(42.54)	2.58
V_5-Dsb-1	10.92	11.15	0.85	1248	49.18	(44.51)	3.02
V_6-NRC-7	11.93	12.48	1.39	1223	39.78	(39.09)	3.14
Mean	13.32	16.94	1.09	1898	42.40	(40.59)	2.67
S.E.±	0.35	0.36	0.02	48	2.01		0.01
C.D. (P=0.01)	1.34	1.37	0.06	184	6.03		0.05
Seed dropping (D)							
D_0- 0 feet	13.93	17.96	1.12	2215	42.99	(40.95)	2.51
D_1- 3 feet	13.53	17.26	1.10	2044	42.56	(40.71)	2.59
D_2- 6 feet	13.01	16.48	1.08	1787	42.23	(40.51)	2.69
D_3- 9 feet	12.79	16.07	1.04	1545	41.83	(40.28)	2.88
Mean	13.32	16.94	1.09	1898	42.40	(40.59)	2.67
S.E.±	0.29	0.30	0.01	40	1.03		0.01
C.D. (P=0.01)	1.09	1.12	0.05	150	2.91		0.04
Interaction (VXD)							
V_1D_0	12.52	19.23	1.21	1971	45.63	(42.47)	2.83
V_1D_1	12.43	18.17	1.16	1669	45.29	(42.28)	2.93
V_1D_2	11.83	17.47	1.16	1485	44.96	(42.09)	3.02
V_1D_3	11.73	16.53	1.08	1207	44.63	(41.90)	3.12
V_2D_0	17.93	20.80	1.11	3222	39.06	(38.67)	1.78
V_2D_1	17.03	20.60	1.05	3009	38.73	(38.47)	1.84
V_2D_2	16.33	19.43	1.03	2537	38.40	(38.28)	2.03
V_2D_3	16.33	19.27	0.98	2446	38.04	(38.07)	2.52
V_3D_0	14.47	21.50	1.11	2994	36.56	(37.19)	2.09
V_3D_1	14.37	21.30	1.11	2923	36.23	(36.99)	2.21
V_3D_2	14.27	20.30	1.08	2560	35.90	(36.79)	2.30
V_3D_3	13.93	19.83	1.04	2230	35.38	(36.48)	2.40
V_4D_0	15.03	20.27	1.02	2191	46.67	(43.07)	2.43
V_4D_1	14.20	19.70	1.00	1990	45.83	(42.59)	2.51
V_4D_2	13.07	19.10	1.00	1782	45.50	(42.40)	2.56
V_4D_3	12.73	18.60	0.99	1444	45.00	(42.11)	2.84
V_5D_0	11.17	11.63	0.87	1416	49.69	(44.80)	2.90
V_5D_1	10.97	11.60	0.86	1356	49.36	(44.61)	2.96
V_5D_2	10.77	10.80	0.83	1238	49.02	(44.42)	3.06
V_5D_3	10.77	10.57	0.83	981	48.66	(44.21)	3.15
V_6D_0	12.43	14.30	1.43	1497	40.31	(39.40)	3.02
V_6D_1	12.20	12.22	1.43	1316	39.94	(39.18)	3.08
V_6D_2	11.80	11.80	1.39	1118	39.60	(38.98)	3.19
V_6D_3	11.27	11.61	1.29	960	39.27	(38.79)	3.28
S.E.±	0.70	0.72	0.03	97	3.73		0.03
C.D. (P=0.01)	NS	NS	NS	NS	NS		0.10

NS- Non significant * Figures in the parenthesis are arcsine transformed values

dropped (V1D0) interactions (Table 1 and 2). Similar results on genotypic variations and mechanical damages on different seed quantitative parameters were also confirmed by Sharma *et al.* (1991) in green gram, Agasanal (1996) and Carbonell *et al.* (1992) in soybean, Henshaw (2008) and Stoilova and Berova (2009) in cowpea and Gnyandev (2009) in chickpea.

Seed qualitative parameters:

Significant variations on various seed qualitative parameters *viz.*, seed germination, seedling vigour index, seedling dry weight, oil content, reducing sugar, electrical conductivity and field emergence were noticed due to varieties and seed dropping heights except their interactions.

Effect of varieties on seed qualitative parameters:

Irrespective of the seed dropping heights, all the six test varieties exhibited marked variations of seed qualitative parameters. Significantly maximum seed germination (76.33%) was recorded in JS-9305 variety whereas shoot length (16.91 cm) in JS-335 variety, root length (20.73 cm) in JS9305 variety, seedling dry weight (1.39 g) in NRC-7 variety, seedling vigour index (2804) in JS-335 variety, field emergence (49.18%) in DSb^{-1} variety and electrical conductivity (3.14 dSm^{-1}) in NRC-7 variety. On the other hand, minimum values for seed germination (49.83%) in NRC-7, shoot length (10.92 cm) and root length (11.15 cm) and seedling dry weight in DSb-1 variety, seedling vigour index (1223) in NRC-7 variety, field emergence (36.02%) in JS-9305 variety and electrical conductivity (2.04 dSm^{-1}) in JS-335 variety (Table 2 and 3). The significant variations on seed qualitative parameters in different varieties may be due to varietal differences existed between the test varieties. The similar results were also reported by Tiwari *et al.* (1978), Checkov *et al.* (1979) and Negi *et al.* (1988) in soybean.

Effect of seed dropping heights on seed qualitative parameters:

All the seed quality parameters differed significantly due to the effect of different seed dropping heights over varieties (Table 2 and 3). In general, all the seed quality parameters exhibited a significant and consistent declining trend as the seed dropping height increased from zero to nine feet height irrespective of varieties. The significantly maximum seed germination (68.00%), shoot length (13.93 cm), root length (17.96 cm), seedling dry weight (1.12 g), seedling vigour index (2215), field emergence (42.99%) and less electrical conductivity (2.51 dSm^{-1}) were observed in the seeds not dropped (D0). On the other hand, the seeds with nine feet height dropping height recorded minimum values for the respective parameters (43.61g, 51.89%, 12.79 cm, 16.07 cm, 1.04 g, 1545, 41.83% and more electrical conductivity 2.88 dSm^{-1}). These results indicated that the effect of dropping height was more pronounced in the seeds dropped from nine feet height (D2) as against the undropped seeds (D0). This may be due to rapid loss of viability and vigour of the seeds dropped from the nine feet height due to susceptibility of seeds under dropping heights. Similar results on effect of mechanical damages on seed quality are also confirmed by Carbonell *et al.* (1992) and Agasanal (1996) in soybean.

Interaction VxD effect:

The non significant variations on all the seed quality parameters were noticed for treatment combination between varieties and seed dropping height VxD. Among various treatment combinations, the interaction between NRC-7 variety seeds without dropping (V6D0) recorded comparatively more hundred seed weight (15.20 g) and seedling dry weight (1.43 g). Likewise, it recorded more values for seed germination (83.33%) and root length (21.50 cm) in the JS-9305 seeds not dropped (V3D0) interaction; for shoot length (17.93 cm), seedling vigour index (3222) in JS-335 seeds not dropped (V2D0) interactions; for field emergence (49.69%) in Dsb-1 and seeds not dropped (V5D0) interaction and for electrical conductivity (3.28 dSm^{-1}) in NRC-7 seeds dropped from nine feet height (V6D3) interaction. The similar findings were also reported by Tiwari *et al.* (1978), Chekov *et al.* (1979) and Negi *et al.* (1988) and Agasanal (1996) and Carbonell *et al.* (1992) in soybean.

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