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Assessment of the impact of seed treatment and polymer coating on germination and seedling vigour of maize hybrid, DHM 117

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Abstract
The present investigation was carried out to assess the impact of seed treatment and polymer coating on germination and seedling vigour of maize hybrid, DHM 117. The experiment was laid out in Factorial Completely Randomized Design with two factors *viz*., polymer coating (0, 3 and 4 g kg^{-1} seed) and chemical seed treatment (without seed treatment, Thiram @ 3 g, Imidacloprid @ 5 g and Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed) and four replications. Polymer coating of maize hybrid seed showed significant influence on germination, speed of germination and dry weight of the seedling, while chemical seed treatment exhibited significant variation on germination and all the seedling parameters under study except root/shoot ratio. The interaction effects were observed to be significant for germination, root length, shoot length, seedling length, vigour index-I and vigour index-II. Seed treated with thiram without polymer coating showed high germination, while seed treated with either Imidacloprid or thiram + imidacloprid without polymer coating had better seedling performance.

Keywords: Germination, maize, polymer coating, seedling vigour, seed treatment

1. Introduction
Maize is one of the most important cereal crops of the world. It is grown in many parts of the world for its immense potentiality both for adoptation and nutritive value (Girisha, 2014) [1]. Maize is one of the main sources of cereals for food, forage and processed industrial products. Maize is known as "Queen of cereals" in the view of its diversified uses. It is predominantly cross-pollinated species, a feature that has contributed to its broad morphological variability and geographical adaptability. In India, it is grown in an area of 8.80 million hectares with a production of 22.56 million tonnes and average productivity of 2563 kg ha^{-1} (www.indiastat.com) [2].

Quality seed is the key for successful agriculture which demands that each and every seed should be readily germinable and produce a vigorous seedling ensuring higher yield (Ananthi *et al*., 2015) [3]. Seed health is an important attribute of seed quality and the seed used for planting should be free from pests and diseases. Maize is a species with a great capacity to adapt to varied environmental conditions, but pest and disease incidence may result in decreased production and quality.

Seed treatment is a process in which a chemical, typically antimicrobial or fungicidal or insecticidal, is used to treat the seed prior to planting to provide an inexpensive insurance against pests and diseases. Apart from disease control, seed treatment also has a positive effect on crop growth and yield, hence used in many crops for various purposes. Thiram is a fungicide used to protect seed and crops from fungal diseases. Imidacloprid is a systemic insecticide belonging to the chemical class of neonicotinoids which acts by specially blocking the microtinergic neural pathway of insects (Jemec *et al*., 2007) [4].

Seed coating is a process of directly applying useful material to form a thin and uniform coating without altering the shape or size of the seed. It makes room for including all the required ingredients like inoculants, protectants, nutrients, plant growth promoters, hydrophobic/hydrophilic substances, herbicides, oxygen suppliers etc. Seed coating with polymer improves the adherence of the chemical to the seed and ensures dust free handling of treated seed. Functionalized polymers were used to increase the efficiency of pesticides and herbicides, allowing the application of accurate and even dosage of chemicals and to indirectly protect the environment by reducing pollution and clean-up existing pollutants

(Ekebafe *et al*., 2011) [5]. Polymer in combination with fungicides and insecticides can improve the health of the seed. Hence, the present investigation was carried out to know the impact of seed treatment and polymer coating on germination and seedling vigour of maize hybrid, DHM 117.

Material and Methods

The laboratory experiment was conducted in the Department of Seed Science and Technology, Advanced Post Graduate Centre, Lam, Guntur during 2017. The experiment was laid out in Factorial Completely Randomized Design with two factors and four replications. Initially seed was treated with chemicals i.e., in S_1- no chemical treatment was done, in S_2- seed was treated with Thiram @ 3g kg^{-1}, in S_3- seed was treated with Imidacloprid @ 5g kg^{-1} seed and in S_4- seed was treated with Thiram @ 3 g followed by Imidacloprid @ 5 g kg^{-1} seed. During seed treatment required concentration of the chemical(s) was manually mixed with seed thoroughly in polythene bags to ensure uniform coating. After chemical seed treatment, the seed was air dried in shade for 24 h to bring back to 12% moisture content. Then the seed was coated with polymer i.e., in P_1 - no polymer coating was done, while in P_2 and P_3 seed coating was done with polymer @ 3 and 4 g kg^{-1} seed, respectively. During the process of seed coating utmost care was taken to have uniformity in coating. After coating, the seed was again air dried in shade for 24 h to bring back to original moisture content.

The seed was kept for germination test for assessing the germination and seed quality parameters. Four replicates of hundred seed from each treatment were placed on wet germination paper towel at uniform spacing, covered with another wet germination paper towel. Then the paper towels were rolled, secured with rubber bands on both the sides and kept in upright position in plastic trays and incubated in germinator at 25±2°C and 95% RH. Daily germination counts were recorded for seven consecutive days until no further germination occurred. The number of normal seedlings were counted after the test period and the germination (%) was calculated using the formula:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seed sown}} \times 100$$

Speed of germination was calculated by the formula recommended by Adebisi and Oyekale (2005)[6] as mentioned below:

$$\text{Speed of germination} = N_1/T_1 + N_2/T_2 + N_3/T_3 + \text{-------} + N_x/T_x$$

Where, N= Number of seed germinated in days ‘T’

Root length, shoot length, total seedling length, fresh weight and dry weight were measured by randomly selecting ten normal seedlings in each treatment in each replication at the end of the test period. The root/shoot ratio of the ten representative seedlings was computed by dividing the root length with shoot length.

Seedling vigour index-I and II were computed by adopting the following formulae as suggested by Abdul-Baki and Anderson (1973) [7]:

Seedling vigour index-I = Germination (%) × Seedling length (cm) Seedling vigour index-II = Germination (%) × Seedling dry weight (g) Then statistical analysis of the data was done as per the procedure described by Panse and Sukhatme (1978) [8].

Results and Discussion

The results of the present investigation (Tables 1 to 4) clearly revealed that maize hybrid seed coated with polymer showed significant effect on germination, speed of germination and dry weight of the seedling, while chemical seed treatment exhibited significant variation among all the germination and seedling parameters under study except speed of germination and root/shoot ratio. The seed quality parameters *viz.*,germination, root length, shoot length, seedling length, vigour index-I and vigour index-II were significantly influenced by the interaction effects of chemical seed treatment and polymer coating.

Among the polymer coating treatments, seed without polymer coating recorded higher germination (93.19%), speed of germination (39.96) (Table 1), shoot length (14.32 cm) (Table 2), seedling length (33.04 cm), seedling vigour index-I (3079) (Table 3) and fresh weight (1.18 g) (Table 4). Seed coating with polymer @ 3 g kg^{-1} seed had highest root/shoot ratio (1.44), seedling dry weight (0.25 g) and vigour index-II (23.10), while the root length was highest (18.74 cm) in seed coating with polymer @ 4 g kg^{-1} seed. The dry matter production of seedling was higher in polymer coated seed compared to uncoated seed (Table 4). Sherin (2003) [9] and Suresh (2008) [10] earlier reported an improvement in growth parameters due to polykote film coating in maize. Sujatha and Ramamoorthy (2009) [11] found that polymer coating did not show any significant improvement in germination, root length and shoot length immediately after treatment. Polymer coating of seed enhanced shoot length over control in redgram and greengram. The reduction in speed of germination of coated seed might be due to the restriction imposed by the coating material, which causes slow absorption of moisture (John *et al*., 2005) [12].

John *et al*. (2005) [12] reported an improvement in germination, speed of germination, root length, shoot length, dry matter production and vigour index over the control due to seed coating with polykote @ 3 g kg^{-1} seed in maize. A reduction in germination was also noticed with increase in the dosage of polymer beyond 3 g kg^{-1} seed. Satyabhama *et al*. (2016) [13] noticed that seeds coated with polymer @ 4 ml kg^{-1} seed recorded significantly higher germination, total seedling length (shoot and root length) and seedling dry weight. The increase in speed of germination of polymer coated seed is attributed to the hydrophilic nature of the polymer leading to higher water uptake which resulted in quicker radical emergence (Baxter and Waters, 1986 and Henderson and Hensely, 1987) [14, 15].

Among the seed treatments, seed treated with Thiram @ 3 g kg^{-1} seed recorded highest germination (93.25%) and speed of germination (38.79) (Table 1). These results are in agreement with the findings of Kumar *et al*. (2015) [16], who reported that seed treatment with Thiram alone or in combination with polymer significantly enhanced the germination in chickpea. The improvement in germination of seed treated with fungicide over control may be because of the suppression and / or elimination of pathogenic population by fungicide application. Seed treated with Imidacloprid @ 5 g kg^{-1} seed showed highest root length (19.25 cm), shoot length (14.63 cm) (Table 2), seedling length (33.88 cm) and seedling vigour index-I (3128) (Table 3). Highest fresh (1.20 g) and dry weights (0.25 g) of the seedlings and vigour index-II (23.41) (Table 4) were noticed in seed treated with Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed, while seed without chemical treatment (control) exhibited lowest germination (91.58%), dry weight (0.24 g) and seedling vigour index-II (22.32). The enhancement in seedling growth could be attributed to the suppression of microorganisms and pathogens by the chemical seed treatment. Ilieva and Vasileva (2014) [17] noticed that pre-sowing seed treatment with Gaucho 600 FS (Imidacloprid) @ 1 L/100 Kg seed recorded higher root length and dry root biomass in soybean.

Among the interactions of polymer seed coating and chemical seed treatments, the speed of germination was found to be highest (40.50) in seed without chemical seed treatment and polymer coating (control) followed by the seed treated with Thiram @ 3 g kg^{-1} seed and without polymer coating (40.05). However the highest speed of germination does not influence the overall germination of seed as evidenced by the low germination (91.50%) noticed in seed without chemical treatment and polymer coating (control). Seed treated with Imidacloprid @ 5 g kg^{-1} seed without polymer coating recorded higher root (21.00 cm) and shoot length (15.53 cm), which might have been reflected in more seedling length (36.53 cm) and vigour index-I (3399). The higher dry weight of the seedling (0.26 g) from the seed treated with Thiram @ 3 g + Imidacloprid @ 5 g and coated with polymer @ 4 g kg^{-1} might be the main reason for the realization of higher seedling vigour index-II (23.96) in this treatment.

A close analysis of the results of the present investigation revealed that polymer coating of the seed could not able to improve the germination of maize hybrid seed but enhanced the dry matter production of seedling. Seed treatment with Imidacloprid either alone or in combination with Thiram improved the seedling growth and vigour. Among the interaction effects, seed treated with Thiram and without polymer coating showed high germination percent, while seed treated with either Imidacloprid or Thiram + Imidacloprid without polymer coating had better seedling performance.

Table 1: Influence of seed treatment and polymer coating on germination of maize

Seed treatment	Germination (%)				Speed of germination			
	Polymer coating				Polymer coating			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1	91.50 (73.05)	92.25 (73.81)	91.00 (72.55)	91.58 (73.14)	40.50	36.76	36.98	38.08
S_2	94.25 (76.11)	92.25 (73.83)	93.25 (74.94)	93.25 (74.96)	40.05	37.98	38.34	38.79
S_3	93.00 (74.67)	91.00 (72.54)	92.75 (74.46)	92.25 (73.89)	39.96	36.46	36.70	37.71
S_4	94.00 (75.79)	91.25 (72.78)	91.50 (73.08)	92.25 (73.89)	39.33	37.61	38.03	38.32
Mean	93.19 (74.90)	91.50 (73.24)	92.13 (73.76)	92.33 (73.97)	39.96	37.20	37.51	38.22
CV (%)	1.70				4.01			
	CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±	
P	1.92		0.31		2.33		0.38	
S	1.64		0.36		NS		0.44	
S×P	1.81		0.63		NS		0.77	

NS – Non Significant

Figures in Parenthesis indicate arc sine transformation

Seed coating with polymer (P)

P_1 – Without polymer coating

P_2 – Seed coating with polymer @ 3 g kg^{-1} seed

P_3 – Seed coating with polymer @ 4 g kg^{-1} seed

Chemical seed treatment (S)

S_1 – No chemical seed treatment

S_2 – Seed treatment with Thiram @ 3 g kg^{-1} seed

S_3 – Seed treatment with Imidacloprid @ 5 g kg^{-1} seed

S_4 – Seed treatment with Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed

Table 2: Influence of seed treatment and polymer coating on root and shoot growth of maize

Seed treatment	Root length (cm)				Shoot length (cm)				Root/shoot ratio			
	Polymer coating				Polymer coating				Polymer coating			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1	18.55	19.15	18.97	18.89	12.35	15.26	14.29	13.97	1.51 (1.58)	1.33 (1.52)	1.39 (1.55)	1.41 (1.55)
S_2	16.96	17.56	17.67	17.39	13.93	12.41	12.35	12.90	1.28 (1.51)	1.44 (1.56)	1.49 (1.58)	1.40 (1.55)
S_3	21.00	17.35	19.40	19.25	15.53	13.35	15.02	14.63	1.39 (1.55)	1.51 (1.58)	1.33 (1.53)	1.41 (1.55)
S_4	18.38	19.65	18.94	18.99	15.46	13.84	14.38	14.56	1.24 (1.50)	1.48 (1.57)	1.33 (1.53)	1.35 (1.53)
Mean	18.72	18.42	18.74	18.63	14.32	13.71	14.01	14.01	1.36 (1.53)	1.44 (1.56)	1.39 (1.54)	1.39 (1.55)
CV (%)	7.73				10.86				3.40			
	CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±	
P	NS		0.42		NS		0.38		NS		0.01	
S	1.87		0.36		1.98		0.44		NS		0.01	
S×P	2.07		0.72		2.18		0.76		NS		0.03	

NS – Non Significant

Figures in Parenthesis indicate square root transformation

Seed coating with polymer (P)

P_1 – Without polymer coating

P_2 – Seed coating with polymer @ 3 g kg^{-1} seed

P_3 – Seed coating with polymer @ 4 g kg^{-1} seed

Chemical seed treatment (S)

S_1 – No chemical seed treatment

S_2 – Seed treatment with Thiram @ 3 g kg^{-1} seed

S_3 – Seed treatment with Imidacloprid @ 5 g kg^{-1} seed

S_4 – Seed treatment with Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed

Table 3: Influence of seed treatment and polymer coating on seedling length (cm) and vigour index-I of maize

Seed treatment	Seedling length (cm)				Seedling vigour index-I			
	Polymer coating				Polymer coating			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1	30.91	34.41	33.26	32.86	2828	3174	3026	3009
S_2	30.89	29.96	30.17	30.34	2911	2764	2798	2824
S_3	36.53	30.70	34.42	33.88	3399	2795	3189	3128
S_4	33.83	33.49	33.63	33.65	3180	3055	3051	3095
Mean	33.04	32.14	32.87	32.68	3079	2947	3016	3014
CV (%)	7.43				7.70			
	CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±	
P	NS		0.61		NS		66.95	
S	3.16		0.70		301.30		78.29	
S×P	3.48		1.21		332.60		135.60	

NS – Non Significant

Seed coating with polymer (P)
P_1 – Without polymer coating
P_2 – Seed coating with polymer @ 3 g kg^{-1} seed
P_3 – Seed coating with polymer @ 4 g kg^{-1} seed

Chemical seed treatment (S)
S_1 – No chemical seed treatment
S_2 – Seed treatment with Thiram @ 3 g kg^{-1} seed
S_3 – Seed treatment with Imidacloprid @ 5 g kg^{-1} seed
S_4 – Seed treatment with Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed

Table 4: Influence of seed treatment and polymer coating on seedling weight (g) and vigour index-II of maize

Seed treatment	Seedling fresh weight (g)				Seedling dry weight (g)				Seedling vigour index-II			
	Polymer coating				Polymer coating				Polymer coating			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
S_1	1.12	1.19	1.19	1.16	0.23	0.24	0.25	0.24	21.19	23.37	22.41	22.32
S_2	1.11	1.05	1.05	1.07	0.24	0.25	0.25	0.25	23.10	22.76	22.51	22.79
S_3	1.22	1.11	1.18	1.17	0.24	0.25	0.25	0.24	22.88	23.42	21.91	22.74
S_4	1.27	1.17	1.15	1.20	0.25	0.25	0.26	0.25	23.40	22.87	23.96	23.41
Mean	1.18	1.13	1.14	1.15	0.24	0.25	0.25	0.25	22.64	23.10	22.70	22.81
CV (%)	9.82				3.03				3.62			
	CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±		CD (p=0.05)		SEm ±	
P	NS		0.03		0.011		0.0019		NS		0.21	
S	0.15		0.03		0.010		0.0022		1.07		0.24	
S×P	NS		0.06		NS		0.0037		1.19		0.41	

NS – Non Significant

Seed coating with polymer (P)
P_1 – Without polymer coating
P_2 – Seed coating with polymer @ 3 g kg^{-1} seed
P_3 – Seed coating with polymer @ 4 g kg^{-1} seed

Chemical seed treatment (S)
S_1 – No chemical seed treatment
S_2 – Seed treatment with Thiram @ 3 g kg^{-1} seed
S_3 – Seed treatment with Imidacloprid @ 5 g kg^{-1} seed
S_4 – Seed treatment with Thiram @ 3 g + Imidacloprid @ 5 g kg^{-1} seed

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