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Polymer coating for higher pesticide use efficiency, seed yield and quality in onion (*Allium cepa*)

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ABSTRACT

Onion seed crop is infected with several pest and diseases which reduce the seed yield and quality. The present study explores the feasibility of using polymer as an efficient delivery system for seed-protectant chemicals during onion seed production. Polymer coating prolonged the release of pesticides. After 30 DAP, 557% and 1087% higher retention of fungicide and insecticide was observed in polymer coated bulbs over traditional method of bulb treatment. Onion bulb coating with polymer and 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) showed significantly higher values for seed yield attributes *viz.* productive scapes/plant (5.56), lower percent lodged scapes (21.16), seed yield/plant (21.15 g) and seed quality attributes in comparison to control and traditional method of bulb treatment. Lowest percent disease index (36.39) was recorded in treatment- polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) and lowest number of thrips/plant (5.14) was recorded in bulbs coated with polymer + 0.15 % fipronil + 500 ppm streptomycin. Treating of onion bulbs with polymer is beneficial in increasing the efficacy of the applied pesticides, reducing the incidence of pest and diseases and enhancing seed yield and quality.

Key words: *Allium cepa*, Disease, Pesticides, Polymer, Thrips, Seed yield

Onion seed production is a biennial process wherein the bulb produced during first year forms the planting material for seed production during second year. The quality of seed bulb plays an important role in realizing quality seed (Yalamalle 2016). Onion seed crop is infected with various fungal diseases like purple blotch (*Stemphylium vesicarium* Wallr and *Alternaria porri* Ellis), fusarium basal rot (*Fusarium oxysporum* f. sp. *cepae*), pink root disease (*Phoma terrestris*) and white rot (*Sclerotium cepivorum* Berk). Bacterial rot (*Erwinia carotovora* subsp. *carotovora*). These are either soil borne or carried over to the field by infected bulbs. Apart from fungal and bacterial diseases, many viruses are known to infect onion which reduces seed yield and quality. Some of these being Irish yellow spot virus (IYSV) Onion yellow dwarf virus (OYDV) (Hillman and Lawrence 1995). In severe viral infection the yield reduction can be up to 100 % (Papu 2010). Mayer *et al.* (1987) reported that thrips (*Thrips tabaci* L.) survive in bulbs and can be primary source of inoculum. Thrips, a major insect pest apart from feeding injury, it damages the

seed crop by transmitting the viruses. It also predisposes the plants to fungal diseases by injury (Cartwright *et al.* 1995). Conventional method of pesticide application involves application of large quantity of pesticides in the soil/plant, which possess various ecological concerns (Jacob *et al.* 2009). Film coating of seeds with active ingredients by use of polymers is an efficient way to deliver seed treatment chemicals (Taylor 1998). Polymers are reported to prolong the release of pesticides (Choudhary *et al.* 2006, Rahim *et al.* 2016). Application of plant protectant along with polymers has been reported previously (Jacob *et al.* 2009) to reduce the incidence of pest and diseases, enhance seed yield, improve seed viability and vigour. Although there are several reports on the application of polymers as seed treatment agent, but there is limited reports on the suitability of polymers as a bulb treatment agent. The present study explores the suitability of polymer as a bulb treatment agent for delivery seed treatment chemicals in onion seed crop.

MATERIALS AND METHODS

The present study was conducted at ICAR-Indian Agricultural Research Institute, New Delhi during *rabi* 2015-16 and 2016-17. The experiment was laid out in randomized complete block design with three replications. Onion bulbs weighing 50±5 g were used as planting material. The bulbs was coated with polymers along with different combination of pesticides: insecticide- 0.15 % fipronil, Regent[®] 5 SC w/w, Bayer Crop Science; fungicide – 0.25 % (carbendazim 12 % WP + mancozeb 63% WP) Companion[®], Indofil

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Table 1. Treatment details

T ₁ -Polymer coating
T ₂ - Polymer coating + 0.15 % fipronil
T ₃ - Polymer coating + 0.25 % (carbendazim + mancozeb)
T ₄ - Polymer coating +0.15 % fipronil+ 0.25 % (carbendazim + mancozeb)
T ₅ - Polymer coating + 500 ppm streptomycin
T ₆ - Polymer coating + 500 ppm streptomycin + 0.15 % fipronil
T ₇ - Polymer coating + 500 ppm streptomycin + (carbendazim + mancozeb)
T ₈ - Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptomycin
T ₉ - Traditional practice -fungicide + insecticide + streptomycin (in water)
T ₁₀ - No treatment

Industries Ltd, India and bactericide-500 ppm (streptomycin sulphate 90 % w/w + tetracyclin hydrochloride 10%),

Streptomycin[®], Hindustan Antibiotics, Pune, India (Table 1). The polymer coating was done using commercial vinyl based polymer, L-200 (Incotec International B.V. Ltd, The Netherlands) @ 50 ml/liter. The bulbs were soaked in pesticide solutions as per treatments for 30 min and dried for 24 h before planting. The bulbs were planted at a spacing of 45 cm × 20 cm. The experiment plots were fertilized with 100 kg N, 50 kg P and 50 kg K. Half dose of nitrogen and full dose of phosphorous and potassium were given at the time of sowing. Remaining nitrogen was split in two equal dose and applied at 30 and 45 days after planting. The plants were not sprayed with any insecticide and fungicides for 30 DAP and 90 DAP respectively. The data on number of bulb sprouted was recorded at 60 DAP. Productive scapes was calculated by measuring the total number of un-lodged scapes left per-plant after seed filling stage and the average of 10 plants was recorded. Percent lodged scapes were calculated by counting the total number of un-lodged scapes after seed filling stage and percentage was calculated based on the initial scapes number. Seed yield/ plant was recorded on randomly selected 10 plants

Table 2. Effect of polymer coating and plant protectants on bulb sprouting, productive scapes and percent lodged scapes in onion cv. Pusa Ridhi

Treatment	Bulb sprout % 60 DAP			Productive scapes/plant			Percent lodged scape		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T ₁	78.89 (62.65) ab [^]	87.22 (69.09) a	83.06 (65.87) a	4.07 cd\$	4.57 cd [^]	4.32 de	37.63 (37.84) ab	24.71 (29.76) ab	31.17 (33.80) ab
T ₂	77.78 (61.94) ab	84.44 (66.78) ab	81.11 (64.36) abc	5.44 ab	4.84 bcd	5.14 abc	31.10 (33.82) bc	23.96 (29.28) abc	27.53 (31.55) abc
T ₃	80.56 (64.28) a	85.56 (68.58) a	83.06 (66.43) a	4.70 abcd	5.50 a	5.10 ab	31.76 (34.29) bc	15.40 (22.99) d	23.58 (28.64) cd
T ₄	74.44 (59.98) ab	84.44 (68.58) a	79.44 (64.28) ab	5.65 a	5.48 ab	5.56 a	24.69 (29.31) c	17.64 (24.80) cd	21.16 (27.05) d
T ₅	75.00 (60.21) ab	81.11 (64.24) bc	78.06 (62.23) cd	4.26 bcd	4.35 d	4.31 e	37.00 (37.33) ab	18.39 (25.39) bcd	27.70 (31.36) abc
T ₆	74.44 (59.68) ab	80.56 (61.97) cd	77.50 (60.83) de	4.95 abcd	4.87 abcd	4.91 bcd	31.70 (34.19) bc	20.62 (26.89) bcd	26.16 (30.54) bcd
T ₇	62.78 (52.41) c	80.56 (62.29) c	71.67 (57.35) e	3.77 d	5.47 ab	4.62 bcde	45.91 (42.64) a	19.86 (26.43) bcd	32.89 (34.54) a
T ₈	70.56 (57.17) bc	81.11 (66.78) ab	75.83 (61.98) bc	5.44 ab	5.30 ab	5.37 ab	31.13 (33.87) bc	20.45 (26.80) bcd	25.79 (30.33) bcd
T ₉	71.67 (57.86) bc	80.00 (65.07) b	75.83 (61.47) cd	5.23 abc	5.06 abc	5.15 abc	29.92 (32.99) bc	19.68 (26.11) bcd	24.80 (29.55) cd
T ₁₀	75.00 (60.00) ab	75.56 (59.64) d	75.28 (59.82) e	4.49 abcd	4.61 cd	4.55 cde	37.41 (37.68) ab	28.35 (32.15) a	32.88 (34.92) a
General mean	74.11 (59.62)	82.05 (65.30)	78.08 (62.46)	4.80	5.01	4.90	33.83 (35.40)	20.91 (27.06)	27.37 (31.23)
CD (0.05)	5.86*	2.60**	1.17**	1.20*	0.64**	0.91*	6.38*	4.95*	3.89**

T1- Polymer coating, T2- Polymer coating + 0.15 % fipronil, T3- Polymer coating + 0.25 % (carbendazim + mancozeb), T4- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) T5- Polymer coating + streptomycin 500ppm, T6- Polymer coating+ 500 ppm streptomycin + 0.15 % fipronil, T7- Polymer coating + 500 ppm streptomycin + 0.25 % (carbendazim + mancozeb) T8- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptomycin T9- 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptomycin in water, T10- control no treatment.

\$- Means with at least one common letter are not statistically significant using Fishers least significant difference. ^ Value in the parenthesis are arcsine transformed values

after maturity. No of thrips/plant was calculated as average of 10 plants at 30 days after planting. Both the adults as well as nymphs were counted on the whole plant. Disease severity on foliage and scape was recorded at 90 DAP on 0-5 scales as per (Islam *et al.* 1999). The percent disease index (PDI) was calculated by the following formula given by Wheeler (1969): $PDI = \frac{\text{Total sum of numerical ratings}}{\text{Number of observation} \times \text{maximum disease rating in the scale}} \times 100$.

Seed germination was assessed as per ISTA (2015) guidelines. Seedling vigour was calculated as per Abdul-Baki and Anderson (1973). The release kinetics of pesticides was studied after two years of field study; the best performing treatment was used to assess the release kinetics of pesticides. Onion bulbs were coated with insecticide- 0.15 % fipronil and fungicide – 0.25 % (carbendazim 12 % WP + mancozeb 63% WP) with 5 % polymer slurry or in water for 30 minutes and dried for 24 hours in shade. The treated bulbs were planted in pots containing potting mixture (vermiculite and peat moss 1:1 w/w) the releases of pesticide was estimated periodically at different durations- 0, 15 and 30 DAP. The sample preparation was done by modified

buffered ethyl acetate method (Jadhav *et al.* 2015). In brief, 10 ± 0.1 g of samples was extracted with 10ml ethyl acetate, 100 µl acetic acid and 10 g anhydrous sodium sulphate followed by cleanup with 25 mg PSA. The cleaned extract was reconstitute in acidified methanol + water followed by analysis through LC-MS/MS. The analysis was performed through multiple reaction monitoring (MRM) at a dwell time of 0.02s using Atlantis® T3 (100 × 3.0 mm, 5 µm) column.

Statistical analysis: The statistical analysis of was performed by using statistical analysis system (SAS) software. The data collected were subjected to analysis of variance and means were separated by least significant difference test (at P=0.05 or 0.01). The percent data were arcsine transformed prior to analysis. Grouping letters on treatments means were assigned using Fishers least significant difference.

RESULTS AND DISCUSSION

Onion seed crop suffers from losses caused by fungal, viral and bacterial diseases. Thrips being the major insect pest causes direct as well as indirect damage by transmitting onion viruses. For successful seed production programme

Table 3. Effect of polymer coating and plant protectants on seed germination and seedling vigour in onion cv. Pusa Ridhi

Treatment	Germination %			Seedling vigour index-I			Seedling vigour index-II		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T1	93.33 (77.77) ab [^]	80.67 (64.09) ab	87.00 (70.93) bc	876.75 cde	624.17 de	750.46 b	1589.87 b	1265.53 de	1427.70 c
T2	83.33 (66.38) bc	77.33 (61.75) bc	80.33 (64.06) cd	815.43 de	684.16 bcde	749.80 b	1616.87 b	1442.40 bcd	1529.63 bc
T3	98.00 (85.27) a	88.67 (71.82) a	93.33 (78.55) a	1053.65 ab	833.05 a	943.35 a	1953.67 a	1713.67 a	1833.67 a
T4	97.33 (84.52) a	83.33 (65.91) ab	90.33 (75.22) ab	1055.75 a	791.09 ab	923.42 a	1990.93 a	1513.27 abc	1752.10 a
T5	94.67 (76.70) ab	76.00 (60.78) bc	85.33 (68.74) bc	990.57 abc	599.90 e	795.23 b	1805.40 ab	1297.27 cd	1551.33 bc
T6	87.33 (70.58) bc	81.33 (64.60) ab	84.33 (67.59) c	888.26 bcde	723.07 abcd	805.67 b	1681.53 b	1394.40 bcd	1537.97 bc
T7	92.67 (75.24) abc	81.33 (64.45) ab	87.00 (69.84) bc	893.92 abcd	723.91 abcd	808.92 b	1785.67 ab	1381.60 bcd	1583.63 bc
T8	92.00 (74.45) abc	82.67 (65.49) ab	87.33 (69.97) bc	899.88 abcd	736.57 abc	818.22 b	1727.20 b	1279.40 cde	1503.30 bc
T9	84.67 (66.98) bc	82.00 (65.27) ab	83.33 (66.13) c	862.34 cde	674.55 cde	768.44 b	1639.00 b	1549.87 ab	1594.43 b
T10	80.00 (63.51) c	66.00 (54.35) c	73.00 (58.93) d	728.12 e	452.33 f	590.22 c	1343.73 c	1046.13 e	1194.93 d
General mean	90.33 (74.13)	79.93 (63.85)	85.33 (68.99)	906.47	684.28	795.37	1713.39	1388.35	1550.87
CD (0.05)	11.98**	8.18*	7.00**	165.69*	111.81**	96.47**	216.88**	244.15**	157.62**

T1- Polymer coating, T2- Polymer coating + 0.15 % fipronil, T3- Polymer coating + 0.25 % (carbendazim + mancozeb), T4- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) T5- Polymer coating + streptomycin 500 ppm, T6- Polymer coating + 500 ppm streptomycin + 0.15 % fipronil, T7- Polymer coating + 500 ppm streptomycin + 0.25 % (carbendazim + mancozeb) T8- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptomycin T9- 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptomycin in water, T10- control no treatment. \$- Means with at least one common letter are not statistically significant using Fishers least significant difference. ^ Value in the parenthesis are arcsine transformed values

Table 4 Effect of polymer coating and plant protectants on seed yield, PDI and thrips incidence in cv. Pusa Ridhi

Treatment	Seed yield/ plant			PDI			No. of thrips/plant		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T1	18.81 cd	14.85 cd	16.83 de	50.79 a§	42.07 abc	46.43 abc	7.12 d	7.07 ab	7.09 cd
T2	22.81 a	16.07 bcd	19.44 abc	40.30 abc	40.28 bcd	40.29 cde	10.62 bcd	3.07 c	6.84 cd
T3	19.41 bcd	18.59 abc	19.00 abcd	33.52 c	37.67 cd	35.59 de	14.91 ab	5.67 bc	10.29 ab
T4	22.22 ab	20.07 a	21.15 a	33.54 c	36.39 d	34.96 e	7.30 cd	3.40 c	5.35 d
T5	18.96 cd	13.96 d	16.46 e	45.94 ab	46.94 a	46.44 a	12.21 abc	5.07 bc	8.64 bc
T6	21.19 abc	18.44 abc	19.81 ab	43.91 abc	43.89 ab	43.90 abc	6.08 d	4.20 bc	5.14 d
T7	17.78 d	16.59 abcd	17.19 cde	39.69 bc	41.67 abcd	40.68 cd	9.10 cd	5.20 bc	7.15 cd
T8	19.26 bcd	19.89 ab	19.57 abc	35.91 bc	44.44 ab	40.18 bc	6.77 d	3.13 c	4.95 d
T9	21.56 abc	16.48 abcd	19.02 abcd	39.23bc	44.44 ab	41.84 abc	10.67 bcd	3.73 c	7.20 cd
T10	18.96 cd	16.00 ab	17.48 bcde	46.66 ab	45.83 ab	46.25 ab	16.33 a	9.53 a	12.93 a
General mean	20.09	17.12	18.60	40.95	42.36	41.66	10.10	4.98	7.54
CD (0.05)	3.17*	3.90*	2.43**	10.60*	5.63*	4.47*	4.93**	3.29*	2.86**

T1- Polymer coating, T2- Polymer coating + 0.15 % fipronil, T3- Polymer coating + 0.25 % (carbendazim + mancozeb), T4- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) T5- Polymer coating + streptocyclin 500 ppm, T6- Polymer coating + 500 ppm streptocyclin + 0.15 % fipronil, T7- Polymer coating + 500 ppm streptocyclin + 0.25 % (carbendazim + mancozeb) T8- Polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptocyclin T9- 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptocyclin in water, T10- control no treatment.

§- Means with at least one common letter are not statistically significant using Fishers least significant difference.

management of biotic stress is essential. Highest bulb sprouting at 60 DAP was noticed in bulbs treated with polymer and 0.25 % (carbendazim and mancozeb) was 10.33 % higher than control (Table 2). Pre-sowing seed treatments have both the protective as well as curative functions. Uddin *et al.* (2006) reported that mother bulb treatment with mancozeb and foliar spray reduced the disease severity and disease intensity.

Onion bulb coated with polymer along with 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) showed significantly higher values for seed yield attributes *viz.* productive scapes/ plant (5.56), lower percent lodged scapes (21.16), seed yield/plant (21.15 g) than untreated (control) and traditional method of bulb treatment (Table 2 and 4). The major onion diseases- stemphylium blight and purple blotch colonize mainly the scapes region and if the incidence of disease is severe the scapes lodge at or after seed filling stage. Onion bulb treatment protected the seed crop from the disease and hence the treated plants had lower scape lodging and higher productive scapes/plant. Higher seed yield/plant could be due to healthier plants and lower incidence of thrips.

Onion bulb coated with polymer and 0.15% fipronil + 0.25% (carbendazim + mancozeb) showed significantly higher values for seed quality attributes- seedling vigour index-I (923.42), seedling vigour index-II (1752.10) in comparison to untreated (control) and traditional method of bulb treatment. Germination % was highest in onion bulb coating with polymer + 0.25% (carbendazim + mancozeb) (Table 3). The seed quality parameters were superior due to the lower incidence of disease in treated bulbs. Uddin *et al.* (2006) reported that mother bulb treatment with mancozeb

not only had reduced disease severity and disease intensity but also increased seed quality parameters. Hoffman (1998) reported the positively correlation between plant disease intensity and the seed quality in soybean.

Thrips is a major insect pest of onion it not only causes injury due to feeding but it also predisposes the plants to fungal diseases (Cartwright *et al.* 1995). Lowest percent disease index (34.96) was recorded in treatment polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) and lowest number of thrips/plant (4.95) was recorded in treatment polymer coating + 0.15 % fipronil + 0.25 % (carbendazim + mancozeb) + 500 ppm streptocyclin (Table 4). Highest disease as well as thrips incidence was reported in control. The analysis of onion bulbs and plants at different interval revealed significant differences in pesticide and fungicide retention due to polymer coating (Table 5). The quantity of carbendazim retained at 0 days was similar to that of traditional method of bulb treatment but at 15 and 30 DAP there was 355 % and 557 % higher retention of carbendazim in comparison to traditional method of bulb treatment. Similarly the quantity of fipronil retained at 0, 15 and 30 DAP was 155 %, 373 % and 1087 % higher as compared to traditional method of bulb treatment (Table 5). Similar results were reported by Jacob *et al.* (2009), wherein polymer coating increased the retention of pesticides in tomato seeds during storage as well as resulted in higher translocation of pesticides in seedling. Choudhary *et al.* (2006) reported polymer coating increases the half release time of carbofuron to 25.11 days and enhance the effective availability of carbofuron to 43.97 days. Higher mortality of root knot nematode (*Meloidogyne incognita*) was noticed even at half dose as compared to direct soil application.

Table 5 Effect of polymer coating on the release of carbendazim and fipronil in onion cv. Pusa Ridhi

Days	Carbendazim (ppm)		Fipronil (ppm)	
	Polymer coating	Water	Polymer coating	Water
0 days	5.594 a	6.026 a	0.823 a	0.529 d
15 days	3.717 b	1.047 d	0.729 b	0.195 e
30 days	2.042 c	0.366 d	0.609 c	0.056 f
General means	3.784	2.479	0.720	0.260
CD (0.01)	0.064		0.034	

\$- Means with at least one common letter are not statistically significant using Fishers least significant difference.

Rahim *et al.* (2016) reported that polymer coating prolonged the release of pesticides over of period of 35 days. Thus polymer coating not only help in higher pesticide retention but also prolonged the release of pesticides, thus providing the protection against pest and diseases for longer duration.

Polymer coating increased the pesticide use efficiency by increasing the retention and prolonging the release of pesticides. Onion bulbs coated with polymer along with 0.15 % fipronil and 0.25 % (carbendazim + mancozeb) resulted in lower incidence of disease and thrips, higher yield and quality. Thus onion bulb treatment with polymers can be an integral part of integrated pest and disease management for onion seed production.

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