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Manish Kumar Yadav
Ph.D. Scholar, Department of Entomology, Rajendra Prasad Central Agricultural University Pusa Samastipur Bihar, India

Ram Kumar
Ph.D. Scholar, Department of Entomology, Rajendra Prasad Central Agricultural University Pusa Samastipur Bihar, India

Ravendra Sahu
MSc. (Ag) Department of Seed Science and Technology, Narendra Deva University Kumarganj Faizabad, Uttar Pradesh, India

RB Singh
Associate Professor, Department of Entomology, Narendra Deva University Kumarganj Faizabad, Uttar Pradesh, India

Correspondence
Manish Kumar Yadav
Ph.D. Scholar, Department of Entomology, Rajendra Prasad Central Agricultural University Pusa Samastipur Bihar, India

Standardization of seed protectants for improving the seed quality of pigeonpea (*Cajanus cajan* L.) seed under the ambient storage

Manish Kumar Yadav, Ram Kumar, Ravendra Sahu and RB Singh

Abstract
Seven seed protectants *viz.*, Emamectin benzoate (Proclaim 5SG) @2ppm (40.0 mg kg^{-1} seed), Deltamethrin 2.8 EC @1ppm (0.04 ml kg^{-1} seed), Tantani (*Lantana camara*) leaf powder @10mg kg^{-1} seed, Nirgundi (*Vitex negundo*) leaf powder @10g kg^{-1} seed, Citronella oil @5ml kg^{-1} seed), Sweet flag (*Acrous Calamus*) 10ml kg^{-1} seed, Neem (*Azadiractica indica*) 10g kg^{-1} seed were assessed for their effectiveness in which the minimum per cent damage and weight loss were observed when the seed treated with Emamectin benzoate 5SG@40.0 mg kg $^{-1}$ followed by Deltamethrin 2.8 EC @0.04 ml kg $^{-1}$ upto 9 months of storage under ambient condition. Germination percent was found significantly above the IMSCS level up to 9 months of storage when seed was treated with Emamectin benzoate 5SG@40.0 g kg^{-1} seed followed by Deltamethrin @0.04ml kg^{-1} seed. Percent seed moisture was depending on nature of seed protectants and storage environment. Seed vigour index was found significantly higher up to 9 months of storage when seed was treated with Emamectin benzoate 5SG@40.0 mg kg $^{-1}$ followed by Deltamethrin @0.04ml kg^{-1} seed.

Keywords: seed, germination, seed quality, storage

Introduction
In a country like India where a large population is vegetarian, pulses are the cheapest and best source of total dietary protein (Swaminathan, 1937) [18]. The steady increase in the population taken together with the stagnant production of pulses over the decades resulted in insufficiency in calories and imbalance in nutritional supply. In recent years, there has been understandable concern about decline the per capita availability of pulses. The per capita availability of pulse has declined from 64 g/capita/day (1951-56) to less than 50 g/capita/day in (2012-13) as against the FAO/WHO's recommendation of 80 g/capita/day. If we account the total protein nutrition derived from other such as food milk and its product, egg, fish meat *etc*., 55 g/capita/day requirement of pulse may be the realistic target. Several aspect of decimal performance of pulses have to be considered. Firstly, there has been failure to realize to be expansion of area and adoption of yield improving inputs, secondly losses, costs and ultimately consumer prices also play a significant role.

Among the various pulses 'red gram or pigeonpea' is an important crop both in respect of area as well as production. It is one of the important *Kharif* crop belong to family Fabaceae and botanically known as *Cajanus cajan* L. Mills. It is major pulse crop of the world and most important item of human and supplying a major portion of protein requirement which contains 21.1 per cent.

Post-harvest losses to seed are increasing year after year with increase in production. Even after several technological advancements of seed, we have not been able to lower down its losses due to insect pest infestation during storage. In India where a major portion of seed is stored in seed godowns, lack of scientific storage facilities and incompatible insect control operation leads to colossal loss of seed during storage.

Among various traditional seed protectants, plants originated seed protectants to possess the effective and acceptable active ingredient against stored insects, (Grainge and Ahmed, 1988) [7], botanicals seed protectants are known to suppress the feeding and breeding of insects in various ways in addition to causing direct mortality. Although such properties of plants are known to human being from pre-historic period, they came under purview of scientific scrutiny in the beginning of twentieth century (Jilani, 1984) [8].

Post-harvest storage of pigeonpea (*Cajanus cajan* L.) seeds is susceptible to insect infestation, therefore seed viability deteriorates rapidly during storage and cause considerable economic loss. In the present investigation effects made to studies the effects of a traditional method using red soil in storing pigeonpea seeds over two years. Seeds at the time of collection germinated to 85 ± 6.9%. Results of seed storage experiments showed that 58 ± 8.1% of seeds coated with red soil were viable after 6 months and 44 ±7.9% of the seeds germinated after 12 months of storage. Sun-dried seeds stored under laboratory condition germinated only to 14 ± 5.7% and 4 ± 3.4% after 6 and 12 months, respectively. However, after one year of storage the number of viable seeds is very low and no statistically significant difference in germination (P>0.05) was observed between red soil coated and sundried seeds stored in room temperature. We observed seeds coated with red soil were completely dry, a reason attributable to less insect infestation. Given its easy use and better efficacy compared to solar heating method reported previously, we expect this cost-effective technique will serve as a reliable way for storing pigeonpea seed.

Keeping all the facts in mind, the present study was made for improving the seed quality parameters in pigeon pea (*Cajanus cajan* L.) during storage condition and find alternative seed protectants for long term seed storage in farmers godowns.

Materials and Method

Seed of pigeonpea (*Cajanus cajan* L.) variety Narendra Arhar-1 was obtained from Seed Processing Plant unit of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad and the collected seed were fumigated with aluminium phosphide (3g Tab each) to disinfest them before start of the experiment. The mature green leaves of *Lantana camara*, *Vitex negundo* and *Azadiractica indica* were plucked from their respective trees, cleaned and grinded after drying in shadow. To find out the fine powder from such grinded leaves was sieved with 20 no. mesh. Emamectin benzoate 5 SG, Deltamethrin 2.8 EC and Citronella oil purchased from market. Whereas, Sweet flag (*Acrous calamus*) oil collected from Seed Science & Technology Laboratory.

One kg pigeonpea seed of each replication of each treatment were mixed with seed protectants in order to conduct the experiment. The experiment was conducted in three replications. Thus, treated seed packed in 2kg gunny (jute) bags and kept them on racks in laboratory under ambient condition.

Observations

For observations according to the experiment the required number of seed was randomly obtained from each bags of every treatment in each replication.

Effect of seed Protectants on seed quality

Seed Germination

To know the germination of pigeonpea seed the germination paper (towel paper) method was adopted. One hundred randomly selected seed of each replication from each treatment placed on already water-soaked towel paper, which were rolled after covering them with another water-soaked towel paper. The rolled towel papers were covered with butter paper and kept in seed germinator at 25^0C and 75% RH at 7^{th} day the germination per cent were recorded on the basis of normal seed ling. The germination was recorded at 0, 3, 6 & 9 months.

Seed Moisture Content

Seed moisture of variety in each replication was recorded with the help of Electronic Moisture Meter at 0, 3, 6, & 9 months.

Seed Vigour Index

Seedling vigour index was computed by adopting the following formula as suggested by Abdul-Baki and Anderson (1973) [1] and was expressed in whole number for seed vigour index, germination percentage of was multiplied by total seedling length.

Vigour index = germination (%) X Seed ling length (cm)

Effect of seed Protectants on Percent seed damage by *C. chinensis* from each sample of each replication hundred seed will be randomly selected carefully to short out healthy and unhealthy seed with the help of magnifying lens (10x). The observation will be recorded at 90,180 and 270 days after treatment. The data thus obtained will be used for computing per cent damage seed by using above formula.

$$\text{Per cent seed damage} = \frac{\text{Number of Seed in Sample}}{\text{Total number of seed in Sample}} \times 100$$

Determination of percentage weight loss of seed

To calculate the per cent weight loss of seed, 100 seed will be taken from each replication of different treatment and carefully examined with the help of magnifying lens (10x) in order to find out the bored seeds. The observations were recorded at the end of experiment (270 days). The data thus obtained will be used for computing weight loss per cent by using above formula (Dawae, 2008) [4].

$$\text{Per cent weigh t loss in seed} = \frac{\text{Weight of damage seed of sample}}{\text{Total weight of seed in sample}} \text{ x } 100$$

Results

The initial germination percentage, vigour, moisture and damage percentage of seed were 92.33%, 1945.68, 13.33% and 0.22%, respectively. The results obtained from different studies have been presented below under different sections.

The results (Table-1.1 Fig. 1.1) showed variation in germination per cent among all the treatments. All the seed protectants were significantly superior over control at different storage period. It was also observed that the germination percent was highest in chemical seed protectants in respect to botanicals up to 9 months of storage.

At 3 moths of storage period, the germination per cent within seed protectants ranged between 83.67% to 88.33%. The maximum germination (88.33%) was recorded in Emamectin benzoate 5 SG @ 40mg kg $^{-1}$, followed by Deltamethrin 2.8 EC (87.33%) @ 0.04ml kg $^{-1}$, which was statistically at par with each other with 87% of germination. The minimum germination (83.67%) was observed in *Acrous calamus* oil @ 10ml kg $^{-1}$ followed by Citronella oil @ 5ml kg $^{-1}$ (85.33%). At 6 months of storage period the germination per cent was ranged from 80.00% to 85.00%.

At 6 month, the maximum germination 85.00% was recorded in Emamectin benzoate 5SG @ 40 mg kg $^{-1}$, followed by Deltamethrin 2.8 EC @ 0.04ml kg $^{-1}$, (84.67%) and (84.33%) germination. The minimum germination (80.67%) was observed in Citronella oil @ 5ml kg $^{-1}$ followed by *Acrous calamus* oil @ 10ml kg $^{-1}$, (82.33%).

At 9 months of storage period the germination per cent within the seed protectants ranged between 78.33% to 84.33%. The maximum germination (84.33%) was recorded in Emamectin

benzoate 5SG @ 40 mg kg $^{-1}$, followed by Deltamethrin 2.8 EC @ 0.04ml kg $^{-1}$, (83.00%). The minimum germination (78.33%) was observed in Citronella oil @ 5ml kg $^{-1}$, followed by *Acrous calamus* oil @ 10ml kg $^{-1}$ with 80.33% of germination.

Table 1.1: Effect of treatments (seed protectants) on seed germination (%) of pigeonpea at different storage period.

Treatment	Seed Protectant (Insecticide/Botanical)	Dose (kg $^{-1}$ Seed)	Storage Month After Treatment (Germination %)		
			3	6	9
T_1	Emamectin benzoate 2 ppm	40 mg	88.33 (70.03)	85.00 (67.22)	84.33 (66.69)
T_2	Deltamethrin 1 ppm	0.04 ml	87.33 (68.87)	84.67 (66.95)	83.00 (65.65)
T_3	*Lantana camara* (Tantani)	10 mg	86.67 (68.58)	83.67 (66.17)	80.67 (63.92)
T_4	*Vitex negundo* (Nirgundi)	10 g	87.00 (69.16)	84.33 (66.69)	82.67 (65.39)
T_5	*Citronella* oil	5 ml	85.33 (67.49)	80.67 (63.91)	78.33 (62.26)
T_6	*Acrous calamus* (Sweet flag)	10 ml	83.67 (66.16)	82.33 (65.15)	80.33 (63.68)
T_7	*Azadirachta indica* (Neem)	10 gm	86.67 (68.58)	84.00 (66.42)	82.67 65.40
T_8	Control	Untreated	79.67 (63.19)	76.00 (60.66)	72.33 (58.28)
S.Em ±			0.43	0.62	0.68
C.D. (5%)			1.17	1.47	1.86

1.2 Effect of seed protectants on moisture content in pigeonpea seed at different storage period

The results pertaining to moisture content of seed was influenced by seed treatment at different storage months are furnished in Table – 1.2. The effect of treatments regarding to the seed moisture content were recorded with significant difference. Numerically higher value showed in *Azadiractica indica* leaf powder @ 10 gm kg $^{-1}$ over control at different storage period *i.e*. 13.9, 15.0 and 14.7% in 3, 6, 9 months respectably. It was also observed that the seed moisture content per cent was highest in botanical seed protectants in respect to chemicals up to 9 months of storage.

At 3 months of storage period the moisture content per cent within the seed protectants ranged between 12.9% to 13.9%. The maximum moisture content (13.9%) was recorded in *Azadiractica indica* @ 10 gm kg $^{-1}$, which was significantly higher with all the remaining treatments. The minimum moisture content (12.9%) was observed in Emamectin benzoate 5SG @ 40 mg kg $^{-1}$, followed by deltamethrin 2.8 EC @ 0.04ml kg $^{-1}$, *i.e*. (13.2%).

Table 1.2: Effect of treatments (seed protectants) on seed moisture content (%) of pigeonpea at different storage period

Treatment	Seed Protectant (Insecticide/Botanical)	Dose (kg $^{-1}$seed)	Storage Month After Treatment (Moisture %)		
			3	6	9
T_1	Emamectin benzoate 2 ppm	40 mg	12.9 (21.10)	15.1 (22.86)	12.5 (20.70)
T_2	Deltamethrin 1 ppm	0.04 ml	13.2 (21.27)	14.9 (22.70)	12.8 (20.99)
T_3	*Lantana camara* (Tantani)	10 mg	13.3 (21.44)	14.7 (22.54)	14.4 (22.32)
T_4	*Vitex negundo* (Nirgundi)	10 g	13.5 (21.58)	14.8 (22.65)	15.0 22.81
T_5	*Citronella* oil	5 ml	13.3 (21.41)	14.8 (22.70)	12.6 (20.85)
T_6	*Acrous calamus* (Sweet flag)	10 ml	13.5 (21.58)	14.8 (22.78)	14.0 (22.02)
T_7	*Azadirachta indica* (Neem)	10 gm	13.9 (21.91)	15.0 (22.78)	14.7 (22.59)
T_8	Control	Untreated	12.7 (20.93)	14.8 (22.62)	15.1 (22.91)
S.E.±			0.10	0.06	0.21
C.D. (5%)			0.28	0.15	0.58

At 6 months of storage period the moisture content per cent within the seed protectants ranged between 14.7% to 15.1%. The significant maximum moisture content was recorded in Emamectin benzoate 5SG @ 40 mg kg $^{-1}$ (15.1%) which was at par with *Azadiractica indica* @ 10 gm kg $^{-1}$, seed moisture content. The minimum seed moisture content (14.7%) was observed in *Lantana camara* leaf powder @ 10 mg kg $^{-1}$ followed by *Vitex negundo* @ 10 gm kg $^{-1}$, Citronella oil @ 5 ml kg $^{-1}$, *Acrous calamus* oil @ 10 ml kg $^{-1}$, i.e. (14.8%.).

At 9 months of storage period the moisture content per cent within the seed protectants ranged between 12.5% to 15.0%. The maximum moisture content (15.0%) was recorded in *vitex negundo @ 10 gm* kg $^{-1}$ followed by *Azadiractica indica* @ 10 gm kg $^{-1}$ 14.7% which were significant with each other followed by *Lantana camara* @ 10mg kg $^{-1}$ (14.4%) seed moisture content. The minimum moisture content 12.5 %was observed in Emamectin benzoate 5SG @ 40 mg kg $^{-1}$ followed by Citronella oil @ 5 ml kg $^{-1}$ *i.e.* 12.6%.

1.3 Effect of seed protectants on seed vigour index in pigeonpea seed at different storage period

The data (Table-1.3) revealed that the seed vigour index was influenced by seed treatment at different storage period. All seed protectants were superior over the control at significant level. Seed vigour index was exhibited maximum when seed treated with Emamectin benzoate @ 40mg kg $^{-1}$, different storage period. It was also observed that the seed vigour index per cent was highest in chemicals seed protectants in respect to botanical up to 9 months of storage.

At 3 months of storage period the seed vigour index per cent within the seed protectants ranged between 1425.36 to 1711.25. The maximum seed vigour index (1711.25) was recorded in Emamectin benzoate 5SG @ 40 mg kg $^{-1}$, followed by Deltamethrin 2.8 EC @ 0.04ml kg $^{-1}$, (1589.49) which were at par with each other. The minimum seed vigour index (1425.36) was observed in Citronella oil @ 5 ml followed by *Acrous calamus* oil @ 10ml kg $^{-1}$, with1452.19 vigour index.

Table 1.3: Effect of treatments (seed protectant) on seed vigour index [germination (%) x seedling length (cm)] of pigeonpea at different storage period

Treatment	Seed Protectant (Insecticide/Botanical)	Dose (kg^{-1} Seed)	Storage Month After Treatment (Vigour index)		
			3	6	9
T_1	Emamectin benzoate 2 ppm	40 mg	1711.25	2352.80	2618.35
T_2	Deltamethrin 1 ppm	0.04 ml	1589.49	2272.50	2548.93
T_3	*Lantana camara* (Tantani)	10 mg	1504.24	2067.39	2386.28
T_4	*Vitex negundo* (Nirgundi)	10 g	1538.22	2206.13	2511.51
T_5	*Citronella* oil	5 ml	1425.36	1934.30	2306.71
T_6	*Acrous calamus* (Sweet flag)	10 ml	1452.19	1985.07	2376.16
T_7	*Azadirachta indica* (Neem)	10 gm	1517.25	2126.86	2503.24
T_8	Control	Untreated	1175.57	1770.80	2127.22
S.E.±			4.86	8.21	7.03
C.D. (5%)			10.31	17.41	14.91

At 6 months of storage period the seed vigour index per cent within the seed protectants was ranged between 1934.30 to 2352.80. The maximum seed vigour index (2352.8) was recorded in Emamectin benzoate 5SG @ 40 mg kg^{-1}, followed by Deltamethrin 2.8 EC @ 0.04ml kg^{-1}, (2272.50) vigour index which were at par with each other. The minimum seed vigour index (1935.30) was observed in Citronella oil @ 5 ml kg^{-1}, followed by *Acrous calamus* oil @ 10ml kg^{-1}, (1985.07) vigour index.

At 9 months of storage period the seed vigour index per cent within the seed protectants ranged between 2306.71 to 2618.35. The maximum seed vigour index (2618.35) was recorded in Emamectin benzoate 5SG @ 40mg kg^{-1}, followed by Deltamethrin 2.8 EC @ 0.04ml kg^{-1} (2548.93) vigour index which was at par with each other. The minimum seed vigour index (2306.71) was observed in Citronella oil @ 5 ml kg^{-1}, followed by *Acrous calamus* @ 10ml kg^{-1}, (2376.16) vigour index.

1.4: Effect of seed protectants (treatment) on seed infestation in pigeon pea by pulse beetle at different storage period

The results (Table-1.4) showed variation in seed infestation in pigeon pea at different storage periods. All the Seed protectants at 9 months were significant over control but infestations by bruchids were non-significant at 3 and 6 months during storage periods.

At 9 months of storage period the seed infestation per cent within the seed protectants was ranged between 0.33% to 3.67%. The maximum seed infestation per cent was recorded in Citronella oil @ 5ml kg^{-1}, (3.67%) followed by *Acrous calamus* oil @ 10ml kg^{-1}, (2%). The infestation in all protectants were at par with each other. The minimum seed infestation 0.33% was observed in Emamectin benzoate 5SG @ 40 mg kg^{-1}, followed by Deltamethrin 2.8 EC @ 0.04 ml kg^{-1} (1%).

Table 1.4: Effect of treatment (Seed protectants) on insect infestation by pulse beetle in pigeonpea at different storage period

Treatment	Seed protectant (Insecticide/Botanical)	Dose (kg^{-1} Seed)	Storage Month After Treatments (Insect infestation %)		
			3	6	9
T_1	Emamectin benzoate 2 ppm	40 mg	0.33 (2.30)	0.33 (2.30)	0.33 (2.30)
T_2	Deltamethrin 1 ppm	0.04 ml	0.33 (2.30)	0.67 (4.02)	1.00 (5.73)
T_3	*Lantana camara* (Tantani)	10 mg	0.33 (2.30)	0.67 (4.02)	1.33 (6.53)
T_4	*Vitex negundo* (Nirgundi)	10 g	0.33 (2.30)	0.67 (4.02)	1.33 (6.53)
T_5	*Citronella* oil	5 ml	0.33 (2.30)	1.33 (6.53)	3.67 (10.76)
T_6	*Acrous calamus* (Sweet flag)	10 ml	0.67 (4.02)	1.67 (6.22)	2.00 (7.94)
T_7	*Azadirachta indica* (Neem)	10 gm	0.33 (2.30)	0.67 (4.02)	1.33 (5.61)
T_8	Control	Untreated	1.67 (7.15)	3.00 (9.88)	6.33(14.39)
S.E.±			0.52	0.32	1.91
C.D. (5%)			NS	NS	5.89

1.5: Effect of seed protectants treatment on seed weight loss pigeonpea at 9months of storage period

The data (Table-1.5) revealed that the weight loss within the protectants ranged between 0.29 to 1.46 per cent which was significantly less than control.

Table 1.5: Effect of treatment (Seed Protectants) on seed weight loss (%) in pigeonpea by pulse beetle at 9 months of ambient storage

Treatment	Seed Protectant	Dose (kg^{-1} Seed)	Seed weight loss (%)	Seed saved (%)
T_1	Emamectin benzoate 2 ppm	40 mg	0.29 (3.85)	93.27
T_2	Deltamethrin 1 ppm	0.04 ml	0.30 (3.17)	93.04
T_3	*Lantana camara* (Tantani)	10 mg	0.97 (5.67)	77.49
T_4	*Vitex negundo* (Nirgundi)	10 g	0.74 (4.93)	82.83
T_5	*Citronella* oil	5 ml	1.46 (6.93)	66.12
T_6	*Acrous calamus* (Sweet flag)	10 ml	1.00 (5.73)	76.79
T_7	*Azadirachta indica* (Neem)	10 gm	0.78 (5.06)	81.90
T_8	Control	Untreated	4.31 (11.97)	
S.E.±			0.34	
C.D. (5%)			0.92	

Deltamethrin 2.8 EC @0.04 ml kg $^{-1}$, seed (0.30%), *Vitex negundo* leaf powder @ 10gm kg $^{-1}$seed (0.74%) and *Azadiractica indica* leaf powder @ 10gm kg $^{-1}$ seed (0.78%) and *Lantana camara* leaf powder @ 10mg kg $^{-1}$ seed (0.97%) per cent weight loss.

The maximum weight loss was observed in Citronella oil @ 5ml kg^{-1}seed 1.46 per cent followed by *Acrous calamus* oil @ 10ml kg^{-1}seed per cent. The result also showed that the seed saved by seed protectants observed maximum 93.27% in Emamectin benzoate 5 SG @ 40mg kg $^{-1}$, followed by Deltamethrin @ 0.04ml kg $^{-1}$ 93.04%, 82.83%. The minimum seed was saved by 66.12% Citronella oil @ 5ml kg $^{-1}$ followed by *Acrous calamus* @ 10 ml kg $^{-1}$ and *Lantana camara* @ 10mg kg $^{-1}$ 76.79%, 77.40% respectively.

Discussion

Results clearly indicate that chemical seed protectants were better than botanical seed protectants upto 9 months of storage, related to germination (%), seed moisture content (%), seed vigour index, infested seed (%) and weight loss (%). Salient findings were emerged out from the experiments are highlighted in the light of the results reported by earlier workers.

The germination percentage was decreased in all treatments as increased in storage period of seed. These results were also supported by Raghvani and Kapadia (2003) [15], Lal and Raj (2012) [9] and Singh *et al.* (2014) [17] in Pigeonpea, Babu *et al.* (2008) [2] in Soyabean.

The seed moisture content is mainly dependent on room temperature and relative humidity during storage period. The seed protectants provide a coating on seed that affected the moisture percent of seed significantly upto 9 months.

However, at 9 month of storage seed treated with Emamectin benzoate 5 SG @ 40mg kg^{-1} again showed lowest seed moister content with 12.5%, followed by citronella oil @ 5ml kg^{-1}, Deltamethrin (2.8EC) @ 0.04ml kg^{-1}, *Acrous calamus* oil and *Lantana camara* leaf powder @ 10mg kg^{-1}, more or less similar work has also been reported by Doharey e*t al.* (1988) [5], Babu *et al.* (2008) [2] Pal and Katiyar (2013) [12] and, Patole and Mahajan (2008) [14]. The effect of Emamectin benzoate (5 SG), Deltamethrin and botanical-seed protectants on vigour index among different treatments were significantly superior over control. The highest vigour index (2618.35) was observed in Emamectin benzoate (5 SG) @ 40mg kg^{-1}, followed by Deltamethrin treated seed up to 9 months of storage. It clearly indicates that all chemical seed protectants showed highest vigor index in comparison to botanicals. Among botanicals, *Vitex negundo* and *Azadirachta indica* had highest vigour index with 2511.51, and 2503.24, respectively. All the botanical seed protectants were also significantly superior over control.

These results were also supported by Bajpai *et al*. (2002) [3] in Urdbean, and Singh *et al.* (2014) [17] in Pigeonpea, Babu *et al.* (2008) [2] in Soyabean.

Seed infestation by bruchid varied in different treatments upto different storage periods and significant over control only at 9 months of storage of seed. However, infestations by bruchids had non-significant at 3 and 6 months storage of seed in all the treatments.

These results were also supported by Signal and Bhanot (2007) [16] in green gram, Mishra *et al.* (2008) [11], Lal and Raj (2012) [9] in pigeonpea, and Mendali and Raddy (2014) in pigeonpea.

The effects of seed protectants on weight loss in stored pigeonpea seed were found minimum in all the treatments over control at different storage periods. The minimum weight loss (0.29%) was observed in Emamectin benzoate followed by Deltamethrin and botanicals. Among botanicals, *Vitex negundo* had lowest weight loss (0.74%) followed by *Azadiractica indica.* The highest seed weight loss was observed in *Citronella* oil (1.46%) followed by *A. calamus* within botanicals.

Similar findings have been reported by several workers, Tripathi *et al.* (2006) [19], Pandey *et al.* (2013) [13] in pigeonpea, Gawade *et al.* (2009) [6] in cowpea in chickpea.

Conclusion

There was significant difference among all the treatments over control in regarding all the experimental parameters. Among all seed protectants, the Emamectin Benzoate (5 SG) @ 40mg kg^{-1}, and Deltamethrin (2.8 EC) @ 0.04ml kg^{-1}, found more effective due to minimum insect infestation and per cent weight loss. All tested seed protectants were able to maintain the seed germination above IMSCS level up to 9 months of storage. The maximum seed germination was maintained by Emamectin benzoate (5 SG) @ 40mg kg^{-1} followed by Deltamethrin (2.8 EC) @ 0.04ml kg^{-1} and Nirgundi (*Vitex negundo*) @ 10g kg^{-1} *at* 3, 6 & 9 months of ambient storage. The maximum vigour was obtained in Emamectin benzoate (5 SG) @ 40mg kg^{-1} followed by Deltamethrin (2.8 EC) @ 0.04ml kg^{-1} and Nirgundi (*Vitex negundo*) @ 10g kg^{-1} upto 9 months of storage. The moisture content of seed directly related with storage condition and nature of seed protectants. The present investigation observed that seed protectants *viz.*, Emamectin benzoate 5SG@ 40mg kg^{-1}, Deltamethrin 2.8 EC @ 0.04ml kg^{-1}, and *Vitex negundo* leaf powder @ 10g kg 1^{-}, may be used as suitable seed protectants in ambient storage of pigeonpea above IMSCS level for a long period.

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