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Storage Potential Evaluation of Proso Millet *(Panicum miliaceum L.)* Seeds

K.P. Ragupathi[1*], K. Sujatha[2] and V. Paramasivam[3]

[1]*Ph.D Scholar, Tamil Nadu Agricultural University*
[2,3]*Professor, Tamil Nadu Agricultural University*
E-mail: [1]seedragu@gmail.com

Abstract—*Proso millet is an important minor millet grown in India. Maintenance of germination and vigour at higher level during storage is very essential. Botanicals were found to be safe and suitable for long term seed storages. So, the study was conducted to investigate the influence of botanicals on Proso millet seed storage. The seeds obtained from field experiment were cleaned and graded using BSS 12×12 sieve and dried to moisture content of twelve per cent was used for storage studies. The graded seeds were treated with botanicals viz., Vitex negundo, Lippia nodiflora, Lantana camara, Clerodendron inerme and Azadirachta indica and stored in both cloth bag and polypropylene bag containers for a period of twelve months. The seed quality parameters (germination, seedling length, vigour index, dry matter production, moisture content) and biochemical parameters of seed leachate (protein content, EC, sugar, amino acid, dehydrogenase activity) were evaluated at bimonthly intervals. Among the different botanicals, seeds treated with Azadirachta indica and stored in polypropylene bag performed better in all seed quality and biochemical parameters.*

1. INTRODUCTION

Minor millets are claimed to be the future foods for better health and nutrition security. Millets are important cereals which play a significant role in the food and nutritional security of developing countries in the semi-arid tropics of Asia, Africa. Thrust to grow millets is given due to their nutritional superiority as compared to the major cereals. Proso millet is important minor millet grown in India. The present study mainly focussed to identify the effect of storage potential in proso millet. Seed ageing is known to cause appreciable changes in viability, producing large number of changes in qualitative and quantitative characters and can be used on large scale with simple equipment for inducing variability [1]. Accelerated aging is an excellent predictor of seed storability. Natural ageing of seeds will also help in proper planning of storage or sowing.

2. MATERIALS AND METHODS

The field and laboratory experiments were conducted at Tamil Nadu Agricultural University, Tamil Nadu, India. The seeds of proso millet cv. CO (PV) 5 obtained from field experiment were cleaned and graded using BSS 12×12 sieve and dried to moisture content of twelve per cent and used for storage studies. The graded seeds of proso millet treated with leaf powders of *Vitex negundo* (T_2), *Lippia nodiflora* (T_3), *Lantana camara* (T_4), *Clerodendron inerme* (T_5), *Azadirachta indica* (T_6) at the concentration of 100g/kg of seed and Control (T_1) under aerated condition at room temperature (26 ± 1^0C). The treated seeds were dried under shade and then stored in cloth bag (C_1) and poly propylene bag (C_2) for twelve months under ambient conditions. The stored seeds were evaluated at bimonthly intervals for assessing the following seed quality and biochemical parameters. The tests were conducted by adopting the following methods Germination test [2], Seedling vigour index [3], Seed moisture content [4], Electrical conductivity [5], Dehydrogenase activity [6], Leachate amino acid [7], Leachate sugars [8], Protein content [9] and the data obtained were analysed using methods described by [10].

3. RESULTS

3.1. Germination (%)

In general there was a decline in the germination percentage with increa se in storage periods. Among the treatments, seeds treated with neem leaf powder (T_6) recorded higher germination (91 %) and control (T_1) seeds had minimum germination (85 %). Between containers, seed stored in polypropylene bags maintained the germination of 89 per cent when compared to the seed stored in cloth bag (88 %). (Table 1)

3.2. Dry matter production (g seedlings^{-10})

The dry matter production was higher in polypropylene bag (0.048 g seedlings^{-10}) than cloth bag (0.046 g seedlings^{-10}) irrespective of containers and periods of storage. The dry matter production was more in neem leaf powder treated seeds (0.053 g seedlings^{-10}) followed by notchi leaf powder (0.051 g seedlings^{-10}). The control recorded minimum dry weight (0.040 g seedlings^{-10}). The reduction in dry matter production over the period of storage was minimal. Within the periods the dry matter production reduced from 0 to 12 months of storage irrespective of containers and seed treatments (0.056 to 0.037 g seedlings^{-10}). (Table 2)

3.3. Vigour index

Among the seed treatments neem leaf powder treated seeds recorded the maximum vigour index (2168), which was followed by notchi leaf powder (2095). However, the minimum vigour index was observed with control (1791). Among the containers polypropylene bags showed maximum vigour index (2022) of followed by cloth bag (1937). The vigour index of (2494) was recorded at the time of storage was found to decreased to (1479) at 12 months of storage. (Table 3)

3.4. Seed moisture content (%)

Among the seed treatments neem leaf powder treated seeds recorded the minimum moisture content (12.6 %) followed by notchi and lippia leaf powder (12.7 %). The higher moisture content was observed with control (13.2 %). Between containers, seeds stored in polypropylene bags showed minimum increase in moisture content (12.8 %) when compared to seeds stored in cloth bag (12.9 %). As the storage period increased from 0 to 12 months, the moisture content also increased from 12.4 to 13.3 %. (Figure 1)

3.5. Electrical conductivity (dSm^{-1})

Electrical conductivity was significantly influenced by botanical seed treatments, containers, periods of storage and their interactions. Among the treatments, neem leaf powder recorded the lowest electrical conductivity (0.106 dSm^{-1}) compared to other treatments. Between the containers, seeds stored in polypropylene bags maintained the electrical conductivity at lower level (0.133 dSm^{-1}) than cloth bag (0.139 dSm^{-1}). As the storage period advanced from 0 to 12 months, the electrical conductivity also increased linearly from 0.094 to 0.175 dSm^{-1}. (Table 4)

3.6. Dehydrogenase activity (OD)

Data on dehydrogenase activity showed significant due to botanical seed treatments, containers, periods of storage. Between the containers, seed stored in polypropylene bag maintained higher dehydrogenase activity (0.041) than cloth bag (0.040). Dehydrogenase activity declined from 0.054 to 0.027 as the storage period increased from 0 to 12 months. Among the seed treatments notchi leaf powder treated seeds maintained higher dehydrogenase activity (0.048), which was followed by neem leaf powder (0.045). However, the lower dehydrogenase activity (0.033) was observed with control. (Table 5)

3.7. Leachate amino acid (μg g^{-1})

The leachate amino acids had an escalating trend at all periods of storage. The rate of increase was more in control (0.033 μg g^{-1}) as compared to neem leaf powder treatment which was recorded lower values (0.018 μg g^{-1}). Polypropylene bag was very effective (0.025 μg g^{-1}) compared to cloth bag (0.026 μg g^{-1}). After 12 months of storage the leachate amino acids was less in neem leaf powder treated seeds which stored better in polypropylene bag (0.023 μg g^{-1}) compared to control (0.053 μg g^{-1}). (Table 6)

3.8. Leachate sugars (μg g^{-1})

Leachate sugars had an increasing trend at periods of storage. Between the treatments, neem leaf powder treated seeds recorded the lowest leachate sugar content (0.092 μg g^{-1}) when compared to other treatments. Among the containers, seeds stored in polypropylene bags maintained lower level leachate sugar (0.100 μg g^{-1}) than cloth bag (0.101 μg g^{-1}). As the storage period increased from initial to 12 months, the leachate sugar content also increased from 0.086 to 0.114 μg g^{-1} irrespective of the containers and seed treatments. (Table 7)

3.9. Protein content (%)

Significant differences were observed in protein content due to botanical seed treatments, containers, periods of storage and their interactions. Among the seed treatments neem leaf powder treated seeds recorded the maximum protein content (12.20 %) followed by lippia leaf powder treated seeds (11.90 %). However the minimum protein content was observed in control (10.70 %). As the storage period increased from 0 to 12 months, the protein content declined from 12.54 to 10.39 % irrespective of containers and seed treatments. Among the containers polypropylene bags showed maximum protein content of 11.49 % followed by cloth bag 11.40 %. (Figure 2)

4. DISCUSSION

Seed storage is an essential segment of seed industry. As the seed is hygroscopic in nature, seed quality deterioration during storage is mainly attributed to periods of storage, chemical composition, seed moisture content, seed treatment and storage containers [11]. Maintenance of germination and vigour at higher level during storage period is most important, in carryover of seed to next generation.

Table 1. Influence of seed treatment, storage containers and period of storage on germination (%) in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	96 (78.47)	93 (74.66)	89 (70.63)	84 (66.42)	80 (63.44)	76 (60.67)	70 (56.80)	**84 (66.42)**	96 (78.47)	94 (75.82)	90 (71.57)	86 (68.03)	83 (65.65)	79 (62.73)	74 (59.35)	**86 (68.03)**	**85 (67.22)**
T_2	96 (78.47)	94 (75.82)	91 (71.55)	90 (71.57)	87 (68.87)	85 (67.22)	82 (64.90)	**89 (70.63)**	96 (78.47)	95 (77.08)	93 (74.66)	91 (71.55)	88 (69.73)	86 (68.03)	84 (66.42)	**90 (71.57)**	**90 (71.57)**
T_3	96 (78.47)	94 (75.82)	91 (71.55)	89 (70.63)	86 (68.03)	83 (65.65)	81 (64.16)	**89 (70.63)**	96 (78.47)	95 (77.08)	92 (73.57)	90 (71.57)	87 (68.87)	85 (67.22)	82 (64.90)	**90 (71.57)**	**89 (70.63)**
T_4	96 (78.47)	94 (75.82)	91 (71.55)	88 (69.73)	85 (67.22)	83 (65.65)	79 (62.73)	**88 (69.73)**	96 (78.47)	94 (75.82)	91 (71.55)	89 (70.63	86 (68.03)	84 (66.42)	80 (63.44)	**89 (70.63)**	**88 (69.73)**
T_5	96 (78.47)	94 (75.82)	90 (71.57)	87 (68.87)	84 (66.42)	82 (64.90)	78 (62.03)	**87 (68.87)**	96 (78.47)	94 (75.82)	91 (71.55)	88 (69.73)	85 (67.22)	83 (65.65)	79 (62.73)	**88 (69.73)**	**88 (69.73)**
T_6	96 (78.47)	94 (75.82)	92 (73.57)	90 (71.57)	88 (69.73)	86 (68.03)	84 (66.42)	**90 (71.57)**	96 (78.47)	95 (77.08)	93 (74.66)	92 (73.57)	89 (70.63)	87 (68.87)	86 (68.03)	**91 (71.55)**	**91 (71.55)**
Mean	**96 (78.47)**	**94 (75.82)**	**91 (71.55)**	**88 (69.73)**	**85 (67.22)**	**83 (65.65)**	**79 (62.73)**	**88 (69.73)**	**96 (78.47)**	**95 (77.08)**	**92 (73.57)**	**89 (70.63)**	**86 (68.03)**	**84 (66.42)**	**81 (64.16)**	**89 (70.63)**	**89 (70.63)**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	96 (78.47)	94 (75.82)	91 (71.55)	89 (70.63)	86 (68.03)	83 (65.65)	80 (63.44)	**89 (70.63)**

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.51	0.55	0.30	1.36	0.73	0.78	1.92
CD (P = 0.05)	1.01**	1.10**	0.59**	NS	NS	NS	NS

(Values in parentheses indicate arcsine transformed values); (** - Highly significant at 5% level); (NS – Non Significant at 5% level); C- Containers; P- Storage period in months; T- Treatments

T_1 Control
T_2 *Vitex negundo* leaf powder @ 100g Kg^{-1} of seed
T_3 *Lippia nodiflora* leaf powder @ 100g Kg^{-1} of seed
T_4 *Lantana camara* leaf powder @ 100g Kg^{-1} of seed
T_5 *Clerodendron inerme* leaf powder @ 100g Kg^{-1} of seed
T_6 *Azadirachta indica* leaf powder @ 100g Kg^{-1} of seed

Table 2. Influence of seed treatment, storage containers and period of storage on dry matter production (g $seedlings^{-10}$) in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	0.056	0.050	0.044	0.038	0.032	0.026	0.020	**0.038**	0.056	0.051	0.050	0.044	0.038	0.032	0.026	**0.042**	**0.040**
T_2	0.056	0.054	0.052	0.050	0.048	0.046	0.044	**0.050**	0.056	0.055	0.054	0.052	0.050	0.048	0.046	**0.052**	**0.051**
T_3	0.056	0.053	0.050	0.047	0.044	0.041	0.038	**0.047**	0.056	0.054	0.053	0.050	0.047	0.044	0.041	**0.049**	**0.048**
T_4	0.056	0.052	0.048	0.044	0.040	0.036	0.032	**0.044**	0.056	0.053	0.052	0.048	0.044	0.040	0.036	**0.047**	**0.046**
T_5	0.056	0.051	0.046	0.041	0.036	0.031	0.026	**0.041**	0.056	0.052	0.051	0.046	0.041	0.036	0.031	**0.045**	**0.043**
T_6	0.056	0.055	0.054	0.053	0.052	0.051	0.050	**0.053**	0.056	0.056	0.055	0.054	0.053	0.052	0.051	**0.054**	**0.053**
Mean	**0.056**	**0.053**	**0.049**	**0.046**	**0.042**	**0.039**	**0.035**	**0.046**	**0.056**	**0.054**	**0.053**	**0.049**	**0.046**	**0.042**	**0.039**	**0.048**	**0.047**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	0.056	0.053	0.051	0.047	0.044	0.040	0.037	**0.047**

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.0003	0.0003	0.0002	0.0007	0.0004	0.0004	0.0010
CD (P = 0.05)	0.0005**	0.0006**	0.0003**	0.0013**	0.0007**	0.0008**	NS

(Other details same as in table 1)

Table 3. Influence of seed treatment, storage containers and period of storage on vigour index in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	2494	2294	1969	1629	1456	1290	1072	**1743**	2494	2341	2075	1799	1596	1365	1200	**1839**	**1791**
T_2	2494	2405	2172	2019	1906	1731	1622	**2050**	2494	2445	2322	2124	2008	1868	1714	**2139**	**2095**
T_3	2494	2390	2114	1943	1735	1596	1494	**1967**	2494	2423	2283	2054	1860	1769	1568	**2064**	**2016**
T_4	2494	2365	2091	1788	1677	1570	1360	**1906**	2494	2370	2145	1895	1736	1675	1478	**1970**	**1938**
T_5	2494	2340	2012	1716	1580	1410	1292	**1835**	2494	2353	2122	1833	1653	1515	1362	**1905**	**1870**
T_6	2494	2412	2232	2156	1960	1850	1748	**2122**	2494	2461	2365	2260	2101	1986	1837	**2215**	**2168**
Mean	**2494**	**2368**	**2098**	**1875**	**1719**	**1575**	**1431**	**1937**	**2494**	**2399**	**2219**	**1994**	**1826**	**1696**	**1527**	**2022**	**1980**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	2494	2383	2159	1935	1772	1635	1479	**1980**

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	12.31	13.29	7.11	32.56	16.01	18.80	39.23
CD (P = 0.05)	24.30**	26.25**	14.03**	64.29**	NS	37.12**	NS

(Other details same as in table 1)

Table 4. Influence of seed treatment, storage containers and period of storage on electrical conductivity (dSm⁻¹) in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	0.094	0.129	0.152	0.175	0.198	0.221	0.244	**0.173**	0.094	0.117	0.140	0.163	0.186	0.209	0.232	**0.163**	**0.168**
T_2	0.094	0.107	0.114	0.121	0.128	0.135	0.142	**0.120**	0.094	0.101	0.108	0.115	0.122	0.129	0.136	**0.115**	**0.118**
T_3	0.094	0.112	0.123	0.134	0.145	0.156	0.167	**0.133**	0.094	0.105	0.116	0.127	0.138	0.149	0.160	**0.127**	**0.130**
T_4	0.094	0.116	0.130	0.144	0.158	0.172	0.186	**0.143**	0.094	0.108	0.122	0.136	0.150	0.164	0.178	**0.136**	**0.139**
T_5	0.094	0.122	0.141	0.16	0.179	0.198	0.217	**0.159**	0.094	0.113	0.132	0.151	0.170	0.189	0.208	**0.151**	**0.155**
T_6	0.094	0.103	0.106	0.109	0.112	0.115	0.118	**0.108**	0.094	0.097	0.100	0.103	0.106	0.109	0.112	**0.103**	**0.106**
Mean	**0.094**	**0.115**	**0.128**	**0.141**	**0.153**	**0.166**	**0.179**	**0.139**	**0.094**	**0.107**	**0.120**	**0.133**	**0.145**	**0.158**	**0.171**	**0.133**	**0.136**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	0.094	0.111	0.124	0.137	0.149	0.162	0.175	**0.136**

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.0009	0.0009	0.0005	0.002	0.001	0.001	0.003
CD (P = 0.05)	0.0017**	0.0018**	0.0010**	0.004**	0.002**	0.003**	NS

(Other details same as in table 1)

Table 5. Influence of seed treatment, storage containers and period of storage on dehydrogenase activity (OD) in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	0.054	0.046	0.039	0.032	0.025	0.018	0.011	**0.032**	0.054	0.047	0.040	0.033	0.026	0.019	0.012	**0.033**	**0.033**
T_2	0.054	0.051	0.049	0.047	0.045	0.043	0.041	**0.047**	0.054	0.052	0.050	0.048	0.046	0.044	0.042	**0.048**	**0.048**
T_3	0.054	0.049	0.045	0.041	0.037	0.033	0.029	**0.041**	0.054	0.050	0.046	0.042	0.038	0.034	0.030	**0.042**	**0.042**
T_4	0.054	0.048	0.043	0.038	0.033	0.028	0.023	**0.038**	0.054	0.049	0.044	0.039	0.034	0.029	0.024	**0.039**	**0.039**
T_5	0.054	0.047	0.041	0.035	0.029	0.023	0.017	**0.035**	0.054	0.048	0.042	0.036	0.030	0.024	0.018	**0.036**	**0.036**
T_6	0.054	0.050	0.047	0.044	0.041	0.038	0.035	**0.044**	0.054	0.051	0.048	0.045	0.042	0.039	0.036	**0.045**	**0.045**
Mean	**0.054**	**0.049**	**0.044**	**0.040**	**0.035**	**0.031**	**0.026**	**0.040**	**0.054**	**0.050**	**0.045**	**0.041**	**0.036**	**0.032**	**0.027**	**0.041**	**0.040**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	0.054	0.049	0.045	0.040	0.036	0.031	0.027	**0.040**

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.0002	0.0003	0.0001	0.0006	0.0003	0.0004	0.0008
CD (P = 0.05)	0.0005**	0.0005**	0.0003**	0.0012**	NS	NS	NS

(Other details same as in table 1)

Table 6. Influence of seed treatment, storage containers and period of storage on amino acids (µg g^{-1}) in Proso millet cv. CO (PV) 5

T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	0.012	0.019	0.026	0.033	0.040	0.047	0.054	**0.033**	0.012	0.018	0.025	0.032	0.039	0.046	0.053	**0.032**	**0.033**
T_2	0.012	0.015	0.018	0.021	0.024	0.027	0.030	**0.021**	0.012	0.014	0.017	0.020	0.023	0.026	0.029	**0.020**	**0.021**
T_3	0.012	0.016	0.020	0.024	0.028	0.032	0.036	**0.024**	0.012	0.015	0.019	0.023	0.027	0.031	0.035	**0.023**	**0.024**
T_4	0.012	0.017	0.022	0.027	0.032	0.037	0.042	**0.027**	0.012	0.016	0.021	0.026	0.031	0.036	0.041	**0.026**	**0.027**
T_5	0.012	0.018	0.024	0.030	0.036	0.042	0.048	**0.030**	0.012	0.017	0.023	0.029	0.035	0.041	0.047	**0.029**	**0.030**
T_6	0.012	0.014	0.016	0.018	0.020	0.022	0.024	**0.018**	0.012	0.013	0.015	0.017	0.019	0.021	0.023	**0.017**	**0.018**
Mean	**0.012**	**0.017**	**0.021**	**0.026**	**0.030**	**0.035**	**0.039**	**0.026**	**0.012**	**0.016**	**0.020**	**0.025**	**0.029**	**0.034**	**0.038**	**0.025**	**0.025**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	0.012	0.016	0.021	0.025	0.030	0.034	0.039	0.025

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.0002	0.0002	0.0001	0.0005	0.0003	0.0003	0.0006
CD (P = 0.05)	0.0003**	0.0004**	0.0002**	0.0009**	NS	0.0005**	NS

(Other details same as in table 1)

Table 7. Influence of seed treatment, storage containers and period of storage on leachate sugars (µg g^{-1}) in Proso millet cv. CO (PV) 5

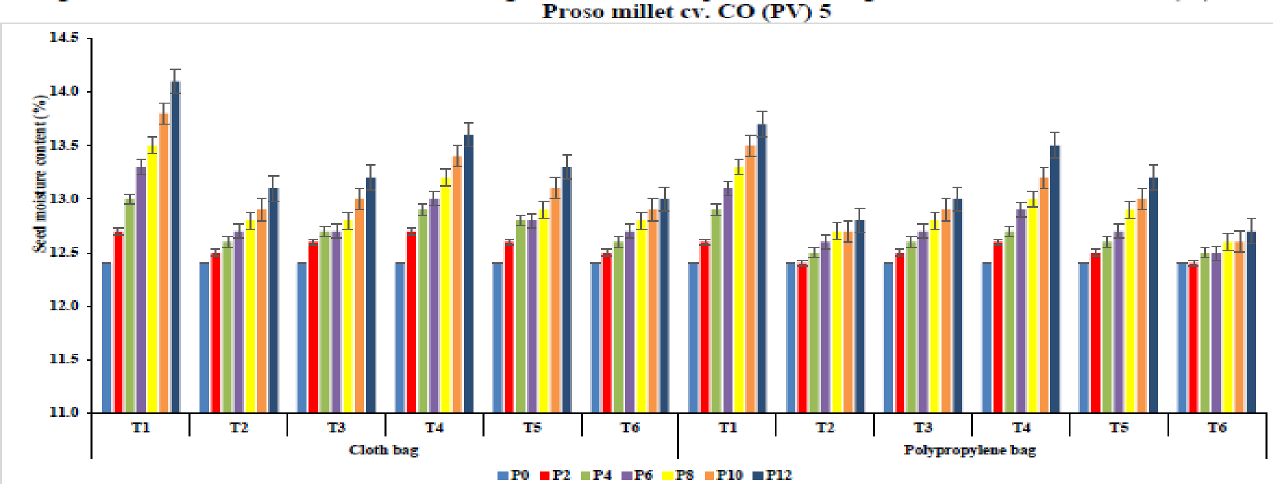
T	Containers (C) and Storage period in months (P)																Grand Mean
	Cloth bag (C_1)								Polypropylene bag (C_2)								
	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Mean	
T_1	0.086	0.094	0.101	0.108	0.115	0.122	0.129	**0.108**	0.086	0.093	0.100	0.107	0.114	0.121	0.128	**0.107**	**0.107**
T_2	0.086	0.090	0.093	0.096	0.099	0.102	0.105	**0.096**	0.086	0.089	0.092	0.095	0.098	0.101	0.104	**0.095**	**0.095**
T_3	0.086	0.093	0.099	0.105	0.111	0.117	0.123	**0.105**	0.086	0.092	0.098	0.104	0.110	0.116	0.122	**0.104**	**0.104**
T_4	0.086	0.092	0.097	0.102	0.107	0.112	0.117	**0.102**	0.086	0.091	0.096	0.101	0.106	0.111	0.116	**0.101**	**0.101**
T_5	0.086	0.091	0.095	0.099	0.103	0.107	0.111	**0.099**	0.086	0.090	0.094	0.098	0.102	0.106	0.110	**0.098**	**0.098**
T_6	0.086	0.089	0.091	0.093	0.095	0.097	0.099	**0.093**	0.086	0.088	0.090	0.092	0.094	0.096	0.098	**0.092**	**0.092**
Mean	**0.086**	**0.092**	**0.096**	**0.101**	**0.105**	**0.110**	**0.114**	**0.101**	**0.086**	**0.091**	**0.095**	**0.100**	**0.104**	**0.109**	**0.113**	**0.100**	**0.100**

Storage period (P)	P_0	P_2	P_4	P_6	P_8	P_{10}	P_{12}	Grand Mean
Mean	0.086	0.091	0.096	0.100	0.105	0.109	0.114	0.100

	T	P	C	T x P	T x C	P x C	T x P x C
SEd	0.0006	0.0006	0.0003	0.002	0.0009	0.0010	0.0018
CD (P = 0.05)	0.0011**	0.0012**	0.0006**	0.003**	NS	NS	NS

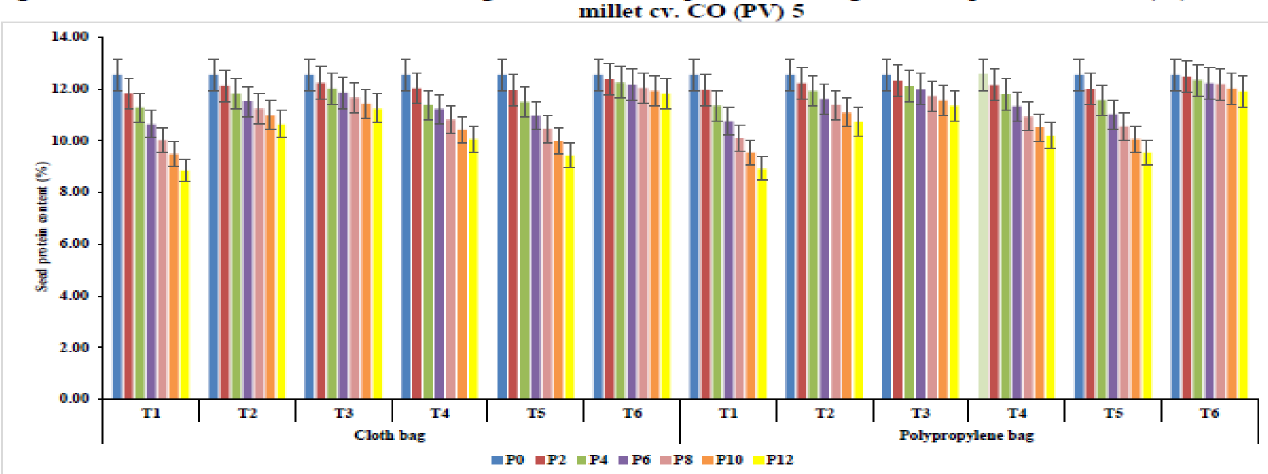
(Other details same as in table 1)

Figure 1. Influence of seed treatment, storage containers and period of storage on seed moisture content (%) in Proso millet cv. CO (PV) 5



T1 - Control
T2 – *Vitex negundo* leaf powder
T3 - *Lippia nodiflora* leaf powder
T4 – *Lantana camara* leaf powder
T5 – *Clerodendron inerme* leaf powder
T6 – *Azadirachta indica* leaf powder
T – Treatment
P – Period of Storage

Figure 2. Influence of seed treatment, storage containers and period of storage on seed protein content (%) in Proso millet cv. CO (PV) 5



T1 - Control
T2 – *Vitex negundo* leaf powder
T3 - *Lippia nodiflora* leaf powder
T4 – *Lantana camara* leaf powder
T5 – *Clerodendron inerme* leaf powder
T6 – *Azadirachta indica* leaf powder
T – Treatment
P – Period of Storage

Since agriculture is season bound, the storage of seed has become inevitable for farmers, seed producers, breeders and seed businessman. The loss of seed viability due to seed deterioration is inexorable, irreversible and inevitable but the rate of deterioration could be slow down to a greater extent during storage by manipulating storage conditions or by imposing certain seed treatments before storage. With the advancement in the storage period, irrespective of seed source, all the seed quality parameters were gradually decreased. Germination decreases with increase in ageing period, as seen by [12] in wheat, [13] in maize due to natural ageing. Generally, seeds stored in moisture impervious sealed containers store better compared to moisture pervious containers under ambient storage conditions. Similar results were observed by [14].

Deterioration of physiological quality of seeds during storage is mainly attributed to storage containers [15] and seed treatments. Further, higher germination noticed with seed stored in polypropylene bag may be related to lesser microbial activity and lesser seed infestation. The results are in analogous with the earlier reports of [16] in garden pea. The extent of decrease of seed quality parameters was more in seeds stored in cloth bag compared to polypropylene bag. Similar results were obtained by [17] in chilli, [18] in soybean, [19] in daincha. Among the seed treatments, neem leaf powder of seeds recorded higher germination percentage of and viguor index when compared to other treatments. Similar results were also reported by [20] in cowpea, [21] in wheat seeds. Neem leaf powder also enhanced better seedling vigour index maintenance throughout the storage time and this is line with the works of [22] and [21] in wheat seeds.

The beneficial role of botanicals in controlling seed deterioration was claimed to be due to ascorbic acid content having antioxidant properties that reduced lipid auto oxidation and peroxidation and contents of reducing sugars, beside insect repellent property of neem leaf powder [23]. The storage potential of seed is gradually affected by seed moisture content during storage. At higher moisture content seed deterioration occurs more rapidly owing to more invasion of fungi, increased activity of storage pest, higher metabolic and enzymic activity. The electrical conductance of the seed leachate is considered as a good indicator of deterioration and is likely to be caused due to the breakdown of the lipoprotein membrane structure [24]. Electrical conductivity of seed leachate increased gradually over period of storage irrespective of seed treatments and containers due to loss of membrane integrity [25] and the increase was slow with neem leaf powder treated seeds stored in polypropylene bags. The EC values in the present study were found to be more in seed stored in cloth bag than in polypropylene bag in all the months of storage. Protein content of the seeds decreased with increase in periods of storage irrespective of treatments and containers due to degradation of protein by proteases and denaturation [26].

Considering the work focused on the plant products in recent days, leaf powder of neem will be a better alternative to the chemical seed protectants and can be very effectively used in eco-friendly manner with a dose of 100 g/kg of seeds as a low cost technology.

5. CONCLUSION

Proso millet seeds treated with neem leaf powder (100g/kg of seeds) and stored in polypropylene bag recorded higher seed quality and biochemical parameters even after 12 months of storage.

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