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Effect of seed coating with synthetic polymer and additives on storability of soybean seeds under mid hill condition of Himachal Pradesh

Shipra Thakur and K.C. Dhiman
Department of Seed Science and Technology
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 062, India.
Corresponding author: karam_dhiman@yahoo.co.in

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Abstract

An experiment was conducted at Seed Technology Laboratory, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during 2013-14 to study the effect of seed coating with polymer, fungicides and insecticide on seed quality of soybean var. Harasoya. The seeds were coated with polymer, fungicides, insecticide, polymer-fungicides and polymer insectiside combinations and stored in polythene bag for 12 months. Irrepective of seed coating with synthetic polymer and additives, seed deteriorated and the vigour declined with increased fungal infection and insect infestation after twelve months of storage seeds. Seed coated with polymer @ 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) maintained the highest soybean seed germination (84.00%), seedling length (28.80cm), field emergence (76.5%), seedling dry weight (0.435g) and seedling vigour index (2419) upto 12 months over the untreated control (T_0). Seed coated with polymer @ 3.0 ml per kg of seed and imidacloprid @ 6 ml per kg of seed (T_7) recorded lowest insect infestation (0.50%) and seed coated with polymer @ 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) exhibited lowest seed infection (1.25%) as compared to untreated control ($T_{0)}$ at the end of 12 months of storage.

Key words: Soybean, synthetic polymer, additives, seed quality, storability.

Soybean [*Glycine max* (L.) Merr.] is an important leguminous oilseed crop in India. It has wide significance as food, feed and raw material in industries. It contains about 40 per cent protein and 20 per cent oil content (Singh and Chung, 2007). Its Protein is rich in lysine and its oil is rich in essential fatty acids like Omega-3 and Omega-6. In addition, it is a good source of dietary fibres, vitamins and minerals, hence termed as "miracle crop". It also contains various phytochemicals as isoflavones (genistein, daidzein and glycitein) that protect human body from chronic diseases such as prostate cancer, diabetes, osteoporosis, blood pressure, postmenopausal syndromes, coronary heart diseases etc. A number of protein rich products like soymilk, soypaneer (TOFU), soysauce, soy flour etc. are produced from soybean seeds. In Himachal Pradesh, it occupies an area of 601 ha with a production of 837 tonnes and productivity of 13.93 quintal per hectare (Anonymous, 2004) and has a lot of scope for further expansion in terms of area and production in places like Kangra, Mandi and Kullu districts.

For effective soybean cultivation, the availability of good quality seed remains one of the major constraints as the soybean seed has poor storability and loose viability and vigour during storage. With the development of organized seed production and marketing, seeds men are becoming aware of the problems of seed storage and systematic research has been initiated. It is stipulated that 80 per cent of seeds produced in India require storage for one planting season and 20 per cent of seed is carried over for a subsequent sowing (Bal, 1976). However, if the awareness and infrastructure developed substantially, quality seeds can be stored for few planting season as a safeguard against monsoon failure and as a precaution against poor quality seed being supplied to the farmers. Therefore, the present study was undertaken to investigate the utility of coating of seed with polymer alone and in combination with other additives like thiram, vitavax and imidacloprid for improving the storability and to know the effect of these treatments on seed quality during storage.

Materials and Methods

The laboratory experiment was carried out during 2013-14 in the Seed Technology Laboratory of Department of Seed Science and Technology, CSKHPKV, Palampur. Eight treatments viz., T_0 - control (untreated seeds), T_1 - polymer coating (polykote @ 3 ml per kg of seed, diluted with 5 ml of water), T_2 - flowable thiram (Royal flow 40 SC) @ 2.4 ml per kg of seed, T_3 - polymer + flowable thiram (Royal flow 40 SC) @ 2.4 ml per kg of seed, T_4 - vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2g per kg of seed, T_5 - polymer + vitavax 200 (containing thiram, 37.5% and carboxil, 37.5%) @ 2g per kg of seed, T_6 - imidacloprid (17.8 % SL) @ 6 ml per kg of seed and T_7 - polymer + imidacloprid (17.8 % SL) @ 6 ml per kg of seed were evaluated in completely randomized block design with four replications. The coated seeds of various treatments were packed in HDPE (high density polyethylene) interwoven bags in the month of December 2013 and stored under ambient condition in Seed Technology Laboratory of Department of Seed Science and Technology, CSK HPKV, Palampur. Evaluation of seed quality parameters, namely, germination (%), seedling length (cm), field emergence (%), seedling dry weight (g), seedling vigour index, seed moisture content and seed health status i.e. insect infestation (%) and fungal infection (%) was made initially and subsequently at bimonthly intervals in order to determine the suitable polymer-chemical combinations for better storage of soybean.

Results and Discussion

Seed deterioration is irreversible and inexorable process. However, the rate of seed deterioration could be slowed down either by storing the seeds under controlled conditions or by imposing certain treatments with either chemicals or any other protectants. Seed coating with polymers is one such pre-storage treatment that can be used either singly or in combination with other pesticides to protect seeds against pests and diseases. (Duan and Burris, 1997) explained the possibilities of using polymers along with other chemicals to ensure the keeping quality of seeds. The rapid deterioration of stored seed is a serious problem, particularly, in high relative humidity areas and associate with accelerated ageing phenomenon. Since the controlled condition involves huge cost, the seed coating could be one of the best alternative approaches to maintain seed quality during storage.

Significant results were obtained due to polymer coating for all the seed quality parameters evaluated in the laboratory. Germination percentage declined in all the treatments gradually from 84.0 to 74.5 with the advancement in the storage period but it was above minimum seed certification standards (i.e. 70.0%) at the end of 12 months of storage (Table 1). Among the different treatments, seed coated with polymer 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) recorded significantly higher germination (84.0%) followed by 83.0% in T_5 (seed coating

Fig 1. Soybean (var. Hara soya) seed coated with polymer and chemicals, and stored for 12 months

with polymer @ 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to control (74.5%). The polymer with fungicide reduces the impact of ageing enzymes by acting as protective agents against seed deterioration due to fungal invasion, insect attack and physiological ageing as a result of which the seed viability could be maintained for a comparatively longer period of time. These results are in conformity in maize (Vanangamudi *et al.*, 2003) and chilli (Manjunatha *et al.*, 2008).

Significantly higher seedling length (28.80 cm) was recorded for seed coated with polymer 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) followed by 28.35 cm in T_5 (polymer 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to untreated seeds (T_0) which recorded lower seedling length (25.78 cm) at the end of 12 months of storage (Table 1). The decline in seedling length may be attributed to age induced decline in germination and damage caused by fungi and insects, and higher seedling length in polymer and flowable thiram (T_3) coated seeds was due to higher percentage of germination and better initial growth of seedlings, as it protect fungal invasion leading to better germination and subsequent higher seedling length. Similar results were reported in rice (Dadlani *et al.,* 1992) and soybean (Polimero *et al.*, 2007).

Field emergence due to seed treatment with synthetic polymer and additives varied throughout the storage period. Significantly higher field emergence (76.50%) was recorded in seeds coated with polymer @ 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) followed by 74.50% in T_5 (polymer 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to untreated seeds (T_0) which recorded lower field emergence (68.50%) at the end of 12 months of storage (Table 2). This decrease in field emergence may be due to age induced deteriorative changes in cell and cell organelles and germination capacity of seed under natural soil conditions. Higher field emergence can be seen in polymer dye coated seeds. It is due to increase in the rate of imbibitions where the fine particles in the coating act as a moisture attracting material or perhaps to improve seed soil contact. Coating with hydrophilic polymer regulates the rate of water uptake, reduce imbibitions damage and improve the emergence of soybean seeds. Similar findings were reported in soybean (Hwang and Sung, 1991; Chachalis and Smith, 2001).

The seedling dry weight varied significantly throughout the storage period till the end and continued to decrease from initial to last month of the storage period, irrespective of seed treatment with synthetic polymer and additives. Significantly higher seedling dry weight (0.435 g) was recorded for seed coated with polymer 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) followed by (0.430 g) in T_5 (polymer 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to untreated seeds (T_0) which recorded lower seedling dry weight (0.362 g) at the end of 12 months of storage (Table 2). The dry matter production of seedling is the ultimate manifestation of physiological vigour. This is essentially a physiological phenomenon influenced by the reserve metabolites, enzyme activities and growth regulators. Similar findings were recorded in rice (Dadlani *et al.*, 1992) and chickpea (Khatun and Bhuiyan, 2011).

Gradual decrease in seedling vigour index (germination percentage x seedling length) was recorded with increase in storage period irrespective of seed treatment. Significantly higher vigour index (2419) was recorded in seeds coated with polymer 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) followed by 2353 in T_5 (polymer 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to untreated seeds (T_0) which recorded lower seedling vigour index (1920) at the end of 12 months of storage (Table 3). The decrease in vigour index may be due to age induced decline in germination, decrease in dry matter accumulation in seedlings and decrease in seedling length. Similar findings were reported in maize (Vanangamudi *et al.*, 2003) and cluster bean (Renugadevi *et al.,* 2008).

Amount of moisture in seeds is probably the most important factor influencing seed viability during storage. The moisture content of seed due to polymer and additive coating varied significantly throughout the storage period (Table 3). Among the different treatments, seed coated with imidacloprid @ 6 ml per kg of seed (T_6) recorded significantly lowest moisture content (6.73%) followed by 6.75% in T_7 (seed coated with polymer @ 3.00 ml per kg of seed and imidacloprid @ 6 ml per kg of seed) as compared to control (6.95%). In storage conditions, where the relative humidity fluctuates and especially at night, seed moisture content varies in equilibrium with atmospheric water vapour and to obtain that equilibrium seed gains and looses the moisture. In the

Table 1. Effect of seed coating with synthetic polymer and additives on germination (%) and seedling length (cm) during storage in soybean

Treatment	Months after storage													
	Germination (%)							Seedling length (cm)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	86.5	85.0	83.5	81.0	79.0	77.0	74.5	30.11	29.99	28.94	28.65	28.02	26.89	25.78
	(68.45)	(67.22)	(67.22)	(64.17)	(62.73)	(61.35)	(59.67)							
T_1	87.5	87.5	85.0	83.5	81.0	79.0	77.0	30.13	30.03	29.02	28.93	28.19	27.04	26.18
	(69.31)	(69.31)	(67.22)	(66.04)	(64.17)	(62.73)	(61.35)							
T_2	90.0	89.0	87.5	86.5	85.0	83.5	81.0	30.69	30.50	30.08	29.98	29.16	28.35	27.55
	(71.57)	(70.65)	(69.31)	(68.45)	(67.22)	(66.04)	(64.17)							
T_3	91.5	90.5	89.5	88.5	87.0	85.5	84.0	30.99	30.88	30.70	30.24	29.96	29.09	28.80
	(73.07)	(72.07)	(71.11)	(70.19)	(68.88)	(67.63)	(66.42)							
T_4	89.0	88.0	87.0	85.5	84.0	82.5	80.5	30.45	30.32	30.02	29.82	29.01	28.45	27.46
	(70.65)	(69.73)	(68.88)	(67.63)	(66.42)	(65.28)	(63.80)							
T_5	90.5	89.5	88.5	87.0	86.0	84.5	83.0	30.88	30.76	30.55	30.12	29.78	28.93	28.35
	(72.07)	(71.11)	(70.19)	(68.88)	(68.03)	(66.82)	(65.66)							
T_6	88.0	87.0	84.0	84.0	82.5	81.0	79.0	30.21	30.12	29.85	29.60	28.86	28.08	27.07
	(69.73)	(68.88)	(66.44)	(66.42)	(65.28)	(64.17)	(62.73)							
T_7	88.5	87.5	86.5	84.5	83.5	82.0	80.0	30.30	30.19	29.96	29.72	28.93	28.13	27.23
	(70.65)	(69.31)	(68.45)	(66.82)	(66.04)	(64.90)	(63.43)							
Mean	88.9	87.9	86.4	85.1	83.5	81.9	79.9	30.47	30.35	29.89	29.63	28.99	28.12	27.30
	(70.69)	(69.98)	(68.46)	(67.32)	(66.10)	(64.86)	(63.40)							
SEm±	0.42	0.44	0.47	0.40	0.37	0.37	0.34	0.02	0.01	0.02	0.03	0.02	0.02	0.02
CD (P=0.05)	1.23	1.29	1.38	1.17	1.08	1.09	1.00	0.05	0.03	0.05	0.10	0.05	0.05	0.05

Figures in parenthesis indicates arcsine values
T_0 - Untreated control
T_1 - Polymer coating (Polykote @ 3 ml/kg of seed)
T_2 - Flowable Thiram @ 2.4 ml/kg of seed
T_3 - Polymer + Flowable Thiram @ 2.4 ml/kg of seed
T_4 - Vitavax 200 @ 2g/kg of seed.
T_5 - Polymer + Vitavax 200 @ 2g/kg of seed.
T_6 - Imidacloprid @ 6 ml/kg of seed
T_7 - Polymer + Imidacloprid @ 6 ml/kg of seed

present study moisture content reduced till six months, but thereafter seeds gained moisture as the ambient RH was more during that period and then again started to decrease with decrease in RH. An ideal polymer could overcome the moisture content fluctuations during storage (West *et al.*, 1985).

Irrespective of seed coating with polymer and other additives the insect infestation (%) increased gradually and after eight months of storage all the treatments were recorded to have insect infestation upto 12 months. Significantly lower infestation (0.50%) was recorded in seed coated with polymer @ 3.0 ml per kg of seed and imidacloprid @ 6ml per kg of seed (T_7) followed by 0.75% in T_3 (polymer @ 3.0 ml per kg of seed and flowable thiram @ 2.4 ml/kg of seed) which was at par with T_5 (polymer @ 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) and T_6(imidacloprid @ 6 ml per kg of seed as compared to untreated control (T_0) which recorded higher seed infestation (2.75%) at the end of 12 months of storage (Table 4). The infestation by the insect was comparatively low in the above treatments compared to control (2.75%) due to the preventive mechanism in seeds coated with systemic insecticide and similar findings were reported in soybean (Ludwig, 2011).

Fungal infection (%), irrespective of seed coating with polymer and other additives increased gradually from 2 months of storage upto 12 months. Significantly lower seed infection (1.25%) was recorded for seed coated with polymer @ 3.0 ml per kg of seed and flowable thiram @ 2.4 ml per kg of seed (T_3) which was at par with T_5 (polymer @ 3.0 ml per kg of seed and vitavax 200 @ 2 g per kg of seed) as compared to

Table 2 . Effect of seed coating with synthetic polymer and additives on field emergence (%) and seedling dry weight (g) during storage in soybean

Treatment	Months after storage													
	Field emergence (%)							Seedling dry weight (g)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	84.5	82.5	80.5	77.5	74.5	71.0	68.5	0.507	0.497	0.467	0.441	0.402	0.390	0.362
	(66.82)	(65.28)	(63.80)	(61.69)	(59.67)	(57.42)	(55.86)							
T_1	85.0	83.0	81.0	79.0	76.0	73.0	70.5	0.540	0.530	0.520	0.501	0.488	0.473	0.435
	(67.23)	(65.66)	(64.17)	(62.73)	(60.67)	(58.70)	(57.10)							
T_2	87.0	85.5	83.5	82.0	79.0	77.0	73.5	0.530	0.520	0.500	0.484	0.473	0.451	0.413
	(67.88)	(67.63)	(66.04)	(64.90)	(62.73)	(61.35)	(59.01)							
T_3	89.0	87.5	85.5	83.5	81.0	79.0	76.5	0.540	0.530	0.520	0.501	0.488	0.473	0.435
	(70.65)	(69.30)	(67.63)	(66.04)	(64.17)	(62.73)	(61.02)							
T_4	86.5	85.0	83.0	80.5	78.5	76.5	73.5	0.528	0.518	0.506	0.477	0.442	0.435	0.410
	(68.45)	(67.22)	(65.66)	(63.80)	(62.38)	(61.01)	(59.02)							
T_5	88.0	86.0	84.5	82.5	80.0	77.5	74.5	0.535	0.523	0.508	0.498	0.476	0.457	0.430
	(69.73)	(68.03)	(66.82)	(65.36)	(63.43)	(61.69)	(59.67)							
T_6	85.5	83.5	81.5	80.0	77.0	75.0	72.0	0.520	0.508	0.475	0.449	0.432	0.402	0.387
	(67.63)	(66.04)	(64.53)	(63.43)	(61.35)	(60.01)	(58.05)							
T_7	86.0	84.5	82.5	81.0	78.0	76.0	73.0	0.525	0.513	0.496	0.454	0.440	0.408	0.397
	(68.03)	(66.82)	(65.28)	(64.17)	(62.03)	(60.67)	(58.05)							
Mean	86.4	84.7	82.8	80.8	78.0	75.5	72.8	0.525	0.514	0.493	0.469	0.447	0.427	0.400
	(68.43)	(67.00)	(65.49)	(64.01)	(62.05)	(60.45)	(58.55)							
SEm±	0.39	0.39	0.40	0.34	0.30	0.35	0.30	0.001	0.001	0.01	0.02	0.01	0.01	0.02
CD (P=0.05)	1.15	1.13	1.16	1.00	0.88	1.01	1.90	0.003	0.003	0.02	0.04	0.02	0.03	0.02

Figures in parenthesis indicates arcsine values
T_0 - Untreated control
T_1 - Polymer coating (Polykote @ 3 ml/kg of seed)
T_2 - Flowable Thiram @ 2.4 ml/kg of seed
T_3 - Polymer + Flowable Thiram @ 2.4 ml/kg of seed
T_4 - Vitavax 200 @ 2g/kg of seed.
T_5 - Polymer + Vitavax 200 @ 2g/kg of seed.
T_6 - Imidacloprid @ 6 ml/kg of seed
T_7 - Polymer + Imidacloprid @ 6 ml/kg of seed

untreated control (T_0) which recorded higher seed infection (2.82%) at the end of 12 months of storage (Table 4). The infection by the fungal pathogen was comparatively low in the above treatments compared to control (2.80%) due to the preventive mechanism developed by the polymer and fungicides coating which reduced the growth of the pathogen and favoured germination and other parameters in coated seeds. Similar results were reported in chilli (Grover and Bansal, 1970) and soybean (Kumar *et al.*, 2007).

The present study shows that germination percentage, seedling length, field emergence seedling dry weight and seedling vigour index and lower fungal infection was recorded in the seeds coated with polymer coating @ 3 ml per kg of seed and thiram @ 2.4 ml per kg of seed (T_3) or polymer coating @ 3 ml per kg of seed and vitavax 200 @ 2 g per kg of seed (T_3) and packed in high density polyethylene (HDPE) interwoven bag prolonged storage period by more than 12 months.

Table 3. Effect of seed coating with synthetic polymer and additives on seed vigour index and moisture content (%) during storage in soybean

Treatment	Months after storage													
	Seedling vigour index (%)							Moisture content (%)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	2604	2550	2416	2321	2214	2071	1920	10.43	8.13	7.88	6.60	8.93	7.85	6.95
T_1	2637	2598	2466	2415	2284	2136	2016	10.33	8.01	7.83	6.33	8.88	7.83	6.93
T_2	2762	2715	2632	2593	2478	2368	2231	10.40	8.05	7.85	6.35	8.83	7.80	6.88
T_3	2836	2795	2747	2676	2607	2487	2419	10.30	8.03	7.80	6.30	8.80	7.73	6.85
T_4	2710	2668	2612	2550	2437	2347	2211	10.38	7.95	7.58	6.50	8.73	7.63	6.78
T_5	2795	2753	2704	2620	2561	2445	2353	10.20	7.93	7.75	6.15	8.75	7.68	6.83
T_6	2659	2620	2507	2486	2381	2274	2138	10.23	7.98	7.60	6.13	8.68	7.50	6.73
T_7	2681	2641	2592	2511	2416	2307	2178	10.35	8.08	7.73	6.20	8.70	7.58	6.75
Mean	2710	2667	2585	2522	2422	2304	2183	10.33	8.03	7.75	6.32	8.78	7.70	6.83
SEm±	13.03	13.68	12.20	11.38	10.50	10.89	9.00	0.04	0.03	0.02	0.09	0.04	0.03	0.03
CD (P=0.05)	38.03	39.93	35.62	33.22	30.64	31.79	26.27	0.11	0.09	0.06	0.26	0.11	0.09	0.08

T_0 - Untreated control
T_1 - Polymer coating (Polykote @ 3 ml/kg of seed)
T_2 - Flowable Thiram @ 2.4 ml/kg of seed
T_3 - Polymer + Flowable Thiram @ 2.4 ml/kg of seed
T_4 - Vitavax 200 @ 2g/kg of seed.
T_5 - Polymer + Vitavax 200 @ 2g/kg of seed.
T_6 - Imidacloprid @ 6 ml/kg of seed
T_7 - Polymer + Imidacloprid @ 6 ml/kg of seed

Table 4. Effect of seed coating with synthetic polymer and additives on insect infestation (%) and fungal infection (%) during storage in soybean

Treatment	Months after storage													
	Insect infestation (%)							Fungal infection (%)						
	0	2	4	6	8	10	12	0	2	4	6	8	10	12
T_0	0.00 (1.00)	0.75 (1.31)	1.25 (1.49)	1.50 (1.57)	1.75 (1.65)	2.50 (1.87)	2.75 (1.93)	0.94 (1.37)	1.25 (1.49)	1.56 (1.60)	1.87 (1.69)	2.03 (1.73)	2.34 (1.83)	2.82 (1.95)
T_1	0.00 (1.00)	0.50 (1.21)	0.50 (1.21)	1.00 (1.39)	1.25 (1.49)	1.75 (1.65)	2.25 (1.80)	0.63 (1.26)	0.94 (1.38)	1.09 (1.42)	1.56 (1.58)	1.88 (1.69)	2.03 (1.73)	2.35 (1.82)
T_2	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	0.75 (1.31)	1.00 (1.41)	1.25 (1.49)	1.50 (1.57)	0.00 (1.00)	0.00 (1.00)	0.16 (1.07)	0.31 (1.14)	0.63 (1.26)	1.25 (1.49)	1.87 (1.69)
T_3	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	0.50 (1.21)	0.75 (1.31)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.16 (1.07)	0.47 (1.21)	0.63 (1.26)	1.25 (1.49)
T_4	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	0.50 (1.21)	0.75 (1.31)	1.00 (1.41)	1.25 (1.49)	0.16 (1.07)	0.31 (1.14)	0.47 (1.19)	0.94 (1.37)	1.09 (1.44)	1.40 (1.54)	2.03 (1.73)
T_5	0.00 (1.00)	0.00 (1.00)	0.25 (1.10)	0.50 (1.21)	0.75 (1.31)	0.75 (1.41)	0.75 (1.49)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.16 (1.07)	0.47 (1.21)	0.78 (1.33)	1.25 (1.49)
T_6	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	0.50 (1.21)	0.75 (1.31)	0.31 (1.13)	0.63 (1.26)	0.78 (1.32)	1.09 (1.44)	1.56 (1.60)	1.87 (1.69)	2.34 (1.82)
T_7	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.50 (1.21)	0.50 (1.21)	0.50 (1.21)	0.50 (1.21)	0.16 (1.07)	0.31 (1.14)	0.47 (1.19)	1.09 (1.44)	1.40 (1.54)	1.72 (1.64)	2.19 (1.78)
Mean	0.00 (1.00)	0.16 (1.06)	0.38 (1.15)	0.53 (1.21)	0.88 (1.35)	1.09 (1.42)	1.31 (1.49)	0.27 (1.11)	0.43 (1.18)	0.57 (1.22)	0.90 (1.35)	1.19 (1.46)	1.50 (1.56)	2.01 (1.72)
SEm±	0.00	0.06	0.09	0.09	0.10	0.10	0.09	0.09	0.08	0.10	0.10	0.09	0.08	0.08
CD (P=0.05)	NS	0.16	0.25	0.27	0.29	0.28	0.27	0.25	0.22	0.28	0.29	0.26	0.24	0.24

Figures in parenthesis indicates arcsine values
T_0 - Untreated control
T_1 - Polymer coating (Polykote @ 3 ml/kg of seed)
T_2 - Flowable Thiram @ 2.4 ml/kg of seed
T_3 - Polymer + Flowable Thiram @ 2.4 ml/kg of seed
T_4 - Vitavax 200 @ 2g/kg of seed.
T_5 - Polymer + Vitavax 200 @ 2g/kg of seed.
T_6 - Imidacloprid @ 6 ml/kg of seed
T_7 - Polymer + Imidacloprid @ 6 ml/kg of seed

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