Forage Res., **40** (2) : pp. 80-85 (2014) **http://forageresearch.in**

STUDIES ON SEED VIABILITY AND VIGOUR OF FODDER SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] SEEDS STORED UNDER AMBIENT CONDITIONS

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(Received : 17 June 2014; Accepted : 7 August 2014)

SUMMARY

Six varieties of fodder sorghum viz., SSG-59-3, HC-308, HJ-513, HC-171, HC-136 and HJ-541were collected and stored under ambient conditions for 15 months. Initially, all the varieties were subjected to the different seed viability and vigour parameters and the observations were recorded on standard germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour index-I & II, electrical conductivity (µS/cm/seed), accelerated ageing test (%) and field emergence (%) after six months of storage. The results showed that all the varieties recorded germination percentage above the Indian Minimum Seed Certification Standard (IMSCS) and ranged from 75.67 to 79.78 per cent after six months of storage. Further seeds of all the varieties were stored under ambient conditions and the observations were recorded at the interval of three months. After nine months of storage, the standard germination and seedling vigour index ranged from 74.60 to 77.33 per cent and 2113.09 to 2685.88, respectively. The EC increased with the passage of time and it ranged from 0.433 to 0.893. The results revealed that germination (%) and seed vigour index decreased drastically in all the varieties after 12 months of storage. The germination ranged from 38.00 to 58.00 per cent after 12 months of storage. The results showed that germination and vigour index of all the varieties decreased as the age of the seed increased. It was concluded that the sorghum seeds maintained their viability and vigour up to nine months of storage under ambient conditions and there was a sharp decline in the quality of sorghum seed after 12 months of storage. Hence, the sorghum seed could be stored for nine months under ambient conditions.

Key words : Fodder sorghum, standard germination, seed viability and vigour, electrical conductivity, accelerated ageing test, field emergence

Sorghum [*Sorghum bicolor* (L.) Moench], besides being fifth most important cereal crop of the world, is a food, feed and fuel crop in different parts of the world and has achieved a special significance after wheat, rice and maize among cereals. Sorghum fodder is suitable for silage and hay making. In India, it is an important **kharif** crop and its fodder is highly palatable and digestible as far as its nutritional quality is concerned. It has been in demand for industrial uses mainly as animal and poultry feed, ethanol industry and as food items. It is one of the major crops of the world and is originated in Africa and it is often cross-pollinated crop and can be grown in a wild range of ecological conditions and yields well under unfavourable conditions of drought stress and high temperatures. It is mainly grown for food and fodder purpose and is preferred over other non-leguminous fodder due to its high yielding capacity, better quality and palatability and its utilization in various forms i. e. green fodder, stover, silage and hay. Besides food and fodder, it is also used for preparation of alcoholic beverages, fibres, sugar and syrup. Indian economy is primarily agriculture-based where animal health is very important. To establish and improve the animal production, the availability of quality forage crops and grasses and their production needs urgent attention.

To see the importance of this crop, it is necessary to know the seed quality before it is sown in the field and also to know the seed storability under

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ambient conditions. Seed quality is determined by different factors including seed viability and vigour which impart inherent capacity to grow under favourable and unfavourable conditions. Fodder sorghum seeds are poor storage crop and it deteriorates sharply with passage of time under ambient conditions. Seed quality deterioration during storage is well known phenomenon; however the extent of loss is governed by a number of intrinsic and extrinsic factors. Intrinsic factors include all such variation in seed metabolism which occurs due to the differences in environmental and edaphic conditions during the plant growth, particularly during development and growth of seed. The extrinsic factors include relative humidity, temperature and oxygen availability in storage. Due to these factors, the rate and extent of decline in seed quality with respect to viability and vigour vary considerably among different cultivars of same species and different seed lots of the same varieties.

Seed vigour is a concept describing several characteristics which include the rate and uniformity of germination and growth, tolerance to environmental stress after sowing and retention of performance after storage. The seed vigour comprises those seed properties which determine the potential for rapid, uniform emergence and development of normal seedling under a wide range of field conditions. Vigour is the first component of seed quality, which is lost, followed by a loss of germination capacity and viability (Trawath *et al.*, 1995). Now-a-days, the seed vigour as a quality attribute has gained significance which is a highly complex character influenced by many parameters. As fodder sorghum is one of the most potential forage crops, hence, it is essential to study seed viability and vigour of different varieties of fodder sorghum seed stored under ambient conditions. In natural conditions, it is very difficult to keep the sorghum seed for longer period as it deteriorates sharply with passage of time. So far, only limited information is available on the above aspects and hence, the present investigation/study was conducted to determine the seed viability and vigour of different varieties of fodder sorghum stored under ambient conditions.

MATERIALS AND METHODS

Seeds of six fodder sorghum varieties viz., SSG-59-3, HC-308, HJ-513, HC-171, HC-136 and HJ-541 collected from Forage Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during 2013 were stored under ambient conditions for 15 months. Initially, the observations were recorded after six months of storage. Seeds of all the varieties were studied for different aspects of seed quality and the initial observations were recorded for standard germination (%), seedling length (cm), seedling dry weight (mg), vigour indices-I & II, electrical conductivity (mS/cm/100 seeds), accelerated ageing test (%) and field emergence (%) after six months. After recording the initial observations, seeds of all the six varieties were again stored under ambient conditions and the following observations were recorded at the interval of three months.

Standard Germination Test (%)

One hundred seeds with three replications each of all the fodder sorghum varieties were tested in the laboratory according to the Rules of International Seed Testing Association (ISTA, 2011). The final count of germination was recorded on 8th day and the number of normal seedlings was counted and expressed as per cent germination.

Seedling Length (cm)

Ten normal seedlings in three replications each of all the varieties were selected randomly during germination test and the seedling length was measured in centimetre and average seedling length was calculated.

Seedling Dry Weight (mg)

Ten normal seedlings selected at randomly during germination testing were taken for measuring seedling dry weight (mg). These seedlings were placed in paper bags and then transferred into oven at 80^{O}C for 48 h. The average weight of 10 dry seedlings was taken and seedling dry weight was expressed in milligrams.

Vigour Indices

Seedling vigour indices were calculated according to the formulae suggested by Abdul-Baki and Anderson (1973).

Vigour index-I=Standard germination (%) x Seedling length (cm)

Vigour index-II=Standard germination (%) x Seedling dry weight (mg)

Electrical Conductivity Test (mS/cm/100 seeds)

Electrical conductivity of the seed leachates was measured to know the status of membrane permeability. Hundred normal and undamaged seeds taken randomly with three replications each of all the fodder sorghum varieties were soaked in 100 ml beakers each containing 75 ml of distilled water. The seeds were immersed completely in water and beakers were covered with the aluminium foil. Thereafter, these samples were kept in the germinator at 25°C for 24 h. The electrical conductivity of seed leachates was measured by Conductivity Meter and was expressed in mS/cm/100 seeds.

Accelerated Ageing Test (%)

Sufficient number of seeds from each variety were taken and put on in a single layer on wire mesh tray fitted in plastic boxes having 20 ml of distilled water in bottom. The boxes were placed in accelerating ageing chamber after closing their lids. The seeds were aged at 40±1°C temperature and about 100 per cent RH for 72 h and then tested for germination in three replications of 100 seeds each according to the Rules of International Seed Testing Association (ISTA, 2011). The number of normal seedlings was counted and expressed in percentage.

Field Emergence Index

One hundred seeds of all the six fodder sorghum varieties in three replications each were sown in a randomized block design (RBD) at the Research Farm, Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar. Number of seedlings emerged were counted when the emergence was completed or when there was no further addition in the total emergence.

RESULTS AND DISCUSSION

The loss of seed viability in storage is preceded by a wide range of symptoms which collectively contribute to the loss of seed viability and vigour which is usually reflected in the lack of uniformity and decreased field emergence. Generally, the germination standard alone does not give the actual estimate of field performance of any seed lot. So, there is a need to have some reliable parameters for evaluation of the seed quality in sorghum. In order to assess the seed quality of different varieties of sorghum seeds stored under ambient conditions, the seeds were subjected to a number of physiological and biochemical tests which can be used reliably to predict crop establishment under the field conditions.

Standard Germination Test (%)

In the present investigation, all the sorghum varieties recorded germination percentage above Minimum Seed Certification Standard (75.0%) and it ranged from 75.67 to 79.78 per cent after six months of storage (Table 1). The variety HC 136 recorded maximum germination (79.78%) followed by SSG 59-3

TABLE 1
Seed germination parameters of different varieties of fodder sorghum [*Sorghum bicolor* (L.) Moench] stored under ambient conditions

Variety	Storage period (months)	SG (%)	SL (cm)	SDW (mg)
SSG-59-3	6	78.33	36.23	159.33
	9	74.67	35.97	147.00
	12	58.00	29.30	135.33
	15	47.00	25.03	130.37
HC 308	6	75.67	32.22	177.67
	9	74.80	30.63	149.86
	12	54.67	27.77	126.83
	15	46.88	24.63	117.30
HJ 513	6	75.67	35.40	166.67
	9	74.60	28.33	147.44
	12	50.33	23.57	124.67
	15	40.77	21.37	117.00
HC 171	6	78.20	32.51	142.22
	9	77.33	30.17	138.00
	12	48.17	24.33	128.00
	15	44.83	22.03	112.53
HC136	6	79.78	31.13	197.67
	9	75.33	29.53	179.50
	12	38.00	16.93	160.51
	15	26.40	15.37	157.33
HJ 541	6	75.67	36.43	188.67
	9	75.33	34.37	145.28
	12	44.67	24.60	131.83
	15	38.67	21.43	123.43
C. D. (P=0.05)				
	V	0.54	0.532	6.660
	S	0.44	0.434	5.438
	V x S	1.08	1.063	13.320

(78.33%) and HC 171 (78.20%). Among the varieties, HC 308, HJ 513 and HJ 541 recorded minimum germination (75.67%) and were found at par value with each other. After nine months of storage, the germination declined in all the varieties but all these varieties maintained the value near to germination standard and ranged from 74.60 to 77.33 per cent. After 12 and 15 months, the germination declined with a fast rate in all the varieties and it ranged from 38.00 to 58.0 and 26.40 to 47.0 per cent, respectively.

Vigour Indices

Vigour index-I was calculated by multiplying the standard germination percentage with seedling length (cm), whereas vigour index-II was calculated by multiplying standard germination percentage with seedling dry weight (mg) and the results are presented in Table 2. The variety SSG 59-3 recorded maximum value (2837.90) followed by HJ 541 (2756.66), while the variety HC-308 showed minimum value (2438.09) after six months of storage. The vigour index-I ranged from 2438.09-2837.90 and all the sorghum varieties were significantly superior over HC-308. Vigour index-1 declined sharply after 12 months of storage in all the varieties and the data revealed that the variety HC-136 showed maximum vigour index-II (15770.11), whereas HC 171 had minimum value (11121.60). Vigour index-II ranged from 15770.11-11121.60 and the all fodder sorghum varieties were significantly superior over HC 171. After 12 and 15 months of storage, vigour index declined with a fast rate in all the varieties. The vigour index-I and vigour index-II deceased as the quality of seed became poor due to duration of storage period increased in maize (Basu *et al.,* 2004). Ilbi and Eser (2006) emphasized that seed vigour was an important seed quality parameter because standard germination test did not consistently predict the field performance of seed lot. Verma *et al.* (1999) also found that seedling vigour decreased with increased age of seeds in rapeseed and mustard.

TABLE 2
Seed vigour parameters of different varieties of fodder sorghum [*Sorghum bicolor* (L.) Moench] stored under ambient conditions

Variety	Storage period (months)	S.V. I.-I	S.V. I.-II
SSG-59-3	6	2,837.90	12,480.32
	9	2,685.88	10,976.49
	12	1,699.40	7,849.14
	15	1,176.41	6,127.39
HC 308	6	2,438.09	13,444.29
	9	2,291.12	11,149.58
	12	1,518.19	6,933.80
	15	1,154.65	5,499.02
HJ 513	6	2,678.72	12,611.92
	9	2,113.42	10,940.05
	12	1,186.28	6,274.64
	15	871.25	4,770.09
HC 171	6	2,542.28	11,121.60
	9	2,333.05	10,671.54
	12	1,171.98	6,165.76
	15	987.61	5,044.72
HC 136	6	2,483.55	15,770.11
	9	2,224.50	13,521.74
	12	643.34	6,099.38
	15	405.77	4,153.51
HJ 541	6	2,756.66	14,276.66
	9	2,589.09	10,943.94
	12	1,098.88	5,888.85
	15	828.70	4,773.04
C. D. (P=0.05)			
	V	84.507	442.837
	S	69.000	361.575
	V x S	169.014	885.675

Electrical Conductivity Test

The amount of seed leachates dissolved in the water was measured in all fodder sorghum varieties after 24 h of imbibitions and the results are presented in Table 3. Electrical conductivity test was used to measure the seed viability (Presley, 1958) and later on development into a vigour test for prediction of field emergence. The variety HC 136 recorded maximum value (0.167), while variety HJ-513 showed minimum value (0.074) after six months of storage period, whereas it ranged from 0.433 to 0.893 after nine months of storage. It showed that variety HJ-513 had recorded high vigour potential than other varieties. After 12 months, the EC increased drastically and continued after 15 months of storage in all the varieties that clearly reflected the loss of vigour in all the varieties with the passage of time. Ilbi and Eser (2006) reported that electrical conductivity test rapidly provided information about difference in quality status of seed sample and possibly their vigour in onion. Wang *et al.* (2004) reported that electrical conductivity (EC) test provided the best estimate of seed vigour for legume species purple vetch (*Vicia benghalensis*) and alfalfa

TABLE 3
Electric conductivity, accelerated ageing and field emergence index of different varieties of fodder sorghum [*Sorghum bicolor* (L.) Moench] stored under ambient conditions

Variety	Storage period (months)	EC (µS/cm/seed)	AAT (%)	FEI (%)
SSG-59-3	6	0.113	46.59	55.33
	9	0.893	42.37	
	12	60.57	28.23	
	15	98.15	23.25	16.00
HC 308	6	0.074	52.71	56.00
	9	0.433	45.66	
	12	78.567	29.50	
	15	110.387	22.97	14.33
HJ 513	6	0.090	54.81	67.67
	9	0.442	47.67	
	12	70.633	27.47	
	15	106.407	20.48	16.33
HC 171	6	0.087	45.05	58.00
	9	0.553	40.87	
	12	82.833	27.33	
	15	123.553	21.22	17.67
HC 136	6	0.167	55.71	64.00
	9	0.536	49.40	
	12	97.600	21.87	
	15	196.667	13.74	10.33
HJ 541	6	0.103	47.81	59.33
	9	0.632	41.07	
	12	90.600	23.47	
	15	135.667	18.37	12.33
C. D. (P=0.05)				
	V	1.008	0.337	3.27
	S	0.823	0.275	1.89
	V x S	2.017	0.675	4.62

(*Medicago sativa* L.). Gupta *et al.* (2005) reported that electrical conductivity increased after the seeds were subjected to accelerated ageing because of membrane deterioration and metabolic changes in the seed. Yadav and Dhankhar (2001) reported that vigour index-I & II were positively and significantly correlated with standard germination and negatively correlated with electrical conductivity in okra.

Acceteraled Ageing test

All the sorghum varieties were subjected to stress condition i. e. 40±1ºC and 100 per cent relative humidity for 72 h. The seed lot which gave maximum germination even after going under the stress was regarded as vigorous seed and the results are presented in Table 1. After the accelerated ageing test, the variety HC 136 recorded maximum value (55.71%) followed by HJ 513 (54.81%) and S 308 (52.71%) after six months of storage, whereas the germination percentage ranged from 40.87 to 49.40 per cent after 9 months of storage. The results revealed that the germination percentage decreased sharply after 12 months of storage. The value of accelerated ageing test ranged from 21.87 to 29.50 per cent in all the varieties after 12 months of storage. The variety HC 136 was found significantly superior over all varieties under study. Delouche and Baskin (1973) and AOSA (1983) observed that the germination percentage after accelerating ageing was correlated with vigour of lot and hence to the lot capacity to perform well under field condition. Basra *et al.* (2003) found that vigour level, mean emergence time and quality parameters could be predicted by accelerating ageing test. Rabiei *et al.* (2009) studied that drought stress had significant effect on seed vigour, germination percentage, radical and stem dry weight in oat.

Field Emergence Index

The field emergence of all fodder sorghum varieties was recorded in two seasons and the results are presented in Table 1. Field emergence index has been given different names such as emergence rate index (Allan *et al.* 1962), germination rate (Maguire, 1962), speed of germination (Lawrence, 1963) and germination or peak value (Djavanshir and Pourbeik, 1976). The highest value was recorded in HJ 513 (67.67%) followed by HC 136 (64.00%) after six months of storage. The field emergence ranged from 10.33-17.67 per cent in all the varieties after 15 months of storage. Hampton *et al.* (2009) reported that standard germination of all 26 lots of *Brassica* spp. was not related to field emergence but electrical conductivity was more strongly related to field emergence.

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