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Effect of Newer Insecticides as Fabric Treatment on Maize Seed Viability during Storage under Ambient Conditions

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Abstract

A storage experiment was conducted to study the effect of packaging material with insecticides *viz.*,Flubendiamide 480 SC @100 ppm a.i., Emamectin benzoate 5 SG @100 ppm a.i., Spinosad 45 SC @100 ppm a.i., Deltamethrin 2.8 EC@100 ppm a.i., Untreated control and three different storage bags of Gunny bag, Porous High Density Polyethylene (HDPE) bag and Cloth bag for controlling *Sitophylus zeamais* M., *S. oryzae* (Linn.) insect pests of maize under ambient conditions from 2010 to 2013. The results revealed that spinosad 45SC @100 ppm a.i. was most effective by recording highest germination (85.48 per cent) and least seed damage (0.6 per cent) at nine months after treatment imposition, closely followed by emamectin benzoate 5 SG @100 ppm a.i. (84.74 and 1.24 per cent respectively). However, with respect to packaging material, the highest germination (82.80 per cent) and least seed damage (2.51 per cent) was observed in porous HDPE bags. Among the interactions, the highest germination (87.00 per cent) and least seed damage (0.44 per cent) was observed in porous HDPE bags treated with spinosad 45 SC after nine months of storage. The cost benefit ratio was highest (1:14.98) in HDPE bags treated with spinosad 45 SC.

Keywords : Insecticides, emamectin benzoate, spinosad, fabric, maize, viability

Maize (*Zia mays* L.) is one of the most important cereals of the world. It has worldwide significance as human food, animal feed and as a raw material for large number of industrial products. In India maize is grown in an area of 6.08 million hectares contributing 10.67 million tones of production with a productivity of 1760 kg ha^{-1}. In Karnataka, it is the third largest cereal crop next to sorghum and paddy and it occupies an area of 4.98 lakh ha with an annual production of about 16.18 lakh with a productivity of 3250 kg ha^{-1} (Anon., 2011). The improved quality seed should posses good germination, optimum moisture content and free from insects pests as per seed certification standards. Sometimes hybrid seeds are to be stored for more than one season. In such cases deterioration of valuable seeds due to insect pests is major constraint. The primary damage in stored maize seed is mainly by *Sitophylus zeamais* M., *S. oryzae* (Linn.) all over the world followed by *Rhzopertha dominica* (Fab) and *Tribolium castaneum* Herbest. Little work has been done on fabric treatment with insecticides in which seeds were stored. With this view, the current research has been formulated to investigate the newer insecticides as fabric treatment on improving the storability and seed quality of maize. The experiment was formulated and carried out for three consecutive years.

Material and Methods

A laboratory experiment was carried out to know the efficacy of newer insecticide molecules treated on different packaging materials at All India Coordinated Research Project on Seed Technology, National Seed Project, University of Agricultural Sciences, Bengaluru from 2010-2013. One kilogram of freshly harvested certified maize seeds having highest per cent of germination and optimum moisture content were taken for each treatment. The experiment was initiated by adopting Factorial Completely Randomized Design with following treatments in three replications. The treatments were :

Treat-ments	Treatment details	Concentra-tion of a.i.(ppm)	Quantity of formulation (litre/g) for fabric treatment
T_1	Flubendiamide 480 SC	100	0.2
T_2	Emamectin benzoate 5 SG	100	2.0
T_3	Spinosad 45 SC	100	0.2
T_4	Deltamethrin 2.8 EC	100	3.5
T_5	Untreated control		

Packaging material (2kg capacity each)

1. Gunny bag
2. Porous High Density Poly Ethylene bag (HDPE)
3. Cloth bag

Insecticidal solutions were prepared as mentioned above and treated on package material with 7.5 ml spray fluid per bag of 30 x 40 cm dimension. After shade drying the packaging material, seeds were filled in bags and kept for storage under ambient conditions. The germination test was conducted by between paper method as prescribed by ISTA (2010). Moisture content of maize seeds were estimated by oven drying method by taking 5 grams of seeds from each replication and treatment. The seeds were grinded and kept in oven for 17 hours and final weight was recorded. The moisture content of seeds was calculated by using following formula.

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

Where as 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 damage 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 the following formula :

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

RESULTS AND DISCUSSION

At three months after treatment imposition, significant differences were observed with respect to germination per cent among the treatments and interactions between treatments and packaging materials. The highest germination (91.89 per cent) was recorded in spinosad 45 SC @ 100 ppm which was on par with all other treatments and differed significantly over untreated control (89.33 per cent). The packaging materials did not show any significant differences with respect to germination per cent. However, the porous HDPE bag recorded highest germination (91.62 per cent). Among the interaction between insecticides and packaging materials spinosad 45 SC treated porous HDPE bag (T_3P_2) recorded the highest germination (92.77 per cent) which was on par with interaction of emamectin benzoate 5SG treated gunny bag (T_2P_1) (92.44 per cent) and flubendiamide 480SC treated porous HDPE bag (T_1P_2) (92.00 per cent) and all of them differed significantly over all other interactions. The least germination of 88.67 per cent was recorded in untreated control of cloth bag (Table I).

The germination per cent after six months of storage recorded significant differences among the treatments, packaging materials and interaction between treatments and packaging materials. The highest germination (88.00 per cent) was observed in spinosad 45 SC @100 ppm which was on par with emamectin benzoate 5 SG @100 ppm (87.52 per cent) and deltamethrin 2.8EC (86.15 per cent) and differed significantly over flubendiamide 480 SC (85.55 per cent) and the least was in untreated control (82.22 per cent). Among the packaging material porous HDPE bag recorded the significantly highest germination (88.02 per cent). The interactions between treatment and packaging materials spinosad 45 SC treated porous HDPE bag (T_3P_2) recorded the highest germination (89.89 per cent) which was on par with interaction of emamectin benzoate 5 SG treated porous HDPE bag (T_2P_2) (88.89 per cent) and the first one differed significantly over all other interactions.

The results recorded after nine months of storage revealed significant differences among the treatments (Table I). The highest germination (85.48 per cent) was noticed in seeds treated with spinosad 45 SC @100 ppm, the next best treatment was emamectin benzoate 5SG @100 ppm (84.74 per cent). Both of them were on par with each other and differed significantly over all other treatments and the untreated control recorded least germination (70.04 per cent). Among the packaging materials, porous

TABLE I

Effect of different treatments and packing materials on germination of maizeduring storage 2010-2013 (Pooled data)

Treatments	Germination (%)											
	3 MAT				6 MAT				9 MAT			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
T_1= Flubendiamide480 SC @100 ppm a.i.	91.66 [ab]	92.00 [a]	90.89	91.52 [a]	84.33	87.44	84.89	85.55 [b]	78.11	82.33 [ab]	77.33	79.26 [b]
T_2=Emamectin benzoate SG @ 100 ppm a.i.	92.44 [a]	91.33 [ab]	91.66 [ab]	91.81 [a]	87.33 [ab]	88.89 [ab]	86.33 [bc]	87.52 [a]	84.00	85.11 [ab]	85.11 [ab]	84.74 [a]
T_3=Spinosad45SC @100 ppm a.i	91.67 [ab]	92.77 [a]	91.22	91.89 [a]	87.11	89.89 [a]	87.00	88.00 [a]	84.44 [ab]	87.00 [a]	85.00 [ab]	85.48 [a]
T_4= Deltamethrin2.8 EC @100 ppm a.i	91.22	91.89 [ab]	90.55	91.22 [a]	85.44 [c]	87.67 [ab]	85.33	86.15 [ab]	79.77	82.33	79.44	80.52 [b]
T_5= Untreated control	89.22 [b]	90.11 [ab]	88.67 [c]	89.33 [b]	80.44 [d]	86.22 [bc]	80.00	82.22 [c]	67.00	77.22	65.89	70.04 [c]
Mean	**91.24**	**91.62**	**90.60**		**84.93**	**88.02**	**84.71**		**78.66**	**82.80**	**78.55**	

	SEm±	CD (0.05)	SEm±	CD (0.05)	SEm±	CD (0.05)
Treatments (T)	0.54	1.56	0.65	1.87	1.26	3.64
Packaging Material	0.42	NS	0.50	1.44	0.98	2.83
T x M	0.94	2.71	1.13	3.26	2.18	6.30
	1.79		2.28		4.73	

P_1, P_2, P_3: Gunny bag, Porous HDPE bag and Cloth bag, respectively.

NS: Non significant

Means followed by same alphabet in a column do not differ significantly;

MAT: Months after treatment

HDPE bag recorded significantly highest germination (82.80 per cent) over gunny bag (78.66 per cent) and cloth bag (78.55 per cent). Further, the spinosad 45 SC treated porous HDPE bag (T_3P_2) recorded highest germination (87.00 per cent) and differed significantly over T_5P_1 (67.00 per cent) and T_5P_3 (65.89 per cent). Germination percentage of seeds stored in insecticide incorporated bags was significantly higher during the whole storage period than that of seeds in control. This might be due to high level of insect infestations that resulted in lower germination percentage in seeds stored in gunny bag. These findings are in accordance with the results obtained by Wasala *et al.* (2016) in paddy.

The moisture content after three months of storage did not show significant differences with respect to treatments, packaging materials and among the interactions. However, the least moisture content was observed in the treatment spinosad 45 SC (10.03%) and porous HDPE bag (9.88%) respectively and among the interaction spinosad 45 SC treated porous HDPE bag (T_3P_2) recorded least moisture content (9.83 per cent). After six months of storage, the moisture content recorded non significant results among the treatments, packaging material and interaction between treatments and packaging materials. However, among the interactions the least moisture content (10.42 %) was observed in emamectin benzoate 5SG treated porous HDPE (T_2P_2) bags (Table II). The moisture content recorded non significant results after nine month of storage with respect to treatments, packaging materials and interaction between treatments and packaging materials. 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 insect damage after three months of storage recorded least (0.12 per cent) in the emamectin benzoate 5 SG @100 ppm treated seeds, which was on par with spinosad 45 SC @ 100 ppm (0.13 per cent) and differed significantly with all other treatments. Untreated control recorded the highest seed damage (0.78 per cent). The packaging materials did not show significant differences with respect to seed damage, similar trend was observed among the interactions of packaging materials treated with insecticides. However, spinosad 45 SC treated porous HDPE bag (T_3P_2) recorded the nil insect damage and the highest insect damage (0.72 per cent) was observed in untreated control with gunny bag (Table III).

The insect damage recorded significant results among the treatments after six months, spinosad 45 SC @ 100 ppm recorded least insect damage (0.36 per cent) which was on par with all other treatments and differed significantly over untreated control which recorded the highest insect damage (3.53 per cent). The packaging materials did not show significant differences. However, porous HDPE bags recorded least insect damage (0.88 per cent). Among the interactions spinosad 45SC @100 ppm treated porous HDPE bag (T_3P_2) recorded least insect damage (0.28 per cent) which differed significantly over T_5P_3 (4.08 per cent) and T_5P_1 (4.17 per cent) (Table II).

The insect damage after nine months of storage revealed significant differences among the treatments, the least insect damage (0.60 per cent) was observed in seeds treated with spinosad 45SC @ 100 ppm which was on par with emamectin benzoate 5 SG @ 100 ppm (1.24 per cent) and deltamethrin 280 EC @ 100 ppm and differed significantly over untreated control with highest seed damage (10.50 per cent). The packaging material did not show significant differences. However, porous HDPE bag recorded least seed damage (2.51 per cent). Among the interactions between treatments and packaging materials spinosad 45 SC @100 ppm treated porous HDPE bag (T_3P_2) recorded least insect damage (0.44 per cent) which was on par with many of the interactions and differed significantly over T_5P_2 (8.39 per cent), T_5P_3 (11.42 per cent) and T_5P_1 (11.69 per cent) (Table III).

TABLE II

Effect of different treatments and packing materials on moisture content per cent of maizeduring 2010-2013 (Pooled data)

Treatments	Germination (%)											
	3 MAT				6 MAT				9 MAT			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
T_1= Flubendiamide480 SC @ 100 ppm a.i.	10.10	9.94	10.21	10.08	10.52	10.90	10.55	10.49	11.59	11.82	11.78	11.73
T_2=Emamectin benzoate 5SG @ 100 ppm a.i.	10.10	9.94	10.14	10.06	10.62	10.42	10.69	10.58	11.76	11.58	11.51	11.62
T_3=Spinosad45SC @100 ppm a.i	10.08	9.83	10.12	10.03	10.39	10.50	10.67	10.52	11.64	11.60	11.60	11.61
T_4= Deltamethrin2.8 EC @100 ppm a.i	10.12	9.77	10.17	10.04	10.77	10.58	10.78	10.71	11.46	11.64	11.91	11.67
T_5= Untreated control	10.12	9.91	10.17	10.06	10.82	10.70	10.77	10.76	11.91	11.85	12.00	11.92
Mean	**10.11**	**9.88**	**10.17**		**10.62**	**10.52**	**10.69**		**11.67**	**11.70**	**11.76**	

	SEm±	CD (0.05)	SEm±	CD (0.05)	SEm±	CD (0.05)
Treatments (T)	0.48	NS	0.23	NS	0.25	NS
Packaging Material	0.37	NS	0.18	NS	0.20	NS
T x M	0.83	NS	0.39	NS	0.44	NS
CV (%)	14.38		6.50		6.62	

P_1, P_2, P_3: Gunny bag, Porous HDPE bag and Cloth bag, respectively.

NS: Non significant

Means followed by same alphabet in a column do not differ significantly;

MAT: Months after treatment

TABLE III

Effect of different treatments and packing materials on insect damage of maizeduring 2010-2013 (Pooled data)

Treatments	Germination (%)											
	3 MAT				6 MAT				9 MAT			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
T_1= Flubendiamide480 SC @100 ppm a.i.	0.17	0.05	0.22	0.15 ^{a}	1.10 ^{ab}	0.94 ^{ab}	1.22	1.09 ^{a}	4.00	1.80	3.81	3.20 ^{a}
T_2=Emamectin benzoate 5SG @ 100 ppm a.i.	0.14	0.05	0.17	0.12 ^{a}	0.58 ^{ab}	0.42 ^{a}	0.75 ^{ab}	0.58 ^{a}	1.44 ^{a}	0.64 ^{a}	1.64 ^{a}	1.24 ^{a}
T_3=Spinosad45SC @100 ppm a.i	0.05	0.00	0.33	0.13 ^{a}	0.44 ^{ab}	0.28 ^{a}	0.36 ^{a}	0.36 ^{a}	0.612 ^{a}	0.44 ^{a}	0.75 ^{a}	0.60 ^{a}
T_4= Deltamethrin2.8 EC	0.14	0.14	0.22	0.17 ^{a}	0.50 ^{ab}	0.42 ^{a}	0.56 ^{ab}	0.49 ^{a}	1.83	1.27	2.00	1.70 ^{a}
T_5= Untreated control	0.72	0.66	0.67	0.78 ^{b}	4.17	2.36 ^{b}	4.08	3.53 ^{b}	11.69	8.39	11.42	10.50 ^{b}
Mean	**0.24**	**0.18**	**0.38**		**1.36**	**0.88**	**1.40**		**3.92**	**2.51**	**3.92**	
		SEm±		CD (0.05)		SEm±		CD (0.05)		SEm±		CD (0.05)
Treatments (T)		0.14		0.40		0.37		1.07		0.79		2.28
Packaging Material		0.11		NS		0.29		NS		0.61		NS
T x M		0.25		NS		0.66		1.90		1.38		3.99
CV (%)			101.0				694.06				69.26	

P_1, P_2, P_3: Gunny bag, Porous HDPE bag and Cloth bag, respectively.

NS: Non significant

Means followed by same alphabet in a column do not differ significantly;

MAT: Months after treatment

TABLE IV

Cost Benefit Ratio for adopting fabric treatment of different treatments and packing materials

Chemicals	Dosage/lt	Quantity required per 3 bags	Cost of 3bags (Rs) +chemicals	Damage (%)	Loss due to damage (Rs)	Total loss (Rs)/ Qtl	C:B
Flubendiamide 480 SC 100 ppm ai + Gunny bag			43.00	4.00	560.00	603.00	2.78
Flubendiamide 480 SC 100 ppm ai + HDPE bag	0.2ml	0.01ml	18.00	1.80	252.00	270.00	4.41
Flubendiamide 480 SC 100 ppm ai + Cloth bag			38.00	3.80	532.00	570.00	2.81
Emamectin benzoate5 SG 100 ppm ai + Gunny bag			43.00	1.44	201.60	244.60	6.88
Emamectin benzoate5 SG 100 ppm ai + HDPE bag	2g	0.06g	18.00	0.63	88.20	106.20	11.23
Emamectin benzoate5 SG 100 ppm ai + Cloth bag			38.00	1.63	228.20	266.20	6.02
Spinosad 45 SC 100 ppm ai + Gunny bag			43.00	0.61	85.40	128.40	13.08
Spinosad 45 SC 100 ppm ai + HDPE bag	0.2ml	0.01ml	18.00	0.44	61.60	79.60	14.98
Spinosad 45 SC 100 ppm ai + Clothbag			38.00	0.75	105.0	143.00	11.21
Deltamethrin 2.8EC 100 ppm ai + Gunny bag			43.00	1.83	256.20	299.20	5.61
Deltamethrin 2.8EC 100 ppm ai + HDPE bag	3.5ml	0.12 ml	18.00	1.27	177.80	195.80	6.01
Deltamethrin 2.8EC 100 ppm ai + Cloth bag			38.00	2.00	280.00	318.00	5.04
Untreated control + Gunny bag			43.00	11.69	1636.60	1679.60	-
Untreated control + HDPE bag	-	-	18.00	8.39	1174.60	1192.60	-
Untreated control + Cloth bag			38.00	11.18	1565.20	1603.20	-

Cost of seed Rs. 7000/qtl

The seed infestation with storage insect pest was increased with increase in storage period in all treatment combinations. The insecticide treated bags recorded least insect damage over untreated control. This was due to the effectiveness of seed treatment chemicals against storage insects (Biradar Patil and Shekaragouda, 2007). Similar results were reported by Mulla Mohammed (2012) in hybrid maize.

Cost benefit ratio was calculated to know which combination of treatment and packaging material is most beneficial to farming communities. The data revealed that the highest cost benefit (1:14.98) ratio was in spinosad 45 SC @100 ppm treated porous HDPE bag which was followed by spinosad 45 SC @100 ppm treated gunny bag (1:13.08) and emamectin benzoate 5SG @100 ppm treatedporous HDPE bag (1:11.23) which were far above than all other treatment combinations (Table IV).

The above finding revealed that spinosad 45 SC @100 ppm and porous HDPE bags were effective in managing *Sitophylus zeamais* and *Sitophylus oryzae* upto nine months without affecting the seed quality. These findings are new and no work has been done on these aspects in recent years.

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