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Effect of Packaging Materials and Seed Treatment Chemicals on Seed Quality of Sunnhemp during Storage

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ABSTRACT: *The experiment consisted of three packaging materials* viz., *cloth bag, polyethylene bag (700 gauge) and HDPE bag and four seed treatment chemicals* viz., *control, Thiram and Bavistin @ 1 g / kg of seed, Malathion at 2.5 g /kg of seed and Bioneem @ 3 ml /kg of seed were used. Seeds stored in polyethylene bag (700 gauge) showed lowest moisture content as compared to cloth bag and HDPE bag at the end the study. The moisture content in cloth bag was 9.41, 9.57 and 9.88 %, in polyethylene bag (700 gauge) (8.06, 8.06 and 8.06 %) and HDPE bag (9.26, 9.42 and 9.78 %) at the end of twelve months of storage for the seeds produced during kharif, rabi 2009 and summer, 2010 respectively. The seed treated with Malathion @ 2.5 g/kg and packed in polyethylene bag (700 gauge) recorded highest germination (86.6, 86.3 and 84.6 %), seedling length (16.65, 16.16 and 16.52 cm), total dehydrogenase activity recorded (1.19, 1.16 and 1.14 OD value),seed health per cent (6.44, 6.94 and 7.08 %) and field emergence per cent (82.17, 82.33 and 80.50 %) and lowest electrical conductivity (5.11, 5.40 and 5.29 dSm^{-1}) compared to cloth and HDPE bag at the end of twelve months storage in kharif, rabi 2009 and summer 2010, respectively. Thus, it can be concluded that sunnhemp seeds stored in polyethylene bag and treated with Malathion @ 2.5 g/kg of seed found better and also with moisture of around 9 per cent in cloth bag could be stored under ambient conditions per a period of more than twelve months to maintain minimum seed certification standard (75 %) of germination.*

Keywords: *Packaging, Seed quality, Seed treatment, Sunnhemp.*

INTRODUCTION

Sunnhemp (*Crotalaria juncea* L.) also known as Indian hemp, Bombay hemp or Banaras hemp belongs to the genus *Crotalaria*, consisting of over 600 species out of which *Crotalaria juncea* is the most important. It plays an important role in the national economy by providing raw material for indigenous paper and textile industry. The important sunnhemp growing countries in the world are USSR, Romania, India, Pakistan, China, Hungary, Poland, Turkey, Brazil and Bangladesh. In India, it is grown over an area of 63 thousand hectares with a production of 35 thousand tonnes of fibre. Green manuring is an arable farming practice in which undecomposed green plant material is incorporated into the soil in order to increase immediate productivity. This material may be either obtained from quick growing green manuring crop grown *in situ* or *exsitu*. The non-availability of good quality seed is one of the handicaps in popularizing the practice of green manuring with sunnhemp. Hence, the production and making available sufficient high quality seed of this crop at reasonable price is necessary. For seed production, suitable techniques have to be developed for each agro-climatic situation. The information available on seed production aspects of this crop is very meager. Among the different seed production practices seed packaging and storage are also considered as most important aspects for maintenance of seed quality during storage.

MATERIAL AND METHODS

Freshly harvested seeds collected from different seasons were used for the study. One kg seeds were treated separately with Thiram and Bavistin @ 1 g per kg of seed, Malathion @ 2.5 g per kg of seed and Bioneem @ 3 ml per kg of seed. The treated seeds were air dried under shade for 24 h to bring back to its original moisture content (9%) and were packed in cloth bag, polythene bag (700 guage) and HDPE bag and stored under room condition at the Department

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of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur. Samples were drawn bimonthly to study the seed quality attributes up to twelve months of storage.

Treatment Combination Details

Variety: Local variety	Design: Factorial CRD
Packaging Materials: Three	Chemicals: Four
P_1-Cloth bag,	C_1 -Control
P_2-Polythene bag (700guage)	C_2 - Thiram and Bavistin @ one g/kg of seed
P_3-HDPE bag (Urea bag)	C_3 - Malathion @ 2.5 g/kg of seed C_4 - Bioneem @ 3 ml/ kg of seed

Seed Germination (%)

The germination test was conducted in the laboratory using between paper method as per ISTA (2007). One hundred seeds each of four replications were placed on germination paper and rolled towels were incubated in germination chamber maintained at 25°C and 90 per cent relative humidity. The germinated seedlings were evaluated on 5th and 14th day as first and final count and percentage germination was expressed based on normal seedlings.

Seedling Length (cm)

Ten seedlings were randomly selected from each treatment at final count (14th day) and were separated carefully from the paper towel of laboratory germination test and the total length of seedling after removing the cotyledons was measured using metric scale on the germination table and expressed in centimeters.

Electrical Conductivity of Seed leachate (dSm^{-1})

Four replications of twenty five seeds were weighed up to two decimal places. The seeds were washed thoroughly with distilled water. The surface sterilized seeds were soaked in 25 ml of distilled water and incubated for 24 hours. Then, the steeped water from the soaked seeds were collected and electrical conductivity of the leachate was measured in the digital conductivity meter model. After subtracting the EC of the distilled water from the value obtained from the seed leachate, the actual EC due to the seed leachate of electrolytes was measured and expressed in dSm^{-1} at 25 ± 1°C (Presley, 1958).

Seed Moisture Content (%)

The moisture content of seed was determined by oven dry method as per ISTA (2007). After drawing samples from different treatments, they were subjected to moisture determination immediately. At each stage of harvest, 10 pods were harvested and threshed to estimate the fresh and dry weight of seeds. The seeds were dried at 103°C for 17 hours and then samples were taken out from the drying chamber, cooled to room temperature and their dry weight was recorded. From the primary data, moisture percentage in the seed was computed as detailed below:

$$Seed\ moisture\ content(\%) = \frac{Fresh\ weight\ of\ the\ seed - dry\ weight\ of\ the\ seed}{Fresh\ weight\ of\ the\ seed} \times 100$$

The pods from each treatment after harvest were hand shelled and seeds obtained were dried in the morning hours of sunlight, to bring down the initial seed moisture content to around 9 per cent. These seeds were subjected to laboratory observations.

Total Dehydrogenase Activity (TDH)

Twenty-five seeds soaked in water for 24 hours for pre-conditioning from each treatment. Then ten pre-imbibed seeds were randomly selected in each sample, seed coat was removed and soaked in 2 ml of 0.5 per cent tetrazolium solution. They were incubated at 25 ± 1°C in dark for six hours and then washed thoroughly with distilled water. The red colour (Formazan) developed was extracted from the stained embryos by soaking in 5 ml of 2-methoxy ethanol in screw caped vials until all the seeds discoloured. The extract was decanted and the colour intensity was measured in Spectrophotometer at 480 nm with suitable blank. The TDH was expressed in terms of absorbance (OD) value (Perl *et. al*., 1978).

Seed Health (%)

Detection and identification of seed mycoflora was done by blotter paper method (TP) as per ISTA (2007). Twenty five seeds of two replications were placed equidistantly in sterile glass petridishes of 9 cm diameter containing three moist blotter papers (Whatman No. 1). Then the petridishes were incubated at 20 °C for 7days with alternate 12 hours light and 12 hours dark. After incubation, seeds were examined under stereo binocular microscope for the presence of seed infection/ infestation. The number of seeds infected by insects were recorded and expressed as percentage of infection.

Field Emergence (%)

The field emergence studies were conducted for two hundred seeds in four replication of fifty seeds each. The seeds selected at random were sown on a well-prepared raised seedbed and optimum soil moisture was maintained by watering. Germination count was taken on 14th day of sowing and the germination per cent was calculated taking into account the number of normal seedlings emerged out.

RESULTS AND DISCUSSION

Maintenance of seed quality during storage has become most important part of seed production programme, since agriculture is season bound, the storage of seed has become inevitable for farmers, seed producers, breeders and to all those concerned with seed. The loss of seed during storage may range from 0 to 100 per cent under unhygienic condition. Seed being a biological material, the loss of seed viability and vigour during storage is a quite natural phenomenon occurring due to deterioration process which is inexorable, irreversible and inevitable. Although the complete control of seed deterioration is quite impossible but the rate of degenerative process could be slowed down to a certain extent by providing ideal conditions. In the present study an attempt has been made to gather more information on the nature of sunnhemp seed viability during storage under ambient condition.

Influence of Packaging Materials on Seed Quality Parameters

An increase in moisture content of sunnhemp seeds was observed in cloth bag and HDPE bag. The treatment P_2 (Polyethylene bag – 700 gauge) recorded the lowest seed moisture content (8.04, 8.06 and 8.05 %) and highest (9.41, 9.57 and 9.88 %) was in P_1 (cloth bag) in *kharif*, *rabi* 2009 and summer 2010, respectively. The moisture fluctuation was more in cloth and HDPE bags compared to polyethylene bag (700 gauge). The results are in agreement with the findings of Dharmalingam *et.al*. (1976) in black gram and Verma and Gupta (1975) soybean (Table 7).

Seed germination declined progressively from 85.5to 81.6%, 84.8to 81.5% and 82.9 to 77.7% over a period of twelve months storage in the seeds produced during *kharif*, *rabi* 2009 and summer 2010, respectively (Table 7). The decline in germination percentage may be attributed to ageing effect leading to depletion of food reserves and decline in synthetic activity of embryo apart from death of seed because of fungal invasion, fluctuating temperature, relative humidity and storage container in which seeds were stored. Increased accumulation of total peroxide and leakage of electrolytes was due to ageing of seeds leading to loss of membrane integrity. Germination was higher in polyethylene bag which may be attributed to low rate of respiration compared to cloth bag. These findings are in agreement with the results obtained by Gupta and Aneja (2004) in soybean. The decline in seedling length at the end of twelve months storage was from 16.65 to 15.42 cm, 16.16 to 14.20 cm and 14.73 to 14.22 cm Similar findings were also reported by Indira *et.al.* (2000) in fenugreek and Verma and Gupta (1975) in soybean. (Table).

While, increase in EC may be attributed to permeability of the seed membranes seed ages, many substances such as sugars, free amino acids, organic acids *etc.*, will leach out in the presence of water, disruption of membrane integrity and increase in free fatty acid level. Similar findings obtained by Indira *et.al.* (2000) in fenugreek.

The total dehydrogenase activity (TDH) was decreased with increase in storage at twelve months period. P_2 recorded higher dehydrogenase activity (1.19, 1.16 and 1.14 OD value) compared to (P_1) control (1.15, 1.14 and 1.12 OD value) after twelve months of storage of seeds produced during*kharif*, *rabi* 2009 and summer 2010, respectively (Table 9). This shows that viability of seeds decreased with increase in storage period. These results are similar to the findings obtained by Saxena and Maheswari (1980) in soybean.

Seed health is also one of the important seed quality attributes. In the present investigation, the insect infestation was noticed at the end of twelve months of storage period in the seeds produced in all the three seasons. The maximum infection was recorded in seed stored in cloth bag (6.44, 6.94 and 7.08%) and HDPE bag (6.31, 6.47 and 6.59%) compared to polyethylene bag (2.03, 2.72 and 2.79%) during *kharif*, *rabi* 2009 and summer 2010, respectively (Table 9).

Field emergence decreased progressively with advancement of storage period in all the three seasons. At the end of twelve months storage, polyethylene bag (P_2) recorded highest field emergence (82.17, 82.33 and 80.5%) and lowest was in control (P_1) (77.08, 77.16 and 75.83%) during *kharif*, *rabi* 2009 and summer 2010, respectively. This decrease in field emergence may be due to age induced deteriorative changes in cells and cell organelles and germinative capacity of seed under natural soil conditions. As field emergence and germination are positively correlated, the decline in field emergence may be attributed to decrease in

Table 1
Effect of Packaging Materials, Seed Treatment Chemicals and their Interaction at Initial Stage on Seed Moisture (%), Germination (%) and Seedling Length (cm) of Sunnhemp during *kharif*, *rabi* 2009 and Summer, 2010

Treatments	*Seed moisture (%)*			*Seed germination (%)*			*Seedling length (cm)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials(P)									
P_1	8.08	8.05	8.05	96.92	96.75	95.66	25.37	25.18	24.63
P_2	8.05	8.04	8.04	97.67	96.92	95.67	26.10	25.52	24.68
P_3	8.06	8.04	8.05	97.42	96.67	95.66	25.46	25.06	24.65
SEm±	0.016	0.003	0.003	0.250	0.174	0.117	0.182	0.170	0.079
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Seed treatment chemicals (C)									
C_1	8.06	8.04	8.04	97.00	96.33	95.66	25.36	24.97	24.61
C_2	8.05	8.04	8.04	97.56	96.89	95.77	25.53	25.36	24.66
C_3	8.05	8.04	8.05	97.67	97.22	95.67	26.06	25.50	24.69
C_4	8.07	8.04	8.05	97.11	96.67	95.66	25.64	25.19	24.64
SEm±	0.014	0.004	0.003	0.289	0.301	0.135	0.210	0.196	0.091
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (PxC)									
P_1C_1	8.10	8.05	8.06	96.33	96.33	95.66	24.66	24.50	24.50
P_1C_2	8.06	8.05	8.05	97.33	97.00	95.67	25.42	25.25	24.75
P_1C_3	8.02	8.05	8.05	97.33	97.33	95.67	26.00	25.25	24.67
P_1C_4	8.08	8.04	8.05	96.67	96.33	95.66	25.17	25.17	24.66
P_2C_1	8.03	8.04	8.05	97.33	96.33	95.66	26.17	25.33	24.58
P_2C_2	8.05	8.05	8.04	97.33	97.00	95.67	26.00	25.50	24.66
P_2C_3	8.04	8.04	8.04	98.00	97.00	95.67	26.08	25.83	24.75
P_2C_4	8.06	8.04	8.05	98.00	96.33	95.66	26.16	25.42	24.66
P_3C_1	8.04	8.04	8.06	97.33	96.67	95.66	25.25	25.08	24.66
P_3C_2	8.04	8.04	8.06	98.00	97.00	95.67	25.16	25.33	24.58
P_3C_3	8.07	8.04	8.05	97.67	97.00	95.67	25.08	25.42	24.67
P_3C_4	8.07	8.04	8.05	96.66	96.67	95.66	25.58	25.00	24.66
G. Mean	8.06	8.04	8.05	97.33	96.78	95.69	25.65	25.26	24.65
SEm±	0.028	0.016	0.016	0.600	0.347	0.234	0.464	0.340	0.158
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	2.60	2.14	2.12	3.89	4.62	3.42	3.46	3.33	4.11

Table 2
Effect of Storage Containers, Seed Treatment Chemicals and their Interaction at Initial Stage on Electrical Conductivity, Total Dehydrogenase Activity and Field Emergence of Sunnhemp during *kharif*, *rabi* 2009 and Summer, 2010

Treatments	*Electrical conductivity (dSm^{-1})*			*Total dehydrogenase activity (OD value)*			*Field emergence (%)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials (P)									
P_1	3.67	3.62	3.80	1.25	1.25	1.24	95.42	95.33	94.75
P_2	3.66	3.59	3.79	1.25	1.25	1.24	95.75	95.50	94.83
P_3	3.67	3.59	3.79	1.25	1.25	1.24	95.58	95.33	94.75
SEm±	0.011	0.025	0.006	0.004	0.002	0.005	0.169	0.117	0.096
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Seed treatment chemicals (C)									
C_1	3.67	3.60	3.81	1.25	1.25	1.24	95.44	95.11	94.40
C_2	3.65	3.59	3.80	1.25	1.25	1.25	95.67	95.33	95.00
C_3	3.65	3.59	3.79	1.26	1.26	1.25	95.79	95.79	95.04
C_4	3.67	3.60	3.80	1.25	1.25	1.24	95.44	95.33	94.67
SEm±	0.013	0.029	0.007	0.004	0.003	0.006	0.195	0.135	0.111
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (PxC)									
P_1C_1	3.69	3.64	3.81	1.24	1.25	1.24	95.33	95.00	94.30
P_1C_2	3.65	3.61	3.80	1.25	1.25	1.24	95.67	95.33	95.00
P_1C_3	3.69	3.60	3.81	1.26	1.26	1.24	95.67	95.66	95.00
P_1C_4	3.67	3.61	3.79	1.26	1.25	1.24	95.67	95.33	94.66
P_2C_1	3.66	3.64	3.81	1.25	1.25	1.24	95.33	95.00	94.36
P_2C_2	3.65	3.61	3.79	1.25	1.25	1.24	95.67	95.66	95.00
P_2C_3	3.64	3.59	3.78	1.26	1.26	1.25	96.67	96.00	95.00
P_2C_4	3.66	3.60	3.79	1.25	1.25	1.24	95.00	95.33	94.66
P_3C_1	3.64	3.60	3.79	1.25	1.25	1.24	95.66	95.33	94.66
P_3C_2	3.65	3.61	3.80	1.26	1.25	1.24	95.67	95.00	94.67
P_3C_3	3.66	3.62	3.80	1.26	1.26	1.25	96.00	95.67	95.00
P_3C_4	3.65	3.60	3.79	1.25	1.25	1.24	95.66	95.33	95.00
G. Mean	3.66	3.61	3.80	1.25	1.26	1.25	95.58	95.39	94.79
SEm±	0.021	0.051	0.011	0.008	0.004	0.001	0.337	0.234	0.193
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	2.01	2.43	2.51	2.06	2.50	2.14	4.00	4.42	4.35

Table 3
Effect of Storage Containers, Seed Treatment Chemicals and their Interaction after Six Months Storage on Seed Moisture (%), Seed Germination (%) and Seedling length(cm) of Sunnhemp during *kharif*, *rabi* 2009 and summer, 2010

Treatments	*Seed moisture (%)*			*Seed germination (%)*			*Seedling length (cm)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials (P)									
P_1	8.38	8.39	8.40	93.42	93.25	88.75	23.03	23.06	21.71
P_2	8.06	8.06	8.06	94.75	93.92	90.75	24.65	23.75	22.15
P_3	8.29	8.27	8.28	94.16	93.58	89.08	23.72	23.37	21.44
SEm±	0.014	0.008	0.004	0.177	0.142	0.243	0.097	0.078	0.020
CD(P=0.05)	0.041	0.023	0.010	0.520	0.420	0.710	0.280	0.230	0.160
Seed treatment chemicals (C)									
C_1	8.27	8.25	8.25	93.33	93.33	88.44	23.60	23.14	21.25
C_2	8.24	8.24	8.24	94.44	93.66	89.78	24.11	23.42	21.64
C_3	8.23	8.23	8.24	94.89	94.00	90.89	24.31	23.64	22.17
C_4	8.24	8.24	8.24	93.78	93.33	89.00	23.97	23.38	21.42
SEm±	0.017	0.007	0.004	0.205	0.164	0.281	0.112	0.090	0.235
CD(P=0.05)	0.050	0.020	0.009	0.600	0.480	0.820	0.330	0.260	0.690
Interaction (PxC)									
P_1C_1	8.42	8.40	8.41	92.67	93.00	87.66	23.25	22.83	20.92
P_1C_2	8.37	8.39	8.39	93.66	93.00	89.00	23.58	23.00	21.25
P_1C_3	8.36	8.39	8.40	94.33	93.66	90.33	24.08	23.33	21.83
P_1C_4	8.37	8.38	8.39	93.00	93.00	88.00	23.58	23.08	21.08
P_2C_1	8.07	8.05	8.06	94.00	93.66	90.00	24.25	23.50	21.75
P_2C_2	8.06	8.04	8.06	95.33	94.00	90.67	24.92	23.50	22.25
P_2C_3	8.06	8.04	8.05	95.33	94.67	92.00	24.92	24.00	22.75
P_2C_4	8.07	8.05	8.06	94.33	93.33	90.33	24.50	23.83	21.83
P_3C_1	8.31	8.28	8.28	93.66	93.33	87.66	23.30	23.67	21.08
P_3C_2	8.29	8.27	8.27	94.00	94.00	89.67	23.83	23.08	21.42
P_3C_3	8.28	8.26	8.26	95.00	94.66	90.33	23.92	23.42	21.91
P_3C_4	8.28	8.27	8.27	94.00	93.33	88.67	23.83	23.58	21.33
G. Mean	8.25	8.24	8.24	94.11	93.58	89.53	23.40	23.39	21.62
SEm±	0.029	0.009	0.008	0.354	0.284	0.486	0.194	0.155	0.406
CD(P=0.05)	0.080	0.030	0.023	1.040	0.830	1.430	0.670	0.450	1.190
CV (%)	2.64	2.32	0218	2.65	3.53	2.94	2.40	2.15	3.25

Table 4
Effect of Storage Containers, Seed Treatment Chemicals and their Interaction after Six Months Storage on Electrical Conductivity (dSm^{-1}), Total Dehydrogenase Activity (OD value) and Seed Health (%) of Sunnhemp during *kharif, rabi* 2009 and Summer, 2010

Treatments	*Electrical conductivity (dSm^{-1})*			*Total dehydrogenase activity (OD value)*			*Seed health (%)*			*Field emergence (%)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials (P)												
P_1	4.09	4.17	4.54	1.20	1.21	1.20	1.28	1.06	1.39	92.00	92.08	87.33
P_2	3.88	3.94	4.38	1.24	1.22	1.22	0.18	0.13	0.22	93.67	93.75	88.25
P_3	4.01	4.14	4.51	1.21	1.21	1.20	0.94	0.92	1.16	92.42	92.41	87.67
SEm±	0.029	0.013	0.010	0.006	0.006	0.006	0.041	0.027	0.084	0.197	0.140	0.251
CD(P=0.05)	0.080	0.040	0.029	0.018	0.018	0.018	0.120	0.080	0.240	0.580	0.410	0.740
Seed treatment chemicals (C)												
C_1	4.07	4.13	4.52	1.22	1.21	1.20	1.11	0.89	1.35	92.00	92.11	86.11
C_2	3.94	4.08	4.45	1.22	1.21	1.21	0.73	0.66	0.62	93.00	92.77	88.21
C_3	3.89	4.01	4.43	1.23	1.22	1.21	0.39	0.44	0.51	93.56	93.78	89.44
C_4	4.05	4.10	4.50	1.22	1.21	1.20	0.96	0.82	1.23	92.22	92.33	87.22
SEm±	0.034	0.015	0.011	0.006	0.006	0.007	0.048	0.031	0.097	0.228	0.162	0.290
CD(P=0.05)	0.040	0.040	0.032	0.001	0.001	0.001	0.140	0.090	0.280	0.670	0.480	0.850
Interaction (PxC)												
P_1C_1	4.17	4.24	4.59	1.20	1.20	1.20	1.82	1.31	1.97	91.33	91.33	85.33
P_1C_2	4.03	4.19	4.51	1.21	1.21	1.20	1.08	1.02	1.03	92.33	92.33	88.00
P_1C_3	4.02	4.08	4.48	1.21	1.22	1.21	0.64	0.69	0.77	92.67	93.00	89.33
P_1C_4	4.14	4.17	4.56	1.20	1.21	1.20	1.59	1.22	1.83	91.66	91.67	86.67
P_2C_1	3.96	3.99	4.42	1.23	1.21	1.21	0.31	0.21	0.42	92.66	93.33	87.33
P_2C_2	3.83	3.90	4.37	1.23	1.22	1.22	0.14	0.10	0.11	94.00	93.66	88.00
P_2C_3	3.79	3.87	4.34	1.24	1.22	1.22	0.07	0.04	0.08	95.00	94.67	89.67
P_2C_4	3.94	3.98	4.39	1.23	1.21	1.21	0.18	0.15	0.27	93.00	93.33	88.00
P_3C_1	4.13	4.18	4.56	1.21	1.20	1.20	1.21	1.15	1.67	92.00	91.67	85.67
P_3C_2	3.96	4.16	4.48	1.21	1.21	1.21	0.98	0.88	0.71	92.66	92.33	88.66
P_3C_3	3.86	4.07	4.73	1.22	1.21	1.21	0.46	0.59	0.69	93.00	93.66	89.33
P_3C_4	4.06	4.15	4.54	1.20	1.21	1.20	1.12	1.08	1.58	92.00	92.00	87.00
G. Mean	3.99	4.08	4.48	1.22	1.21	1.21	0.801	0.704	0.927	92.69	92.75	87.75
SEm±	0.059	0.026	0.019	0.014	0.015	0.002	0.083	0.053	0.168	0.395	0.280	0.503
CD(P=0.05)	0.170	0.080	0.060	0.041	0.041	0.057	0.240	0.160	0.490	1.160	0.820	1.480
CV (%)	2.55	2.10	2.73	2.00	2.22	2.17	10.90	10.10	10.35	4.74	4.52	4.99

Table 5
Effect of Storage Containers, Seed Treatment Chemicals and their Interaction after Twelve Months Storage on Seed Moisture (%), Seed Germination (%) and Seedling Length (cm) of Sunnhemp during *kharif, rabi* 2009 and summer 2010

Treatments	*Seed moisture (%)*			*Seed germination (%)*			*Seedling length (cm)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials (P)									
P_1	9.41	9.57	9.88	81.66	81.58	77.75	15.42	14.22	14.22
P_2	8.06	8.06	8.06	85.50	84.83	82.92	16.65	16.16	16.52
P_3	9.26	9.42	9.78	82.08	82.00	79.08	15.75	14.50	14.73
SEm±	0.011	0.001	0.012	0.179	0.150	0.179	0.103	0.136	0.110
CD(P=0.05)	0.032	0.093	0.030	0.530	0.440	0.530	0.302	0.390	0.320
Seed treatment chemicals (C)									
C_1	8.91	9.02	9.27	81.77	81.11	76.67	15.54	14.38	14.44
C_2	8.90	9.02	9.23	84.00	83.44	78.67	15.65	15.25	15.47
C_3	8.90	9.01	9.19	84.78	84.89	79.66	16.75	15.72	16.25
C_4	8.90	9.02	9.27	81.78	81.79	78.22	15.61	14.50	14.72
SEm±	0.013	0.010	0.010	0.207	0.173	0.207	0.119	0.157	0.127
CD(P=0.05)	0.038	0.030	0.030	0.600	0.500	0.600	0.350	0.460	0.370
Interaction (PxC)									
P_1C_1	9.42	9.57	9.96	80.00	79.33	76.00	15.00	13.66	13.50
P_1C_2	9.41	9.57	9.84	83.00	82.33	78.67	15.66	14.58	14.83
P_1C_3	9.40	9.57	9.77	83.66	84.00	79.66	16.50	14.92	15.50
P_1C_4	9.41	9.57	9.95	80.00	80.67	76.67	15.00	13.75	13.83
P_2C_1	8.06	8.07	8.07	84.66	83.66	81.66	16.08	15.58	16.00
P_2C_2	8.05	8.06	8.06	85.66	85.67	83.00	16.91	16.33	16.50
P_2C_3	8.05	8.06	8.06	86.67	86.33	84.67	17.25	17.00	17.33
P_2C_4	8.06	8.06	8.07	85.00	83.67	82.33	16.33	15.75	16.25
P_3C_1	9.26	9.43	9.80	80.66	80.33	77.00	15.33	13.92	13.83
P_3C_2	9.25	9.41	9.77	83.33	82.33	80.00	16.17	14.83	15.08
P_3C_3	9.26	9.40	9.74	84.00	84.33	81.00	16.42	15.25	15.92
P_3C_4	9.26	9.43	9.80	80.33	81.00	78.33	15.08	14.00	14.08
G. Mean	8.91	90.02	9.24	83.08	82.81	79.92	15.98	14.96	15.22
SEm±	0.022	0.018	0.023	0.359	0.300	0.359	0.207	0.272	0.220
CD(P=0.05)	0.060	0.050	0.067	1.052	0.880	1.052	0.600	0.790	0.640
CV (%)	3.43	3.34	3.43	3.75	3.63	3.78	3.24	3.15	3.51

Table 6
Effect of Storage Containers, Seed Treatment Chemicals and their Interaction after Twelve Months Storage on Electricalconductivity (dSm^{-1}), Total Dehydrogenase Activity (OD value) and Seed Health (%) of Sunnhemp during *kharif, rabi* 2009 and Summer 2010

Treatments	*Electrical conductivity (dSm^{-1})*			*Total dehydrogenase activity (OD value)*			*Seed health (%)*			*Field emergence (%)*		
	Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*
Packaging materials (P)												
P_1	5.61	5.78	6.09	1.15	1.14	1.12	6.44	6.94	7.08	77.08	77.16	75.83
P_2	5.20	5.45	5.41	1.19	1.16	1.14	2.03	2.72	2.79	82.17	82.33	80.50
P_3	5.56	5.73	6.01	1.15	1.14	1.13	6.31	6.47	6.59	77.50	77.83	76.50
SEm±	0.027	0.007	0.020	0.001	0.001	0.001	0.096	0.075	0.094	0.195	0.194	0.204
CD(P=0.05)	0.079	0.020	0.058	0.003	0.003	0.003	0.281	0.210	0.275	0.570	0.560	0.598
Seed treatment chemicals (C)												
C_1	5.55	5.72	5.99	1.15	1.14	1.13	6.65	7.19	7.83	77.11	76.77	75.11
C_2	5.47	6.64	5.77	1.17	1.15	1.13	4.26	4.74	4.80	80.11	80.44	78.67
C_3	5.31	5.58	5.69	1.17	1.16	1.14	2.52	2.56	2.59	81.00	81.55	80.44
C_4	5.51	5.69	5.89	1.16	1.14	1.13	6.29	6.43	6.72	77.44	77.67	76.22
SEm±	0.031	0.008	0.023	0.001	0.001	0.001	0.111	0.087	0.108	0.225	0.224	0.235
CD(P=0.05)	0.090	0.020	0.067	0.003	0.003	0.003	0.330	0.250	0.316	0.650	0.600	0.690
Interaction (PxC)												
P_1C_1	5.73	5.88	6.25	1.14	1.13	1.12	8.69	9.92	9.91	75.33	75.00	72.66
P_1C_2	5.61	5.75	6.02	1.15	1.14	1.13	5.78	6.57	6.07	78.00	78.33	77.00
P_1C_3	5.46	5.68	5.96	1.16	1.15	1.13	3.23	3.08	3.57	79.33	79.67	79.33
P_1C_4	5.66	5.81	6.13	1.14	1.13	1.12	8.07	8.19	8.76	75.67	75.66	74.33
P_2C_1	5.27	5.48	5.54	1.18	1.15	1.14	2.75	2.81	3.80	80.33	80.00	79.00
P_2C_2	5.19	5.45	5.35	1.19	1.16	1.14	1.49	1.98	2.37	83.33	83.33	81.33
P_2C_3	5.11	5.40	5.29	1.20	1.18	1.15	1.32	1.51	2.01	84.33	85.00	82.33
P_2C_4	5.24	5.47	5.48	1.18	1.15	1.14	2.56	2.79	2.97	80.66	81.00	79.33
P_3C_1	5.65	5.79	6.19	1.14	1.14	1.12	8.52	8.86	9.78	75.67	75.33	73.67
P_3C_2	5.59	5.71	5.95	1.15	1.15	1.13	5.51	5.65	5.97	79.00	79.66	77.66
P_3C_3	5.37	5.65	5.84	1.16	1.15	1.13	3.01	3.08	2.19	79.33	80.00	79.67
P_3C_4	5.62	5.78	6.06	1.14	1.14	1.13	8.24	8.30	8.43	76.00	76.33	75.00
G. Mean	5.46	5.66	5.84	1.16	1.15	1.13	4.93	5.23	5.47	78.92	79.11	77.61
SEm±	0.054	0.015	0.039	0.002	0.002	0.002	0.193	0.150	0.187	0.389	0.388	0.407
CD(P=0.05)	0.150	0.040	0.114	0.006	0.006	0.006	0.560	0.430	0.548	1.140	1.138	1.193
CV (%)	4.73	4.45	4.16	3.26	3.35	3.22	9.76	10.98	9.92	4.85	4.85	4.91

germination, seedling vigour, seed deterioration and loss of seed viability over a period of storage.

Influence of Seed Treatment Chemicals on Seed Quality Parameters during Storage

Seed treatment with suitable chemical would give alternate protection to the seeds in storage against infection and infestation. The efficiency of fungicide / insecticide as seed protectant mainly depends upon application of minimum effective concentration which controls the diseases before it causes deterioration to seed. It is better to use safer fungicide / insecticide to maintain germination and seedling vigour in many crops.

The seed moisture fluctuation was less among the seed treatment chemicals at the end of storage period in all the three seasons. However, the highest moisture was recorded in control (C_1) (8.91, 9.02 and 9.27 %) compared to C_3 (8.90, 9.01 and 9.19 %) in *kharif*, *rabi* 2009 and summer 2010, respectively (Table 7). This may be due to the fact that when the seeds treated with chemicals it cover the pores in the seed coat and prevents the entry of both moisture as well as insect infestation and provide protection from physical damage which can occur during handling and storage (West *et.al.*, 1985). These results are also in accordance with the findings of Vakkur and Hiremath (2012) in soybean.

At the end of twelve months storage period, the highest germination (84.7, 83.8 and 79.6%), seedling length (16.75, 15.72 and 16.25 cm), field emergence (81.00, 81.55 and 80.44%) and TDH (1.17, 1.16 and 1.14 OD value) were recorded in C_3 (Malathion @ 2.5 g/ kg of seed) compared to other treatments during *kharif*, *rabi* 2009 and summer 2010, respectively (Table 7, 8 and 9). The decline in seedling length and other seed quality parameters may be attributed to age induced decline in germination, the damage caused by decline in viability and also production of toxic metabolites which hinder the seedling growth ultimately increase of abnormal seedlings over a storage period. These findings are in agreement with results obtained by Paul *et.al.* (1996) in mungbean.

EC is one of the biochemical characters assessed for seed deterioration. It was noticed in the present investigation that, among different chemicals, the malathion treated @ 2.5 g/ kg of seed (C_3) seeds recorded (5.31, 5.58 and 5.69 dSm^{-1}) the lowest EC in the seeds produced during *kharif*, *rabi* 2009 and summer 2010, respectively. However, the seed health was maintained maximum in C_3 (2.52, 2.56 and 2.59%) as compared to rest of the treatments. This variation could be due to membrane degradation, damaged by insects, many substances and leakage of electrolytes over a period of time. Similar findings were obtained by Maurya *et.al.* (2002) in soybean.

The interaction of packaging materials and seed treatment chemicals differed significantly at the end of twelve months of storage in all the three seasons. The highest germination (86.6, 86.3 and 84.6%), seedling length (17.25, 17.00 and 17.33 cm), field emergence (84.33, 85.00 and 82.33%) and TDH (1.20, 1.18 and 1.15 OD value) were recorded in P_2C_3 (polyethylene bag (700gauge) and malathion @ 2.5 g/kg of seed) compared to all other treatment combinations in the seeds produced during *kharif*, *rabi* 2009 and summer 2010, respectively (Table 7, 8 and 9). Similar findings were reported by Indira *et. al.* (2000) fenugreek, Vijayakumar *et.al.* (2007) in cotton and Vakkur and Hiremath (2012) in soybean.

At the end of twelve months storage period, the interactions between packaging materials and chemicals were found significant effect on EC and seed health for the seeds produced in all the three seasons. The seeds packed in polyethylene (700 gauge) bag and treated with malathion @ 2.5 g/ kg of seed recorded lowest EC (5.11, 5.40 and 5.29 dSm^{-1}) and seed infection (1.32, 1.51 and 2.01 %) compared to all other treatment combinations for the *kharif*, *rabi* 2009 and summer 2010, produced seeds respectively at the end of twelve months of storage. Similar findings were also reported by Abdul – Baki and Anderson (1972), Maurya *et.al.* (2002) and Vamadevappa (1998) in soybean and Channabasanagowda *et.al.* (2008) in pulses.

CONCLUSION

It can be concluded that Sunnhemp seeds stored in polyethylene bag and treated with malathion @ 2.5 g/kg of seed found better and also with moisture of around 9 per cent in cloth bag could be stored under ambient conditions per a period of more than twelve months to maintain Minimum Seed Certification Standard (75%) of germination.

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