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Effect of Harvesting Method on Seed Quality of Soybean (*Glycine max* L.) during Storage

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ABSTRACT: The present investigation was conducted to study the effect of harvesting method (Hand harvesting and Mechanical harvesting) on the seed quality of soybean under storage using three different varieties (Basara, JS - 335 and ASB - 50). The seed was stored for a period of six months under ambient storage conditions and seed quality parameters were evaluated. The study revealed that hand harvested seed showed better performance than mechanically harvested seed throughout the storage period in terms of germination and seedling vigour. Among the three varieties, Basara variety showed superior seed quality compared to ASB - 50 and JS - 335. However, irrespective of the method of harvest and variety, all the seed quality parameters decreased with the increase of the storage period. In hand harvested seed, per cent decrease recorded in case of germination, seedling length, seedling vigour index I and II were 9.41%, 11.6%, 15.6% and 16.79%, respectively and in mechanically harvested seed, it was 11.76%, 10.78%, 20.61% and 21.49%, respectively.

Keywords: Soybean, Harvesting method, Varieties, Storage and Seed quality.

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) has gained significance worldwide because of its wide range of geographical adaptation, unique chemical composition, high nutritional value with functional health benefits and multifaceted applications in food and allied industries. It is a multipurpose legume rich in both protein and oil content with the ability to resolve food and nutritional security in developing countries hence considered as "Golden bean". Soybean ranks first in the international market among the world's major oil seed crops (FAO 2020). It accounts for 42% of overall oilseed production and 22% of total oil production, 2/3rd of the global protein concentrates for livestock feeding. Soybean was also named as "wonder crop" or "Miracle crop" as its seed contains diverse nutritional characteristics such as 20 % oil with 85 % unsaturated fatty acids including 55 % poly unsaturated fatty acids (PUFA), 40 % good quality protein, antioxidants, 4-5 % minerals and 25-30 % carbohydrates (Karthika and Koti 2017).

India ranks fourth in terms of area of production (129.28 lakh hectares) and fifth in production (12.61 million tonnes) with a productivity of 976 kg per hectare. In India, Madhya Pradesh, Maharashtra, Rajasthan, Karnataka are the major growing states. More than 90% of soybean growing area is under rainfed conditions (INDIASTAT, 2020-21). In Telangana, soybean is grown in an area of 1.6 lakh hectares with an annual production of 2.4 lakh tonnes and productivity of 1505 kg per hectare (INDIASTAT, 2020-21). It is predominantly grown in black cotton soils in Telangana state during *kharif* season and collected seed was stored until the following year for sowing which is a difficult task because of its poor storability. Hence every year supply of quality seed to farmers is a major hurdle in soybean production in the state.

Despite of its high nutritional content, soybean seed is a poor storer due to its genetic makeup, and various factors that influence seed germination and vigour during storage. The major reason associated with rapid loss in seed viability is its fragile seed coat which gets easily damaged during harvest and post-harvest

operations (Mahesha *et al*., 2001). Majority of the farmers in Telangana use mechanical threshers to harvest the seed, which is expected to be one of the main reasons for rapid loss of viability.

Few researchers reported that irrespective of variety, threshing and processing methods, and storage containers, the germination of soybean declined during storage (Shelar *et al*., 2008). The decrease of germination was higher in the variety MACS-124 than the JS-335. The high oil content in soybean and sunflower is associated with greater lipid peroxidation leading to reduction in germination capacity and seed viability (Balesevic - Tubic *et al.,* 2007). Rame *et al.* (2002) reported that soybean threshed by hand shelling maintained maximum viability and vigour during storage. Hence, the current study was conducted to find out the influence of different harvesting methods on seed quality in different varieties of soybean under storage.

MATERIAL AND METHODS

Freshly harvested soybean seed of three varieties viz., Basara, JS - 335, ASB - 50 harvested in two different methods *i.e.,* hand harvesting and mechanical harvesting was collected from Agricultural Research Station, Adilabad, Telangana and seed quality parameters were studied at the Department of Seed Science and Technology, Seed Research and Training Centre, Rajendrangar, Telangana. The laboratory experiment was conducted in two Factorial Completely Randomized Design with three replications. The observations were recorded for seed hardness index, mechanical damage (%), moisture content (%), germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour index-I, seedling vigour index-II, speed of germination, field emergence (%) and electrical conductivity (μScm^{-1} g^{-1}).

Mechanical damage (%) was calculated by following ferric chloride method suggested by Agarwal (1995).

$$\text{Mechanical damage (\%)} = \frac{\text{Number of black stained seeds}}{\text{Total number of seeds taken}} \times 100$$

Seed hardness index was measured by using an instrument grain hardness tester (Model: AGW - 40). The point at which the seed first break point recorded was considered as the maximum hardness value of seed.

Moisture test was conducted as per ISTA (2018) rules by placing five grams of grounded sample into aluminium box in three replicates and dried at 103°C for 17 hours in hot air oven. The per cent moisture content was calculated by using the formula:

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

W_1 - Weight of the empty container along with lid (gm)

W_2 - Weight of the container along with lid and grounded seed sample before drying (gm)

W_3 - Weight of the container along with lid and grounded seed sample after drying (gm)

Germination test in soybean was conducted as per ISTA (2018) using between paper method. Fifty seeds were placed for germination in eight replicates and kept in the germination chamber at a temperature of 25± 1°C and relative humidity of 95 %. The germination percentage was calculated by using following formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \; x \; 100$$

Seedling length and seedling dry weights were evaluated and expressed in centimetres and in milligrams, respectively. Seedling vigour index-I and seedling vigour index-II were calculated as per procedure given by Abdul-Baki and Anderson (1973) and expressed in whole number.

SVI-I = Germination (%) × Seedling length (cm)

SVI-II = Germination (%) × Seedling dry weight (mg)

Randomly hundred seeds from each treatment were placed in the moistened sand trays in three replicates and kept in the germinator at a temperature of 25 ± 1°C with 95% relative humidity. The number of seedlings germinated on each day up to the eighth day after sowing were recorded regularly and index of speed of germination calculated by using the following formula:

Index of speed of germination =

$$\sum [(n1/d1) + (n2 - n1)/d2 + \ldots.. + (n8 - n7)/d8)]$$

Field emergence test was conducted by sowing hundred seeds from each treatment in three replications and evaluated on eighth day and expressed as percentage.

$$\text{Field emergence (\%)} = \frac{\text{Number of seeds germinated on eighth day}}{\text{Total number of seeds sown}} \times 100$$

Electrical conductivity of seed soaking was measured as per ISTA (2018) and expressed in µS $cm^{-1}g^{-1}$.

$$EC(\mu Scm^{-1}g^{-1}) = \frac{\text{Conductivity reading } (\mu S\ cm-1) - \text{Background reading}}{\text{Weight of seed (g)}}$$

The above parameters were analyzed using INDOSTAT software for the interpretation of results.

RESULTS

Analysis of variance revealed there was significant difference between the methods of harvesting for the seed quality parameters.

Basara variety (8.80) recorded significantly higher seed hardness index than other two varieties (ASB - 50 and JS - 335). Hardness of the seed was decreased during storage from initial evaluation to 6 MAS (8.57 to 8.47) (Table 2c). Seeds with higher hardness index showed maximum resistance to seed coat damage during harvesting and threshing process. These results were in conformity with findings of Zahid (2013) who reported that a significant reduction was observed in the hardness of the seed coat with the increase of the storage period.

Mechanically harvested seed recorded maximum mechanical damage per cent than the hand harvested seed. ASB - 50 variety registered highest mechanical damage percent because of its low seed hardness and lowest was noticed in Basara variety, which possess maximum seed hardness. Mechanically harvested seed of ASB - 50 showed 37 % of mechanical damage, whereas lowest was observed in hand harvested seed of Basara variety (18.33 %) (Fig. 1). The lowest mechanical damage was observed in stick threshing than in mechanical threshing method was reported in findings of Gagare *et al.* (2014).

Maximum moisture content (%) was observed in ASB - 50 (8.93 %) followed by JS - 335 (8.76 %) and Basara (8.47 %) seed. The moisture content (%) of the seed was increased from initial evaluation (8.43 %) to 6 MAS (9.02%) (Table 2c). Tubic *et al.* (2011) reported that different moisture content was observed in different genotypes which might be due to the genetic factors and seed chemical composition. Because of its hygroscopic nature, seed absorbed the moisture when the relative humidity was high in the storage conditions. Similar results were observed in findings of Gadhave (2018) who reported that moisture content was found to be increased during storage.

Mechanical harvesting causes breaks in seed coat because of its fragile nature. Maximum EC was recorded in mechanical harvested seed (248.98 μScm^{-1} g^{-1}) whereas lowest in hand harvested seed (216.45 μScm^{-1} g^{-1}) (Fig. 2). Seed leachates from ASB - 50 (325.92 μScm^{-1} g^{-1}) recorded highest conductivity, whereas that of Basara (150.96 μScm^{-1} g^{-1}) recorded lowest (Table 2c). More seed coat damage was found in mechanically harvested seed which lead to increased leakage of electrolytes than hand harvested seed (Maheshwari *et al*, 2020). Seeds stored for six months recorded significantly the highest conductivity value than those stored for three months was reported by Isaac *et al*. (2016).

The Germination percent in soybean was influenced by harvesting method during storage. A significant reduction of germination was observed after storage. Reduction was 9.41 % from initial to 6 MAS (*i.e.,* 85 % to 75 %) in hand harvested seed whereas it was 11.76 % (85 % to 75 %) in case of mechanical harvesting. Basara variety (84 %) registered highest germination followed by ASB - 50 (81 %) and JS - 335 (77 %) (Table 2a). These results were in line with the findings of Abady and Emam (2012) who reported that higher germination per cent was recorded in hand threshed seed than in machine threshed seed.

Basara (24.17) showed superiority for index of speed of germination over ASB - 50 (23.06) and JS - 335 (22.19). Index of speed of germination showed significant reduction from initial evaluation (30.55) to 6 MAS (15.72) (Table 2d). The speed of germination was declined with the progress in the storage period in all the varieties (Kavitha, 2002).

Hand harvested seed (29.86 cm) recorded lengthier seedling than mechanical harvested seed (28.62 cm) with longest being recorded in ASB - 50 (29.99 cm). The reduction per cent was highest in case of ASB - 50 variety (11.79 %) and lowest was recorded in Basara variety (5.79 %) (Table 2a). The results were in conformity with the findings of Shelar *et al*. (2008) stated that reduced seedling length was observed when seeds threshed by mechanical method and also it was decreased gradually with increased storage period.

The seedling dry weight was significantly differed with the method of harvesting. The higher dry weight was recorded in hand harvested seed (86.90 mg) than mechanically harvested seed (85.55 mg). ASB - 50 (100.46 mg) registered maximum seedling dry weight followed by JS - 335 (82.56 mg) and Basara (71.31 mg)(Table 2a). Kapoor *et al*. (2011) reported that seedling dry weight was significantly decreased with increased ageing up to six months of storage.

SVI - I significantly decreased from initial evaluation (2593) to 6 MAS (2125). In hand harvested seed, a reduction of 15.60 % was observed from initial (2634) to 6 MAS (2223), whereas in mechanical harvested seed, 20.61 % (2552 to 2026) reduction was observed (Fig. 4). Basara (2469) recorded highest SVI - I followed by ASB - 50 (2423) and JS - 335 (2185) (Table 2b).

From initial evaluation to 6 MAS, mechanical harvested and hand harvested seed showed a reduction of 21.48 % (7707 to 6413) and 16.79 % (7661 to 6015), respectively in SVI – II (Fig 4). ASB - 50 (8251) recorded significantly highest SVI - II over Basara (6347) and JS - 335 (6249) (Table 2b). Seedling vigour was found higher in manually threshed seed than mechanical threshed than and was gradually decreased with the increase of the storage period (Abady and Emam 2012).

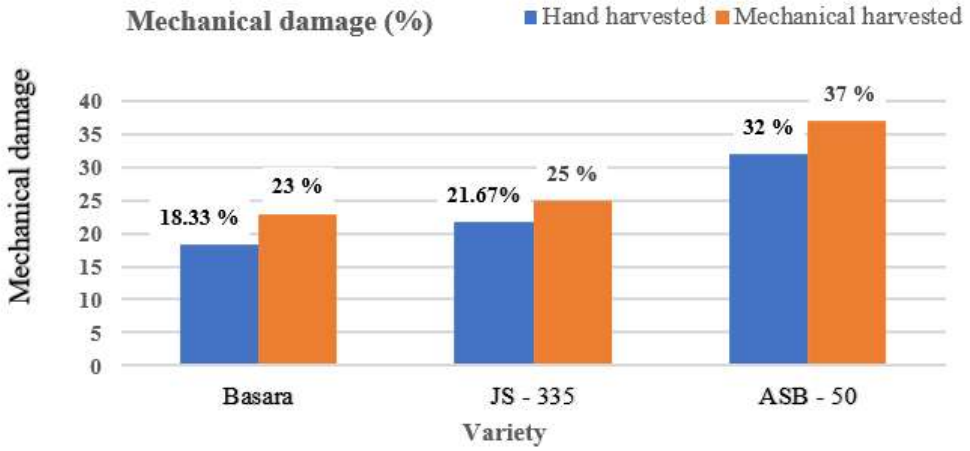

Fig. 1. Influence of harvesting methods on seed coat damage (%) in soybean.

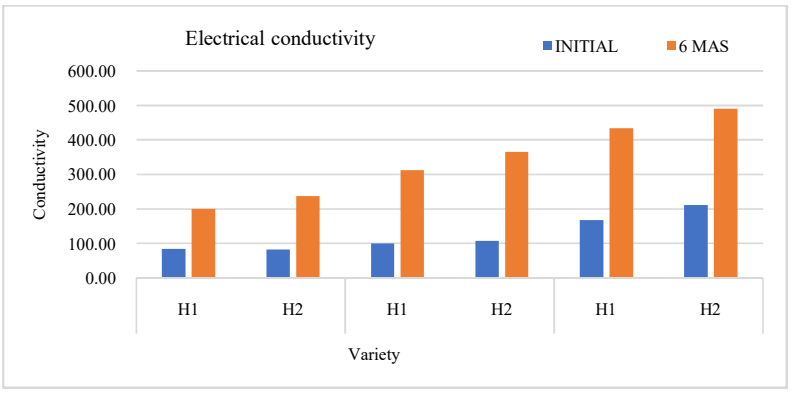

Fig. 2. Influence of harvesting methods on electrical conductivity in soybean.

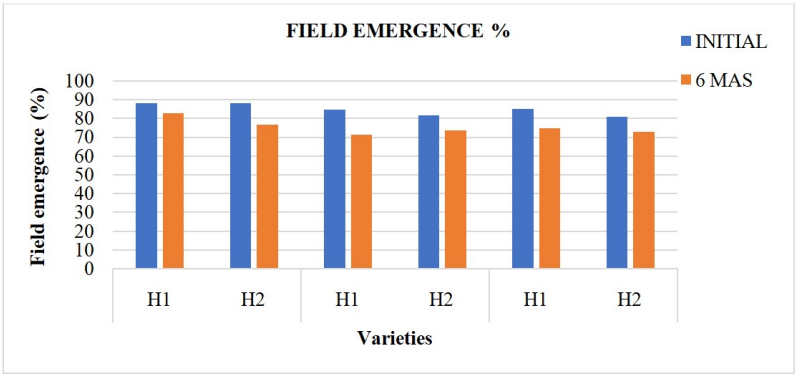

Fig. 3. Influence of harvesting methods on field emergence (%) in soybean.

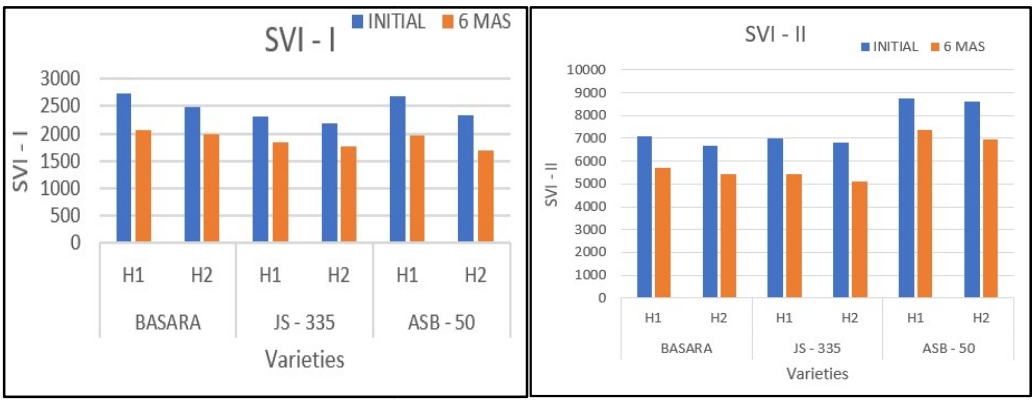

Fig. 4. Influence of harvesting methods on seed vigour indices in soybean.

Among the three varieties, significantly highest field emergence was recorded in Basara (84 %) followed by ASB - 50 (79 %) and JS - 335 (78 %) (Fig. 3). Significant reduction in field emergence from 85 % to 75 % was recorded after storage (Table 2d). These results were in line with the findings of Rame *et al.* (2002) who reported that mechanical threshed seed showed maximum reduction in field emergence compared to manual threshed seed during storage.

CONCLUSION

The present study concluded that between the methods of harvesting, the hand harvested seed showed better performance than mechanical harvested seed for seed quality parameters. Among the three varieties, Basara variety showed superiority for germination %, field emergence, index of speed of germination, seedling length, SVI – I & II, then followed by ASB - 50 and JS - 335 variety. Regardless to the method of harvesting and variety, all the seed quality parameters were decreased with the storage period.

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Conflict of Interest. None.

Table 1a: Analysis of variance (mean squares) for seed quality parameters at initial evaluation of soybean.

Source of variation	DF	Germination (%)	Seedling length (cm)	Seedling dry weight (mg)	Seedling Vigour Index -I	Seedling Vigour Index - II	Moisture content (%)	Seed hardness index	EC ($\mu Scm^{-1} g^{-1}$)	Field emergence (%)	Index of speed of germination
A	1	29.389	14.754***	254.65***	223,223.35***	534,233.39*	0.008	0.185	1192.67	23.347	3.154
B	2	16.722	10.662***	5,002.86***	589,342.79***	25,209,445.88***	1.544***	1.323***	19103.81***	425.54***	23.937 ***
AXB	2	52.722*	6.601**	89.57**	35,267.01*	717,323.01**	0.311***	0.560 **	835.54	43.51**	2.614
Error	12	9.667	0.737	14.171	8,007.33	121,907.74	0.011	0.11	292.92	**7.097**	0.828

Table 1b: Analysis of variance (mean squares) for seed quality parameters at 6 MAS of soybean.

Source of variation	DF	Germination	Seedling length (cm)	Seedling dry weight (mg)	Seedling Vigour Index -I	Seedling Vigour Index - II	Moisture content (%)	Seed hardness index	EC ($\mu Scm^{-1} g^{-1}$)	Field emergence (%)	Index of speed of germination
A	1`	0.889	14.754***	254.65***	223,223.35***	534,233.39*	0.006	0.185	35444.09***	23.347	3.154
B	2	24.222	10.662***	5,002.86***	589,342.79***	25,209,445.88***	0.344***	1.323***	220886.8***	425.54***	23.937 ***
AXB	2	10.889	6.601**	89.57**	35,267.01*	717,323.01**	0.135***	0.560 **	2471.51***	43.51**	2.614
Error	12	12.111	0.737	14.171	8,007.33	121,907.74	0.006	0.11	183.03	**7.097**	0.828

A - Method of harvesting, B – Variety, C – Storage,*-**-*** - Significance at 5%, 1% and 0.1%, respectively.

Table 2a: Effect of harvesting methods on seed quality parameters of soybean.

Treatment	Germination (%)					Seedling length (cm)					Seedling dry weight (mg)				
	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean
	H_1	H_2	H_1	H_2		H_1	H_2	H_1	H_2		H_1	H_2	H_1	H_2	
Basara	89	88	80	77	84	30.56	30.23	28.94	28.32	29.51	79.01	79.00	73.46	71.79	75.81
JS - 335	81	80	75	73	77	29.78	29.39	28.47	25.25	28.22	86.61	86.37	76.55	73.01	80.63
ASB - 50	85	85	77	75	81	32.6	31.13	28.82	27.4	29.99	106.77	107.32	98.98	95.82	100.46
Mean	85	84	77	75	80	30.98	30.25	28.74	26.99	29.24	90.80	90.9	83.00	80.20	85.64
Mean	85		76			30.62		27.87			90.85		81.60		
Total Mean	H_1 - 81		H_2 -79			H_1 - 29.86		H_2 - 28.62			H_1 - 86.90		H_2 - 85.55		
SEm±	1.80		2.01			0.38		0.44			0.89		0.35		
SE.d.	2.54		2.84			0.54		0.62			1.25		0.49		
CD	5.53		6.19			1.18		1.25			2.73		1.07		
CV	3.73		4.68			2.16		2.72			1.69		0.741		

Table 2b: Effect of harvesting methods on seed quality parameters of soybean.

Treatment	SVI - I					SVI - II				
	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean
	H_1	H_2	H_1	H_2		H_1	H_2	H_1	H_2	
Basara	2720	2660	2315	2181	2469	7032	6952	5877	5528	6347
JS – 335	2412	2351	2135	1843	2185	7015	6910	5741	5330	6249
ASB – 50	2771	2646	2219	2055	2423	9075	9122	7621	7186	8251
Mean	2634	2552	2223	2026	2359	7707	7661	6413	6015	6949
Mean	2593		2125			7684		6214		
Total Mean	H_1 - 2429		H_2 –2289			H_1-7060		H_2 - 6838		
SEm±	71.97		38.32			112.97		87.62		
SE.d.	101.78		54.19			159.73		123.92		
CD	221.76		118.06			348.09		269.99		
CV	5.087		3.52			2.611		2.53		

H_1 – Hand harvested seed, H_2 – Mechanical harvested seed, MAS – months after storage

Table 2c: Effect of harvesting methods on seed quality parameters of soybean.

Treatment	Moisture content (%)					EC					SHI				
	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean
	H_1	H_2	H_1	H_2		H_1	H_2	H_1	Mean		H_1	H_2	H_1	H_2	
Basara	7.92	7.82	9.05	9.09	8.47	83.50	82.32	200.6	237.4	150.96	8.74	9.09	8.57	8.78	8.80
JS – 335	8.77	8.30	8.94	9.02	8.76	100.40	107.29	311.83	365.57	221.27	8.65	8.2	8.5	8.22	8.39
ASB - 50	8.65	9.09	8.97	9.02	8.93	167.85	210.98	434.53	490.33	325.92	8.52	8.33	8.45	8.2	8.38
Mean	8.45	8.40	8.99	9.04	8.72	117.25	133.53	315.65	364.43	232.72	8.70	8.65	8.54	8.50	8.59
Mean	8.43		9.02			125.39		340.04			8.59		8.45		
Total Mean	H_1 - 8.72		H_2 - 8.72			H_1 - 216.45		H_2 - 248.98			H_1 - 8.57		H_2 - 8.47		
SEm±	0.06		0.02			9.88		6.61			0.17		0.12		
SE.d.	0.08		0.03			13.97		9.34			0.25		0.17		
CD	0.18***		0.07			30.45		20.35			0.53		0.37		
CV	1.227		0.43			13.65		3.36			3.5		2.47		

Table 2d: Effect of harvesting methods on seed quality parameters of soybean.

Treatment	Field emergence (%)					Index of speed of germination				
	INITIAL		6 MAS		Mean	INITIAL		6 MAS		Mean
	H_1	H_2	H_1	H_2		H_1	H_2	H_1	H_2	
Basara	88	88	83	77	84	32.12	31.79	16.94	15.83	24.17
JS - 335	82	85	71	74	78	30.64	27.57	15.31	15.22	22.18
ASB - 50	85	81	75	73	79	30.27	30.92	15.40	15.63	23.05
Mean	85	85	76	75	80	31.01	30.09	15.88	15.56	23.14
Mean	85		75			30.55		15.72		
Total Mean	H_1 - 81		H_2 - 80			H_1 - 23.45		H_2 - 22.82		
SEm±	1.70		1.52			0.86		0.36		
SE.d.	2.40		2.14			1.22		0.51		
CD	5.24		4.67			2.67		1.11		
CV	3.47		3.48			4.91		3.98		

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