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Efficacy of Insecticide Impregnated Packaging Material on Seed Quality of Cowpea (*Vigna ungiculata* (L.) Walp.) during Storage

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Abstract

A laboratory study was conducted to know the effect of insecticide impregnated packaging materials on seed quality of cowpea *(Vigna unguiculata* (L.) Walp.) during June 2016 to April 2017 in the Department of Seed Science and Technology and National Seed Project, University of Agricultural Sciences, Gandhi KrishiVignana Kendra, Bengaluru. The statistical design used for study was factorial completely randomized block design (FCRD). The study consists of two treatments, three packaging materials with four replications. The experiment results revealed that seed treated with emamectin benzoate 5SG@ 40 mg /kg of seeds recorded significantly highest germination (73%) with least moisture content (10.60%), insect infestation (1.05%) and disease infection (1.83%) after ten months of storage. Among the packaging material, significantly highest germination (73%) with least moisture content (10.52%), seed infestation (1.38%) and diseaseinfection (2.25%) respectively were observed ininsecticide impregnated packaging material. Further, among the interactions between treatments and packaging materials, seeds treated with emamectin benzoate 5SG and stored in insecticide impregnated polypropylene bags (T_1P_1) revealed the highest germination (76%) with least moisture content (10.47%) with no insect infestation after ten months of storage.

Keywords : Impregnated bags, Insecticides, Cowpea, Seed quality

Cowpea an important legume crop is subjected to quantitative and qualitative losses due to infestation both in field and seed storage. The huge post harvest losses and quality deterioration caused by the storage pests is a major obstacle for achieving food security. The use of pesticides although practiced and often effective has disadvantages for the consumer and the environment. There are many reasons for storage losses, among these insect and pests of stored products are important. We cannot completely escape from chemicals due to their abrupt killing and availability. There are two reasons of their residual and harmful effects, like high toxicity and non biodegradable properties of pesticides.

Damage to seed caused by pests includes reduction in seed quality and storability, *viz.,* germination, loss in seedling vigour and commercial value of a seed lot. To avoid these storage losses and residual effects of pesticides, it is need of the hour to combat insects with some advanced methods. A novel and innovative tool, an insecticide impregnated polypropylene bags has been designed to protect seeds against destructive insect pest infestation during storage. Hence, the present study was carried out to evaluate the efficacy of insecticide impregnated polypropylene bag on seed quality and management of storage pest during storage in cowpea (*Vigna unguiculata* (L.) Walp.).

Material and Methods

A laboratory study was carried out to know the effect of insecticide impregnated packaging materials on seed quality of cowpea (*Vigna unguiculata* (L.) Walp.) during storage in the Seed Technology Research Centre, National Seed Project, UAS, GKVK, Bengaluru from June 2016 to April 2017. The freshly harvested certified seedsof cowpea cv. C-152 having highest germination and optimum moisture content were taken for each treatment. The experiment was initiated by adopting FCRD with following treatments in four replications.The treatments were

a. Seed treatments

T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds

T_2: Untreated control

b. Packaging materials

P_1: Insecticide impregnated polypropylene storage bag

P_2: Untreated polypropylene storage bag

P_3: Gunny bag

The experiment was initiated in the month of June, 2016. One kg of seeds were treated with emamectin benzoate 5SG @ 40 mg /kg of seeds and packed in three different packaging materials and stored for 10 months or until the germination percentage falls below MSCS level. For each treatment, one kg seeds were used and the recommended quantity of insecticide was diluted in 5 ml water to treat a kg of seed. The coating was done manually using drum, shade dried and then they were packed in different packaging materials and stored in ambient condition. Bi-monthly observations were recorded upto six months of storage, then after sixth month, monthly observations were recorded till the ten month or until the germination percentage falls below MSCS level.

The germination test was conducted by adopting between paper method as prescribed by ISTA (2010). Moisture content of cowpea seeds was estimated by oven drying method by taking 5 grams of groundnut seeds from each replication and treatment. The cowpeaseeds were ground and kept in oven for 17 hours and final weight was recorded. The moisture content of cowpeaseed was calculated by using following formula.

$$\text{Moisture content (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Whereas, W_1 = weight of empty cup with lid (g)

W_2 = weight of cup with groundnut seed samples before drying (g)

W_3 = weight of cup with groundnut seed sample after drying (g)

Observations on percent seed infestation was recorded as per the method prescribed by International Seed Testing Association (ISTA, 2010) by randomly drawing four hundred seeds from each treatment and replication, number of damaged seeds were counted and expressed as per cent damage by using following formula.

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

Seedling vigour index was calculated as per the formula given by Abdul -Baki and Anderson, 1973.

SVI-I = Germination (%) x mean seedling length (cm)

SVI-II = Germination (%) x mean seedling dry weight (mg)

Results and Discussion

In the present study seeds treated with emamectin benzoate (Proclaim 5 SG) at 40 mg/kg of seeds recorded significantly highest germination (73 %) and lowest (69 %) was in control at tenth month of storage (Table 1). With respect to packaging materials, seeds stored in insecticide impregnated bag recorded the highest germination (73 %) and the lowest (69 %) was in gunny bag after tenth month of storage. Further, among the interactions seeds treated with emamectin benzoate 5SG and stored in insecticide impregnated bags (T_1xP_1) recorded the highest germination (76%) after tenth month of storage. The least germination (68%) was observed in untreated seeds stored in gunny bag (T_2xP_3). Seed germination per cent declined progressively over a period of storage. Germination percentage of seeds stored in insecticide incorporated bags was significantly higher during the storage period than that of seeds in control. This might be due to high level of insect infestations usually resulted in lower germination percentage which was observed in seeds stored in gunny bag. These findings are in accordance with the results obtained by Wasala *et al.,* (2016) in paddy.

In the seed moisture content after tenth month of storage, significant differences were observed among treatments and packaging materials. However, there was no significant differences were observed between interactions of treatments and packaging materials. Between treatments minimum seed moisture content (10.60 %) was recorded in seeds treated with emamectin benzoate (Proclaim 5 SG) 40 mg/kg of seeds (T_1), the maximum seed moisture content

TABLE 1

Effect of insecticide treatment and insecticide impregnated packaging material on seed germination (%) in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	91	89	86	84	80	76	73
T_2	89	87	84	80	77	72	69
S.Em±	0.58	0.55	0.52	0.49	0.46	0.36	0.42
C.D at 5 %	1.71	1.63	1.53	1.45	1.37	1.08	1.25
b. Packaging materials (P)							
P_1	91	90	87	84	80	76	73
P_2	91	89	85	82	79	74	71
P_3	89	87	84	80	77	72	69
S.Em±	0.71	0.67	0.63	0.60	0.57	0.45	0.52
C.D at 5 %	NS	NS	1.87	1.78	1.68	1.33	1.53
Interaction (T×P)							
T_1P_1	93	91	88	86	82	79	76
T_1P_2	92	90	87	84	81	76	73
T_1P_3	90	88	85	82	78	74	70
T_2P_1	90	89	86	83	79	74	71
T_2P_2	90	88	84	80	77	73	69
T_2P_3	89	86	84	79	76	71	68
S.Em±	1.01	0.96	0.90	0.85	0.80	0.64	0.73
C.D at 5 %	NS	NS	2.65	2.51	2.37	1.88	2.17
CV (%)	2.22	2.16	2.10	2.07	2.04	1.71	2.06

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1**:** Insecticide impregnated polypropylene storage bag., P_2**:** Untreated polypropylene storage bag., P_3**:** Gunny bag

TABLE 2

Effect of insecticide treatment and insecticide impregnated packaging materials on seed moisture content (%) in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	9.31	9.47	9.91	10.20	10.39	10.46	10.60
T_2	9.31	9.49	9.95	10.33	10.51	10.56	10.70
S.Em±	0.03	0.03	0.04	0.03	0.03	0.03	0.03
C.D at 5 %	NS	NS	NS	0.11	0.11	0.10	0.09
b. Packaging materials (P)							
P_1	9.22	9.32	9.71	10.10	10.27	10.35	10.52
P_2	9.31	9.45	9.86	10.26	10.48	10.53	10.65
P_3	9.40	9.67	10.22	10.43	10.60	10.65	10.77
S.Em±	0.04	0.03	0.05	0.04	0.04	0.04	0.04
C.D at 5 %	NS	0.10	0.15	0.14	0.13	0.12	0.12
Interaction (T×P)							
T_1P_1	9.22	9.35	9.70	10.00	10.20	10.31	10.47
T_1P_2	9.32	9.42	9.85	10.25	10.45	10.50	10.62
T_1P_3	9.40	9.65	10.20	10.35	10.52	10.57	10.70
T_2P_1	9.23	9.30	9.71	10.20	10.35	10.40	10.57
T_2P_2	9.31	9.47	9.86	10.27	10.52	10.57	10.67
T_2P_3	9.40	9.70	10.22	10.52	10.67	10.72	10.85
S.Em±	0.06	0.05	0.07	0.06	0.06	0.06	0.05
C.D at 5 %	NS	NS	NS	NS	NS	NS	NS
CV (%)	1.47	1.09	1.45	1.32	1.24	1.15	1.08

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1**:** Insecticide impregnated polypropylene storage bag., P_2**:** Untreated polypropylene storage bag., P_3**:** Gunny bag

(10.70 %) was in untreated control (T_2) (Table 2). Seeds stored in insecticide impregnated polypropylene bags showed less variation in seed moisture content compared to gunny bag. The minimum seed moisture content was recorded in seeds stored in insecticide impregnated polypropylene bags (10.52%) and the maximum was noticed in gunny bag (10.77 %) at 10th month of seed storage. The retention of better seed storability in insecticide impregnated bag was probably attributed to its impervious nature of pores, which has offered better protection to seeds by showing less fluctuation in seed moisture content even under variable atmospheric conditions. On the contrary, seeds stored in gunny bag showed wider fluctuations in seed moisture content and greater loss of seed quality due to its permeable nature of pores. These findings are in agreement with the results obtained by Wasala *et al.,* (2016) in paddy. Similar findings were reported by Okonkwo *et al*., (2017) in cowpea and maize.

The minimum seed infestation (1.46%) was noticed in seeds treated with emamectin benzoate (Proclaim 5 SG) 40 mg/kg seeds, while the maximum was in untreated control (3.41 %) at 10 months of seed storage. Among packaging material, insecticide impregnated bag recorded the lowest seed infestation (1.38%), where as gunny bag recorded highest seed infestation (3.11%). The seed infestation during storage increased with increase in storage period in all treatment combinations. The seeds treated with emamectin benzoate (Proclaim 5 SG) 40 mg/kg seeds and stored in insecticide impregnated bag recorded zero per cent seed infestation even after ten months of storage as compared to untreated seeds stored in

TABLE 3

Effect of insecticide treatment and insecticide impregnated packaging material on seed infestation (%) in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.05 (1.19)	1.24 (1.25)	1.46 (1.32)
T_2	0.00 (0.71)	1.05 (1.19)	1.33 (1.28)	1.68 (1.39)	2.53 (1.72)	2.87 (1.82)	3.41 (1.97)
S.Em±	0	0.03	0.02	0.03	0.03	0.04	0.07
C.D at 5 %	0	0.09	0.06	0.09	0.11	0.11	0.22
b. Packaging materials (P)							
P_1	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.67 (1.03)	0.83 (1.09)	1.38 (1.25)
P_2	0.00 (0.71)	0.72 (1.05)	0.97 (1.13)	1.26 (1.22)	2.20 (1.62)	2.51 (1.71)	2.82 (1.80)
P_3	0.00 (0.71)	0.85 (1.09)	1.02 (1.15)	1.26 (1.22)	2.50 (1.71)	2.82 (1.81)	3.11 (1.89)
S.Em±	0	0.03	0.02	0.04	0.04	0.04	0.09
C.D at 5 %	0	0.11	0.07	0.11	0.13	0.14	0.27
Interaction (T×P)							
T_1P_1	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_1P_2	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.35 (1.35)	1.60 (1.44)	1.95 (1.56)
T_1P_3	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.80 (1.51)	2.12 (1.61)	2.45 (1.71)
T_2P_1	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.35 (1.35)	1.67 (1.47)	2.77 (1.80)
T_2P_2	0.00 (0.71)	1.45 (1.39)	1.95 (1.56)	2.52 (1.73)	3.05 (1.88)	3.42 (1.98)	3.70 (2.04)
T_2P_3	0.00 (0.71)	1.70 (1.48)	2.05 (1.59)	2.52 (1.73)	3.20 (1.92)	3.52 (2.00)	3.75 (2.06)
S.Em±	0	0.05	0.03	0.05	0.06	0.06	0.12
C.D at 5 %	0	0.16	0.10	0.16	0.19	0.20	0.38
CV (%)	0	21.53	11.18	13.57	7.32	6.77	10.64

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1**:** Insecticide impregnated polypropylene storage bag., P_2**:** Untreated polypropylene storage bag., P_3**:** Gunny bag

gunny bag which recorded maximum infestation (3.75 %) (Table 3). This might be due to a novel and innovative tool, an insecticide impregnated polypropylene bag which shows powerful killing action to insects and no insects could not bore through this packaging material (Wasala *et al*., 2016) in paddy seeds. Similar findings were observed by Okonkwo *et al*. (2017) in cowpea and maize.

The disease infection (%) after the tenth month of storage, recorded significant differences among the seed treatments and packaging materials. The lowest infection (2.33%) was noticed in the emamectin benzoate (Proclaim 5 SG) 40 mg/kg of seeds (T_1). The highest infection per cent was noticed in untreated control T_2 (6.83 %). Among packaging materials, the lowest per cent of seed infection was recorded in insecticide impregnated polypropylene bag (P_1) (2.25 %) and the highest infection (7.00 %) was recorded in gunny bag (P_3) (Table 4). Meanwhile, significant differences were observed among treatments and packaging materials interactions. The lowest infection (1.75 %) was recorded in T_1P_1, whereas, the highest infection was recorded in T_2P_3 (10.50 %).This was due to the effectiveness of seed treatment chemicals against seed infection. Effectiveness of emamectin benzoate observed in the present study are in partial agreement with results of Raghuraman *et al*., (2008) and Mirmoayedi *et al.* (2011) who also found these chemicals to be quite effective under laboratory conditions.

At tenth month of storage vigour index-I recorded the significant differences with respect to treatments. The highest seedling vigour index-I (2134) was observed in emamectin benzoate (Proclaim 5 SG) 40 mg/kg of seeds (T_1). The lowest seedling vigour index-I (1899) was recorded in untreated control (T_2). Meanwhile

TABLE 4

Effect of insecticide treatment and insecticide impregnated packaging material on seed infection (%) in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	0.50(0.93)	0.91(0.10)	1.41(1.29)	1.75(1.48)	1.83(1.51)	2.66(1.75)	2.33(1.64)
T_2	0.75(1.06)	1.83(1.50)	4.16(2.07)	5.00(2.28)	6.41(2.54)	6.75(2.61)	6.83(2.62)
S.Em±	0.08	0.09	0.12	0.10	0.09	0.08	0.08
C.D at 5 %	NS	0.29	0.37	0.31	0.28	0.26	0.25
b. Packaging materials (P)							
P_1	0.00(0.71)	0.87(1.11)	1.37(1.30)	2.37(1.61)	2.25(1.63)	2.50(1.71)	2.25(1.63)
P_2	0.75(1.05)	1.12(1.20)	2.37(1.58)	3.12(1.85)	4.25(2.05)	4.75(2.19)	4.50(2.12)
P_3	1.12(1.24)	2.12(1.59)	4.62(2.16)	4.62(2.16)	5.87(2.39)	6.87(2.64)	7.00(2.64)
S.Em±	0.10	0.12	0.15	0.13	0.11	0.10	0.10
C.D at 5 %	0.29	0.35	0.46	0.39	0.34	0.32	0.30
Interaction (T×P)							
T_1P_1	0.00(0.71)	0.50(0.92)	1.00(1.12)	1.25(1.31)	1.75(1.47)	2.00(1.56)	1.75(1.47)
T_1P_2	0.50(0.92)	0.75(0.99)	1.25(1.19)	2.00(1.56)	1.50(1.40)	2.25(1.63)	1.75(1.49)
T_1P_3	1.00(1.18)	1.50(1.40)	2.00(1.56)	2.00(1.56)	2.25(1.65)	3.75(2.05)	3.50(1.97)
T_2P_1	0.00(0.71)	1.25(1.31)	1.75(1.47)	3.50(1.92)	2.75(1.78)	3.00(1.86)	2.75(1.78)
T_2P_2	1.00(1.18)	1.50(1.40)	3.50(1.97)	4.25(2.14)	7.00(2.70)	7.25(2.75)	7.25(2.76)
T_2P_3	1.25(1.31)	1.27(1.78)	7.25(2.76)	7.25(2.76)	9.50(3.14)	10.0(3.22)	10.50(3.30)
S.Em±	0.14	0.17	0.22	0.18	0.16	0.15	0.14
C.D at 5 %	NS	NS	NS	NS	0.49	0.45	0.43
CV (%)	28.22	26.42	26.37	19.93	16.56	14.19	13.80

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1: Insecticide impregnated polypropylene storage bag., P_2: Untreated polypropylene storage bag., P_3: Gunny bag

TABLE 5

Effect of insecticide treatment and insecticide impregnated packaging material on seedling vigour index I in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	3672	3475	3198	3011	2780	2470	2134
T_2	3492	3295	2983	2767	2582	2228	1899
S.Em±	43.6	34.8	31.7	31.5	22.6	17.6	16.9
C.D at 5 %	128.36	102.39	93.31	92.84	66.65	52.00	49.74
b. Packaging materials (P)							
P_1	3695	3517	3268	3084	2833	2515	2202
P_2	3552	3359	3046	2832	2655	2306	1997
P_3	3499	3280	2957	2751	2557	2226	1852
S.Em±	53.4	42.6	38.8	38.6	27.7	21.6	20.7
C.D at 5 %	157.22	125.40	114.29	113.7	81.64	63.69	60.92
Interaction (T×P)							
T_1P_1	3750	3565	3306	3141	2889	2653	2337
T_1P_2	3659	3485	3204	3000	2791	2398	2157
T_1P_3	3606	3374	3084	2893	2661	2359	1909
T_2P_1	3639	3468	3230	3027	2776	2376	2067
T_2P_2	3445	3232	2887	2665	2519	2214	1837
T_2P_3	3392	3185	2831	2610	2452	2093	1794
S.Em±	75.6	60.3	54.9	54.6	39.2	30.2	29.3
C.D at 5 %	NS	NS	NS	NS	NS	NS	86.16
CV (%)	4.22	3.56	3.55	3.78	2.92	2.60	2.90

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1: Insecticide impregnated polypropylene storage bag., P_2: Untreated polypropylene storage bag., P_3: Gunny bag

TABLE 6

Effect of insecticide treatment and insecticide impregnated packaging material on seedling vigour index II in cowpea cv. C-152 during storage

Treatments	Storage period (June 2016 - April 2017)						
	2 MAS	4MAS	6 MAS	7 MAS	8 MAS	9 MAS	10 MAS
a. Insecticide treatment (T)							
T_1	4766	4536	4195	3981	3730	3517	3343
T_2	4609	4252	3975	3720	3469	3238	3070
S.Em±	71.7	42.2	36.0	32.6	34.7	27.0	31.3
C.D at 5 %	NS	124.26	105.98	95.94	102.04	79.57	92.02
b. Packaging materials (P)							
P_1	4859	4517	4253	4034	3752	3546	3383
P_2	4733	4440	4097	3869	3645	3398	3231
P_3	4470	4223	3904	3649	3402	3190	3006
S.Em±	87.8	51.7	44.1	39.9	42.5	33.1	38.3
C.D at 5 %	258.50	152.19	129.80	117.50	124.98	97.45	112.7
Interaction (T×P)							
T_1P_1	4978	4646	4361	4152	3879	3741	3572
T_1P_2	4814	4601	4216	4018	3800	3512	3361
$T1P_3$	4505	4360	4007	3733	3511	3298	3097
T_2P_1	4739	4388	4145	3915	3625	3350	3195
T_2P_2	4651	4280	3979	3721	3490	3284	3101
T_2P_3	4436	4087	3801	3525	3293	3081	2915
S.Em±	124.2	73.1	62.4	56.5	60.0	46.8	54.1
C.D at 5 %	NS	NS	NS	NS	NS	NS	NS
CV (%)	5.30	3.33	3.05	2.93	3.33	2.77	3.37

MAS = Months after storage., NS = Non significant., T_1: Emamectin benzoate 5SG @ 40 mg /kg of seeds., T_2: Untreated control., P_1: Insecticide impregnated polypropylene storage bag., P_2: Untreated polypropylene storage bag., P_3: Gunny bag

significant differences with respect to packaging materials was observed. The highest seedling vigour index-I (2202) was in insecticide impregnated polypropylene bag (P_1). The lowest seedling vigour index-I (1852) was recorded in gunny bag (P_3) (Table 5). Further, significant differences among the interactions between treatments and packaging materials were observed at the tenth month of storage. The highest seedling vigour index-I (2337) was recorded in T_1P_1 followed by T_1P_2 (2157), whereas the lowest seedling vigour index-I was observed in T_2P_3 (1794).

Vigour index –II recorded the significant differences after ten months of storage with respect to treatments. The highest seedling vigour index-II (3343) was recorded in emamectin benzoate (Proclaim 5 SG) 40 mg/kg of seeds (T_1). The lowest seedling vigour index-II (3070) was in untreated control (T_2). Further, significant differences with respect to packaging materials were observed. Insecticide impregnated polypropylene bag (P_1) recorded the highest seedling vigour index-II (3383), the lowest seedling vigour index-II (3006) was in gunny bag (P_3). There were no significant differences among the interactions between treatments and packaging materials throughout the storage period upto ten months (Table 6). The decline in seedling vigour indices may be attributed to decrease in germination per cent, seedling length and dry matter accumulation in seedling. These findings are in agreement with the results obtained Shivayogi Ryavalad *et al.* (2009) in cotton.

The above study revealed that the seeds treated with emamectin benzoate (Proclaim 5 SG) 40 mg/kg of seeds and stored in insecticide impregnated packaging material maintained seed quality parameters above minimum seed certification standards up to ten months of storage with negligible seed infection and infestation percentage.

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