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Capability assessment of chemical seed protectants against pulse beetle under ambient storage of pigeon pea seed

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Abstract
Eight chemical seed protectants namely Emamectin benzoate (Proclaim 5SG) @2ppm (40.0mg/kg. seed), Spinosad (Tracer 45SC) @2ppm (4.4mg/kg. seed), Indoxacarb (Avaunt 14.5SC) @2ppm (13.8mg/kg. seed), Rynaxypyr (Coragen 20SC) @2ppm (0.01ml/kg. seed), Chlorfenapyr (Intrepid 10EC) @2ppm (0.02ml/kg. seed), Profenofos (Curacron 50EC) @2ppm (0.004ml/kg. seed), Novaluron (Rimon 10EC) @5ppm 0.05ml/kg. seed), Deltamethrin 2.8EC @1.0 ppm (0.04 ml/kg. seed) along with one untreated control of red gram seed against *C. chinensis* under ambient condition were assessed for a period of 9 months. After 9 months of storage the results revealed that insecticides namely Novaluron 10 EC@ 0.05ml/kg. with 1.33 per cent infestation and 7.08 per cent weight loss followed by Emamectin Benzoate 5 SG@ 40mg/kg. with 1.67 per cent infestation and 8.16 per cent weight loss showed best results. Infestation increased significantly along with the increase in moisture per cent.

Keywords: insecticides, seed protectants, seed, infestation, bruchid, pulse beetle, damage

Introduction
India is the largest producer of pulses in the world with 25% share in the global production. Pulses are the cheapest and the best source of total dietary protein for vegetarian population of our country. About 90% of the worlds' production of pigeon pea is contributed by India, occupying more than 10% of the total area under pulses. Total area under pigeon pea in India is about 3.6 million ha. with annual production of 2.8 million tons and productivity of pigeon pea is about 753 kg./ha. Respectively. (Anonymous, 2016-17) [2] Among the various pulses, red gram or pigeon pea is an important crop both in respect of area as well as production. It is one of the important *kharif* crop belonging to family, Fabaceae. Pulses play an important role in Indian agriculture. Besides, they sustain the productivity of cropping system by fixing atmospheric nitrogen through biological process and improving soil fertility. In order to meet the requirement of protein for increasing population, it is necessary to increase the production of pulses in India. Even after several technological advancements in the post-harvest management of production, we have not been able to lower down its losses due to insect-pests' infestation during storage. (Swaminathan, 1937) [9]

The insects causing damage to the stored pulses are pulse beetle, *Callosobruchus chinensis* khapra beetle, *Trogoderma granarium* and lesser grain borer *Rhyzopertha dominica*. Among these, the pulse beetle is the most important pest causing infestation to pigeon pea, both in field as well as in storage condition. (Thembhare, 2007) [10]

The bruchids are most degraded stored grain pest, causing loss of nearly 10-90%. (Rathore and Sharma, 2002) [7] The bruchids (*Callosobruchus chinensis* L.) breed exclusively on pulses, having a very short life span with high degree of reproductive potential. The pest is developed during storage and is detached only when they became adult beetles. The infestation is maximum in July an accounts up to 50% loss. (Mathur and Upadhyay, 1997) [4]

The Red Gram seed can be protected from insect pests during storage by applying suitable insecticidal treatments. The use of common contact insecticides under storage such as Emamectin Benzoate, Malathion, Spinosad dust etc. for maintenance of seed germination, viability and vigour. (Patil *et al*., 2006) [5]

In view of above backgrounds, an attempt has been made with aim to find out the most suitable seed protectants among chemicals and botanicals for seed treatment for maintaining seed quality during ambient storage condition.

Materials and Methods

Required quantity of pigeon pea seed of var. NDA-1 was collected from seed processing unit of NDUAT, Kumarganj, Faizabad and fumigated with Aluminium Phosphide (3g tab. each) @3 tab/t. in airtight container and disinfested before starting the experiment. One kg. seed of pigeon pea (NDA 1) for each replication (3 replications) were taken under each treatment (9 treatments).

S. No.	Seed protectants		Rate (Per kg. of seed)
	Trade name	Common name	
1.	Proclaim (5 SG)	Emamectin benzoate	2ppm (40.0 mg)
2.	Tracer (45 SC)	Spinosad	2ppm (4.4 mg)
3.	Avaunt (14.5 SC)	Indoxacarb	2ppm (13.8 mg)
4.	Coragen (20 SC)	Rynaxypyr	2ppm (0.01ml)
5.	Intrepid (10 EC)	Chlorfenapyr	2ppm (0.02 ml)
6.	Curacron (50 EC)	Profenofos	2ppm (0.004ml)
7.	Rimon (10 EC)	Novaluron	5ppm (0.05ml)
8.	Decis (2.8 EC)	Deltamethrin	1.0 ppm (0.04 ml)
9.	Control		Untreated

Required quantity of chemical pesticides was diluted in 5 ml. of water for proper coating on seed. Thus treated seeds were packed in 2 kg. gunny bag (1 kg. seed in each bag) and placed in racks in laboratory under ambient condition for further investigations. The data of seed damage, percent weight loss and moisture content of seed were recorded at an interval of 3 months, upto a period of nine months of ambient storage.

Results

1.1 Effect of seed protectants (treatments) on per cent seed damage in pigeon pea by pulse beetle at different storage periods

The results (Table-1.1 and Fig. 1.1) showed variations in percent seed damage in pigeon pea seed at different storage periods. All the Seed protectants at 6 and 9 months were found significant over control however the damage by bruchids was found non-significant at 3 months of storage.

At 3 month of storage, the damage of pulse beetle ranged 0.00-1.00 per cent within the seed protectants and the maximum damage was recorded in profenofos 50 EC@ 0.004ml/Kg. with 1.00 per cent followed by spinosad 45 SC@ 4.4mg/Kg., rynaxypyr, profenofos 50 EC@ 0.004ml/Kg. and deltamethrin 2.8 EC@ 0.04ml/Kg. with 0.67 per cent seed damage and were found statistically at par. The minimum damage was recorded in novaluron 10 EC@ 0.05ml/Kg. with 0.00 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg., indoxacarb 14.5 SC@ 13.8mg/Kg. and chlorfenapyr 10 EC@0.02ml/Kg. with 0.33 per cent damage and were found to be statistically at par.

At 6 month of the storage, per cent seed damage was ranged 0.67-2.67 where the maximum damage was observed in rynaxypyr 20 SC@ 0.01ml/Kg. with 2.67 per cent followed by deltamethrin 2.8 EC@ 0.04ml/Kg. with 2.33, chlorfenapyr 10 EC@ 0.02ml/Kg. 10 EC@ 0.02ml/Kg. and indoxacarb 14.5 SC@ 13.8mg/Kg. with 2.00 per cent seed damage and they were found to be statistically at par. The minimum damage was observed in novaluron 10 EC@ 0.05ml/Kg. with 0.67 per cent damage followed by emamectin benzoate 5 SG@ 40mg/Kg. with 1.33 per cent and profenofos 50 EC@ 0.004ml/Kg. with 1.67 per cent per cent seed damage.

Table 1.1: Effect of Seed Protectant (Insecticide) on Pulse beetle damage (%) in Pigeon pea at different storage periods.

Treatments	Seed Protectant (Insecticides) Common Name	Trade Name	Dose (Per kg. Seed)	Insect Damage (%) at different storage periods (months)		
				3 months	6 months	9 months
T_1	Emamectin benzoate	Proclaim (5SG)	40 mg	0.33	1.33	1.67
T_2	Spinosad	Tracer (45 SC)	4.4 mg	0.67	1.67	2.00
T_3	Indoxacarb	Avaunt (14.5 SC)	13.8 mg	0.33	2.00	2.33
T_4	Rynaxypyr	Coragen (20 SC)	0.01ml	0.67	2.67	3.00
T_5	Chlorfenapyr	Intrepid (10 EC)	0.02ml	0.33	2.00	2.00
T_6	Profenofos	Curacron (50 EC)	0.004ml	1.00	1.67	2.00
T_7	Novaluron	Rimon (10 EC)	90.05ml	0.00	0.67	1.33
T_8	Deltamethrin	Decis (2.8 EC)	0.04 ml	0.67	2.33	2.67
T_9	Control	Untreated	--	1.33	3.33	5.33
CD				Non-significant	0.93	0.57
SEm±				0.38	0.44	0.27

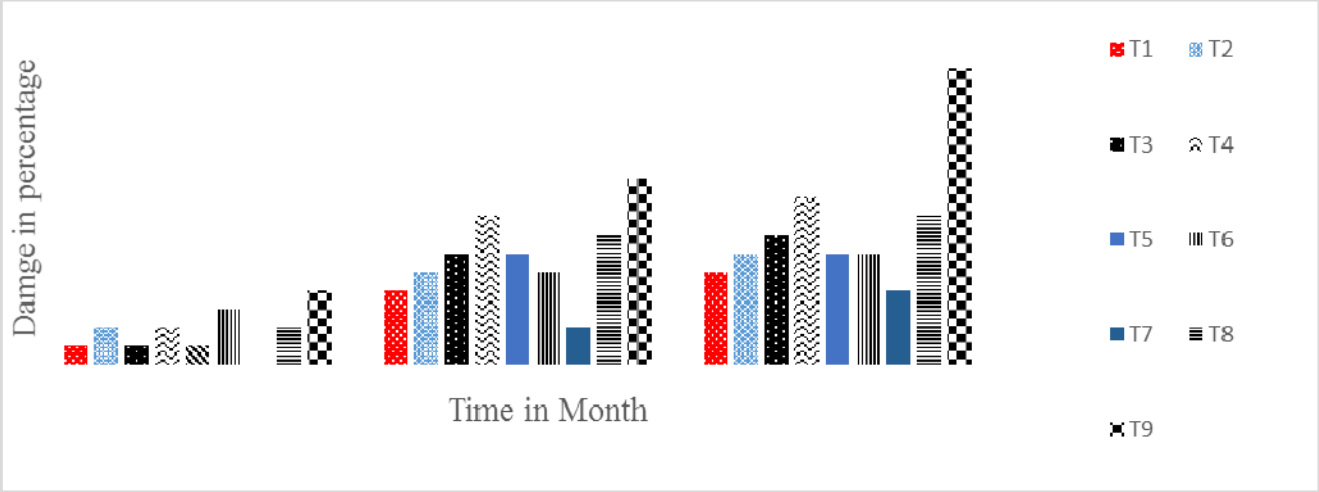

Fig 1.1: Effect of Seed Protectant (Insecticide) on Pulse beetle damage (%) in Pigeon pea at different storage periods.

At 9 month of storage, the percent seed damage ranged 1.33-3.00 per cent. The maximum damage was observed in rynaxypyr 20 SC@ 0.01ml/Kg. with 3.00 per cent seed damage followed by deltamethrin 2.8 EC@ 0.04ml/Kg. with 2.67 per cent seed damage and Indoxacarb 14.5 SC@ 13.8mg/Kg. with 2.33 per cent seed damage. The minimum damage observed in novaluron 10 EC@ 0.05ml/Kg. with 1.33 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg. with 1.67 per cent, spinosad 45 SC@ 4.4mg/Kg., chlorfenapyr 10 EC@0.02ml/Kg. 10 EC@0.02ml/Kg. and indoxacarb 14.5 SC@ 13.8mg/Kg. with 2.00 per cent seed damage. All treatments were significantly superior then the untreated control that have maximum insect damage (5.33%) at nine month of storage period. The effect of storage period significant for insect damage. Seed damage increased significantly as storage period increased and the value of the damage percent less to higher from starting to till 9 month of storage.

1.2 Effect of seed protectants at different storage periods on per cent weight loss of pigeon pea seed

The results (Table-1.2 and Fig. 1.2) showed variations in seed weight loss per cent in pigeon pea seed at different storage periods. All the Seed protectants at 9 months were found significant over control.

At 3 month of storage, the weight loss due to feeding of seed was ranged 8.80-5.33 per cent. The maximum weight loss recorded in indoxacarb 14.5 SC@ 13.8mg/Kg. with 8.80 per cent followed by spinosad 45 SC@ 4.4mg/Kg. with 8.33 per cent and chlorfenapyr 10 EC@0.02ml/Kg. 10 EC@0.02ml/Kg. with 8.16 per cent weight loss. The minimum weight loss was in novaluron 10 EC@ 0.05ml/Kg. with 5.33 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg. 6.67 per cent and deltamethrin 2.8 EC@ 0.04ml/Kg. with 6.75 per cent weight loss. The weight loss in control was higher in compare to treatments and was 11.50 per cent.

At 6 month of storage, the weight loss was ranged 9.67-5.67 per cent. The maximum weight loss was recorded in indoxacarb 14.5 SC@ 13.8mg/Kg. and rynaxypyr 20 SC@ 0.01ml/Kg. with 9.67 per cent weight loss and statistically at par and followed by deltamethrin 2.8 EC@ 0.04ml/Kg. with 9.41 per cent and chlorfenapyr 10 EC@ 0.02ml/Kg. with 9.33 per cent weight loss. The minimum weight loss was observed in novaluron 10 EC@ 0.05ml/Kg. 5.67 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg. 7.16 and profenofos 50 EC@ 0.004ml/Kg. with 7.33 per cent weight loss. The weight loss in control was 12.58 per cent significantly higher than all treatments.

Table 1.2: Effect of Seed Protectant (Insecticide) on Seed weight loss (%) of Pigeon pea at different storage periods.

Treatments	Seed Protectant (Insecticides) Common Name	Dose (Per kg. Seed) Trade Name	Dose (Per kg. Seed)	Seed weight loss (%) at different storage period (months)		
				3	6	9
T_1	Emamectin benzoate	Proclaim (5SG)	40 mg	6.67	7.16	8.16
T_2	Spinosad	Tracer (45 SC)	4.4 mg	8.33	8.67	9.67
T_3	Indoxacarb	Avaunt (14.5 SC)	13.8 mg	8.80	9.67	10.33
T_4	Rynaxypyr	Coragen (20 SC)	0.01ml	7.00	9.67	10.67
T_5	Chlorfenapyr	Intrepid (10 EC)	0.02ml	8.16	9.33	9.67
T_6	Profenofos	Curacron (50 EC)	0.004ml	7.33	7.33	8.16
T_7	Novaluron	Rimon (10 EC)	90.05ml	5.33	5.67	7.08
T_8	Deltamethrin	Decis (2.8 EC)	0.04 ml	6.75	9.41	10.33
T_9	Control	Untreated	--	11.50	12.58	15.16
CD				0.87	3.19	0.73
SEm±				0.41	1.52	0.53

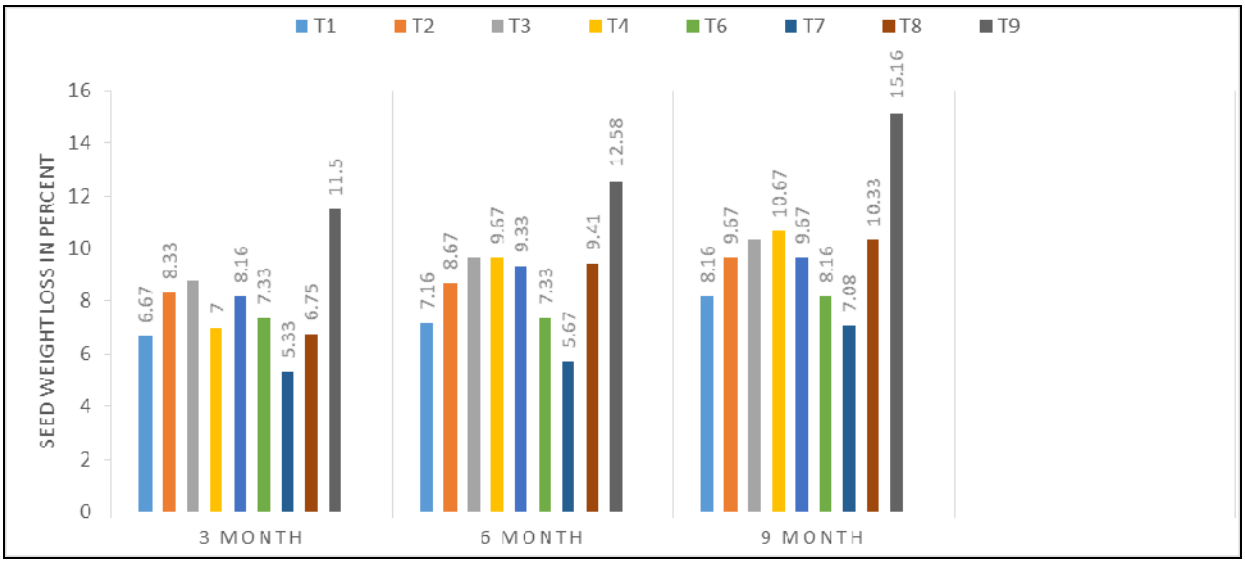

Fig 1.2: Effect of Seed Protectants (Insecticides) on per cent seed weight loss of pigeon pea at different storage periods.

Time in month

At 9 month of storage, the weight loss was ranged 10.67-7.08 per cent. The maximum weight loss was recorded in rynaxypyr 20 SC@ 0.01ml/Kg. 10.67 per cent followed by indoxacarb 14.5 SC@ 13.8mg/Kg., deltamethrin 2.8 EC@ 0.04ml/Kg. with 10.33 per cent and statistically at par for each other and Spinosad 45 SC@ 4.4mg/Kg., chlorfenapyr 10 EC@ 0.02ml/Kg. at par with 9.67 per cent weight loss. The minimum weight loss was recorded in novaluron 10 EC@ 0.05ml/Kg. 7.08 per cent followed by emamectin benzoate and profenofos 50 EC@ 0.004ml/Kg. with 8.16 per cent weight loss and statistically at par. The weight loss in control was higher (15.16 per cent) than all the treatments.

1.3 Effect of seed protectants at different storage periods on per cent moisture content of pigeon pea seed

The results pertaining to moisture content of seed as influenced by seed treatment, storage period and metrological condition, presented in the table 1.3 and figure 1.3. Effect of seed treatments regarding to the seed moisture content was found significant according to nature of seed protectants and the time of storage period.

The higher per cent of moisture was recorded at 3 month of storage in Profenofos 50 EC@ 0.004ml/Kg. with 12.83 per cent followed by novaluron 10 EC@ 0.05ml/Kg. 12.34 per cent moisture content. The minimum moisture was recorded in chlorfenapyr 10 EC@0.02ml/Kg. with 11.2 per cent followed by rynaxypyr 20 SC@ 0.01ml/Kg. with 11.33 per cent moisture. The moisture content in control was 11.84 per cent recorded.

At 6 month of storage, the moisture in treatments ranged from 15.1 per cent-14.1 per cent and the higher moisture was recorded 15.1 per cent in Spinosad 45SC@ 4.4mg/Kg. followed by chlorfenapyr 10 EC@0.02ml/Kg. and deltamethrin 2.8 EC@ 0.04ml/Kg. with 14.9 per cent moisture and both are statistically at par. The minimum seed moisture was recorded in novaluron 10 EC@ 0.05ml/Kg. with 14.1 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg. with 14.55 per cent seed moisture.

Table 1.3: Effect of Seed Protectant (Insecticide) on Seed Moisture Content (SMC) (%) of Pigeon pea at different storage periods.

Treatments	Seed Protectant (Insecticides) Common Name	Trade Name	Dose (Per kg. Seed)	Seed Moisture Content (SMC) (%) after different storage periods		
				3	6	9
T_1	Emamectin benzoate	Proclaim (5SG)	40 mg	11.84	14.5	11.8
T_2	Spinosad	Tracer (45 SC)	4.4 mg	11.84	15.1	14.1
T_3	Indoxacarb	Avaunt (14.5 SC)	13.8 mg	11.84	14.74	14.1
T_4	Rynaxypyr	Coragen (20 SC)	0.01ml	11.77	14.93	14.1
T_5	Chlorfenapyr	Intrepid (10 EC)	0.02ml	11.2	14.9	13.77
T_6	Profenofos	Curacron (50 EC)	0.004ml	12.83	14.87	11.9
T_7	Novaluron	Rimon (10 EC)	90.05ml	12.34	14.1	11.44
T_8	Deltamethrin	Decis (2.8 EC)	0.04 ml	11.84	14.9	12.2
T_9	Control	Untreated	--	11.84	15.14	12.7
CD				0.07	0.32	0.15
SEm±				0.03	0.32	0.07

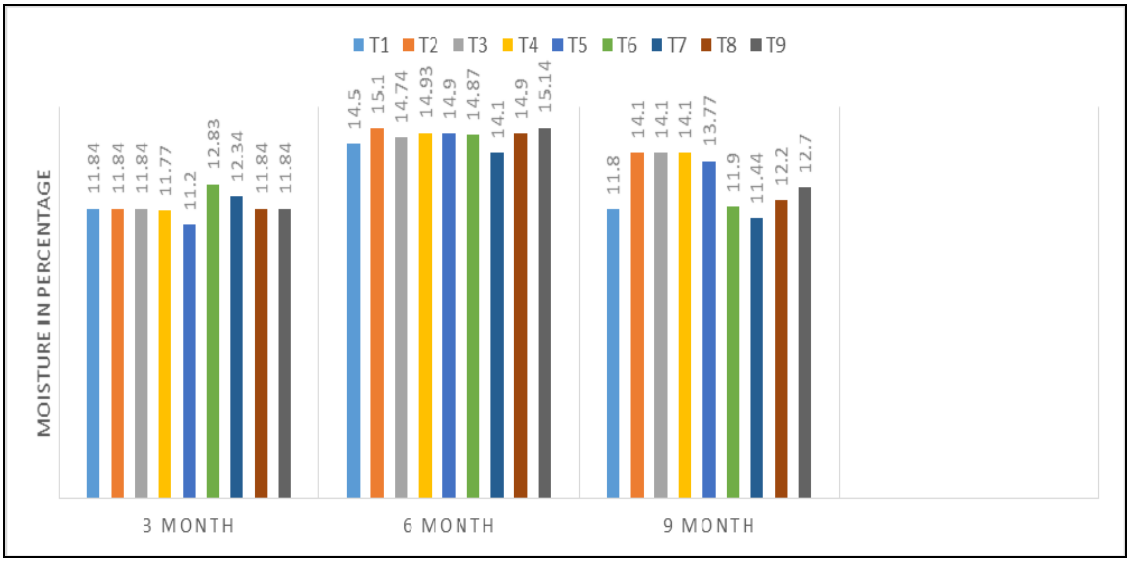

Fig 1.3: Effect of Seed Protectants (Insecticides) on per cent seed moisture content (SMC) of Pigeon pea at different storage periods

Time in month

At 9 month of storage periods numerically, the higher value of moisture recorded in indoxacarb 14.5 SC@13.8mg/Kg., with 14.1 per cent, followed by rynaxypyr 20 SC@0.01ml/Kg. and spinosad 45 SC@ 4.4mg/Kg. with 14.1 per cent. They all are at par for each other. The minimum moisture content was observed in novaluron 10 EC@ 0.05ml/Kg. with 11.44 per cent and followed by emamectin benzoate 5 SG@ 40mg/Kg. with 11.8 per cent.

The significant difference on seed moisture content percent due to insecticidal treatment and month of storage was seen throughout the storage period. The level of seed moisture was directly related to environmental condition with a significant effect of seed coating.

Discussion

After 3 month of storage, the minimum insect damage was observed in novaluron 10EC @0.05ml/kg., with 0.33 per cent followed by emamectin benzoate 5SG @ 40mg/Kg. and profenofos 50EC @0.004ml/kg. It was also repeated at 6 and 9 months of storage in which novaluron 10 EC @0.05ml/kg., again showed very less bruchid infestation, 0.67 per cent and followed by emamectin benzoate 5SG @40mg/Kg. (1.33%) and profenofos 50EC @0.004ml/kg. with 1.67 per cent infestation.

The insect infestation was found non-significant at 3 months of storage but in case of 6 and 9 months of storage the damage was increased up to significant level. In present study, it was cleared that the considerable grain damage increased progressively with increased in storage period along with the combined effects of moisture content and seed protectants nature. (Longnathan *et al.* 2011, [3] Adhikary and Barik, 2012) [1]

Moisture content of seed mainly depends upon the condition of storage environments and nature of seed protectants.

At 3 months of storage the minimum seed moisture per cent was recorded in chlorfenapyr 10 EC@0.02ml/kg. 11.2 followed by rynaxypyr 20 SC@0.01ml/kg. with 11.33 per cent moisture that was significantly lower than control. At 6 months of storage, the minimum seed moisture was recorded in novaluron 10 EC@0.05ml/kg., with 14.1 per cent followed by emamectin benzoate 5 SG@ 40mg/Kg. with 14.55 seed moisture however, at 9 months of storage the moisture started decreasing due to the increasing warmth in April. The minimum moisture content was observed in emamectin benzoate 5 SG@ 40mg/Kg. with 11.8 per cent followed by novaluron 10 EC@0.05ml/kg., 11.44 per cent at 9 months of storage. These findings are also supported by Raheem *et al*., 2011 [6]

The results showed that all the seed protectants showed better performance with respect to percent weight loss with significant level over control at different storage periods.

In case of weight loss at 3 months of storage, the minimum weight loss was observed in seed, treated with novaluron 10 EC@0.05ml/kg., 5.33 per cent followed by emamectin benzoate 5SG@ 40mg/Kg. 6.67 per cent and deltamethrin 2.8 EC@0.04ml/kg. with 6.75 per cent weight loss. The weight loss in control was higher in comparison to other treatments with 11.50 per cent. The differences in weight loss among the treatments were found significant over control up to 9 months of storage and these findings are also supported by Sinha and Singh, 1998. [8]

Conclusion

The results revealed that insecticides namely Novaluron 10 EC@ 0.05ml/kg. with 1.33 per cent infestation and 7.08 per cent weight loss followed by Emamectin Benzoate 5 SG@ 40mg/kg. with 1.67 per cent infestation and 8.16 per cent weight loss showed the best results. Infestation increased significantly along with the increase in moisture per cent. On the basis of above observations, we can say that novaluron 10 EC@0.05ml/kg. seed was best among all the tested seed protectants to protect the seed effectively and can be used to protect the pigeon pea seed above IMSCS Level up to 9 months of ambient storage.

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