Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 1060-1063
Received: 11-05-2018
Accepted: 15-06-2018

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Bio-efficacy evaluation of azoxystrobin 23% SC on potato for the control of late blight disease under the gangetic plains of West Bengal

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Abstract
A field experiment was carried out to evaluate the bio-effectiveness of Azoxystrobin 23% SC against the control of late blight disease of potato its persistence, phytotoxicity and effect on residual level and tuber quality. Experimental findings indicate that effiectiveness of the fungicidal products of Azoxystrobin (Rainbow) 23% SC to increase crop yield and terminal disease incidence values were found to be the lowest (11.97%) when treated with Azoxystrobin 23% SC (Rainbow) @ 600 ml/ha followed by Azoxystrobin 23% SC (Rainbow) @ 500 ml/ha (14.17%). The per cent reduction in disease incidence was also recorded maximum (81.15%) when treated with Azoxystrobin 23% SC (Rainbow) @ 600 ml/ha over un-treated plot.

Keywords: bio-efficacy, azoxystrobin, late blight, potato

Introduction
Potato (*Solanum tuberosum* L.) is one of the most important food crops after wheat, maize and rice, contributing to food and nutritional security in the world. It was introduced to India by early 17th century probably through British missionaries or Portuguese traders. It is an important cash crop throughout the world, used as staple food in many developing countries. Its cultivation spread throughout the India and more than 80% of its area is concentrated in the indo-gangetic plains of which of about 74% area is in the states of Uttar Pradesh, West Bengal and Bihar with 82% share in the total potato production. Among the potato growing states West Bengal got its second place after Uttar Pradesh with their respective production of 11052.60 and 15561.85 thousand tonnes during 2017-2018 (Monthly report potato, 2018) Some important potato varieties under three maturity groups, i.e. early (70-80 days), medium (90-100 days) and late (110-120 days) are commonly grown by the farmers in West Bengal condition are Kufri Jyoti, Kufri Chandramukhi, Kufri Lauvkar and Kufri Surya, Kufri Chipsona-1, Kufri Chipsona-2, Kufri Chipsona-3, Kufri Chipsona- 4, Kufri Himsona, Kufri Frysona. One of major constraints for potato production is late blight disease caused by oomycete *Phytophthora infestans* (Mont.) de Bary has historically been an important disease of potatoes and tomatoes worldwide. In the mid 1800, late blight caused widespread crop failures throughout Northern Europe including Ireland where it was responsible for the Irish famine (Elansky *et al*., 2001) [5]. Since then, it has spread far and wide and now occurs wherever potatoes are grown. In recent years, it has reemerged as a problem which affects both potato foliage in the field and tuber in the storage which can absolutely destroy a crop, producing a 100% crop loss (Tsedaley, 2014) [15]. It is favored by cool, moist weather and can kill plants within two weeks if conditions are right. The pathogen is highly variable and various pathological races exist universally in many food crops. The fungus had developed virulences against almost all the known R-genes in potato. By considering the seriousness of diseases and the economic damage caused by the diseases, the present investigation was carried out by using different doses of Azoxystrobin 23% SC for its Bio-effectiveness studies and Phytotoxicity studies against late blight disease of potato.

Material and Methods
Experimental site and field growing
Field experiments was carried out on November 2016 in the research plots of All India Coordinated Research Project on Vegetable Crops, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, situated at 23.5^0 N latitude and 89^0 E longitude at a mean sea level of

9.75m. Variety (kufri Jyoti) was sown in well-prepared seed bed having sandy loam soil. One deep ploughing followed by 2-3 cross and shallow ploughing were done for making the soil well pulverized, loose, friable, well leveled and good tilth. Well rotten organic manure @ 15 t/ha was applied during land preparation and leveled the land properly to provide good drainage. Applied Phorate 10G @ 15 kg/ha to control soil borne insects like cut worm, mole cricket, weevil etc, uniformly in all the experimental plots. Pre-planting irrigation was done at the time of planting. Used 30 g sized (3-5 cm diameter) disease free healthy cut tubers having 2-3 sprouts. Cutting knife was disinfected with 1% potassium permanganate ($KMnO_4$) solution each time after cutting any infected tubers. Seed tubers were planted on ridges at a depth of 3-5 cm keeping the sprouts upward at a spacing of 60 cm x 20 cm. During planting care was taken so that the seed tubers did not come in direct contact of the fertilizers that have been applied as basal. Applied a general fertilizer dose of 200 kg N, 150 kg P_2O_5 and 150 kg K_2O per hectare. Half the dose of nitrogen and potash and full dose of phosphorus were applied in furrows at the time of planting. Remaining half dose of nitrogen and potash were top-dressed in two split doses at 30 days after planting and 40 days after planting followed by earthing-up. Applied splash irrigation at 3-4 days interval up to 2-3 days before 1st earthing up and then irrigate the crop at an interval of 7-10 days after 1st earthing up. Irrigation was stopped 10 days before harvesting the crop to allow the tuber skin to become firm. The crop was harvested at 90 days after planting.

Treatment details

T_1 - Spraying of Azoxystrobin 23% SC (Rainbow) @ 400 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_2 - Spraying of Azoxystrobin 23% SC (Rainbow) @ 500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_3 - Spraying of Azoxystrobin 23% SC (Rainbow) @ 600 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_4 - Spraying of Azoxystrobin 23% SC (Market sample) @ 500 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_5 - Spraying of Hexaconazole 2% SC @ 3000 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_6 - Spraying of Copper oxy chloride 50% WP @ 2500 gm ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

T_7 – Untreated control – Water spray

T_8 - Spraying of Azoxystrobin 23% SC (Rainbow) for phytotoxicity evaluation only @ 1000 ml ha^{-1} immediately after the first appearance of disease symptoms followed by two sprays at 10 days interval.

Observations recorded

Disease recording

Periodic observations on diseases incidence before first spray and after 10 days of each spray and also 20 days after last spray on randomly selected 3 leaves per plant and 10 plants per plot were recorded for treatments at Sl. 1 to 7 treatments following standard method. Based on the data per cent reduction in disease incidence was calculated.

Phytotoxicity

Visual observations on phytotoxicity parameters viz. leaf injury on tips / surface*, wilting, vein clearing, necrosis, epinasty and hyponasty after 1, 3, 7 and 10 days of each spray were recorded for each of the treatment at Sl. No. 1 to 8 treatment. (*based on 0-10 scale: 0 = no phytotoxicity, 1=1-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9==81-90%, 10=91-100%).

Persistence and residue analysis

Samples of potato tuber and soil samples at harvest (approx 250 gm) for treatments at Sl. No. 2, 7 and 8 were collected replication wise and sent to the testing laboratory for residue analysis.

Yield recorded

The yield per plot was recorded at harvest. Yield per ha was calculated on the basis of yield per plot.

Statistical analysis

The data of disease incidence was transformed into their respective angular values before analysis. Data were analyzed using Statistical Analysis Systems software OP Stat.

Results and Discussion

Effects of different treatments on the incidence of late blight disease

Reactions of plants in terms of disease incidence (%) of late blight differed at different days after sowing (DAS) of potato. All the treated plots showed comparatively lower disease incidence values from 55 to 85 DAS (Table 1 and Fig. 1). The pathogen of potato late blight – the fungus *Phytophthora infestans* – produces spores in the conditions of a wide temperature range from 3 °C to 26 °C, the optimal conditions being 18 °C– 22 °C, and humidity or high relative humidity of 90 – 100% (Mateeva *et al*., 1985; Bahariev *et al*., 1988; Nakov *et al*., 2007) [9, 2, 11]. The terminal disease incidence values were found to be the lowest (11.97%) when treated with Azoxystrobin 23% SC (Rainbow) @ 600 ml/ha followed by Azoxystrobin 23% SC (Rainbow) @ 500 ml/ha (14.17%), Azoxystrobin 23% SC (Market sample) @ 500 ml/ha (19.51%) and Azoxystrobin 23% SC (Rainbow) @ 400 ml/ha (19.60%) at 85 DAS. Islam *et al*. (2018) [8] also reported that significantly lowest infected area was recorded in Ethaboxam (15.24%) followed by Folio Gold (19.41%), Mirador (Azoxystrobin) 23% SC (22.05%) and Kavach (25.56%) Other treatments were comparatively less effective. The maximum disease incidence (63.48%) was noticed in un-treated plots (control). The per cent reduction in disease incidence was also recorded maximum (81.15%) when treated with Azoxystrobin 23% SC (Rainbow) @ 600 ml/ha over un-treated plot. The compound appeared to be effective against *Fusarium moniliforme* (sheath rot of rice), *Drechslera oryzae* (brown leaf spot) and *Aspergillus niger* (collar rot of groundnut) (Thind *et al*., 2002) [14]. Azoxystrobin is the only currently available fungicide to provide effective control of downy mildew (*Plasmopara viticola*) in addition to powdery mildew (*Uncinula. necator*) (Wong and Wilcox, 2001). [16]

Effects of different treatments on tuber yield

The data in (Table 1) and (Fig. 1) revealed that treated plants, in general, increased the potato tuber yield compared with non-treated plants. Crop yield responded differently with various fungicidal products used. Plants treated with

Azoxystrobin 23% SC (Rainbow) @ 600 ml /ha recorded the maximum tuber yield (33.05kg/plot; 27.54q/ha) which was closely followed by Azoxystrobin 23% SC (Rainbow) @ 500 ml/ha (31.42 kg/plot; 26.18 q/ha), Azoxystrobin 23% SC (Rainbow) @ 400 ml/ha (29.27 kg/plot; 24.39 q/ha) and Azoxystrobin 23% SC (Market sample) @ 500 ml/ha (28.57 kg/plot; 23.81 q/ha). Other treatments were comparatively less effective. Plants receiving no treatment exhibited the lowest tuber yield (17.83 kg/plot; 14.86 q/ha). Alexandrov, (2011) [1] also reported that Potato late blight infection of the treated variants in green maturity of fruits was low: from 1.3% in plants treated with the fungicide Acrobat to 7.7% for Quadris (Azoxystrobin).

Phytotoxicity

Visual observations on phytotoxicity parameters viz. leaf injury on tips / surface, wilting, vein clearing, necrosis, epinasty and hyponasty revealed that there was no phytotoxicity in any treatment after 1, 3, 7 and 10 days of each spray to potato crop (Table 2). Ranganathan, (2001) [13] reported that there was no phytotoxic symptom throughout the cropping season due to azoxystrobin application. The other group of fungicides *viz.* sulphur caused phytotoxicity in grapes during hot weather period. (Berry and Smith 1959; Hewit and Jensen, 1973) [3, 7]. There are also reports about phytotoxicity of copper and organic compounds (Bolay and Siman, 1966) [4] and cupric hydroxide (Haesler and Petersen, 1974) [6] to grapevine leaves.

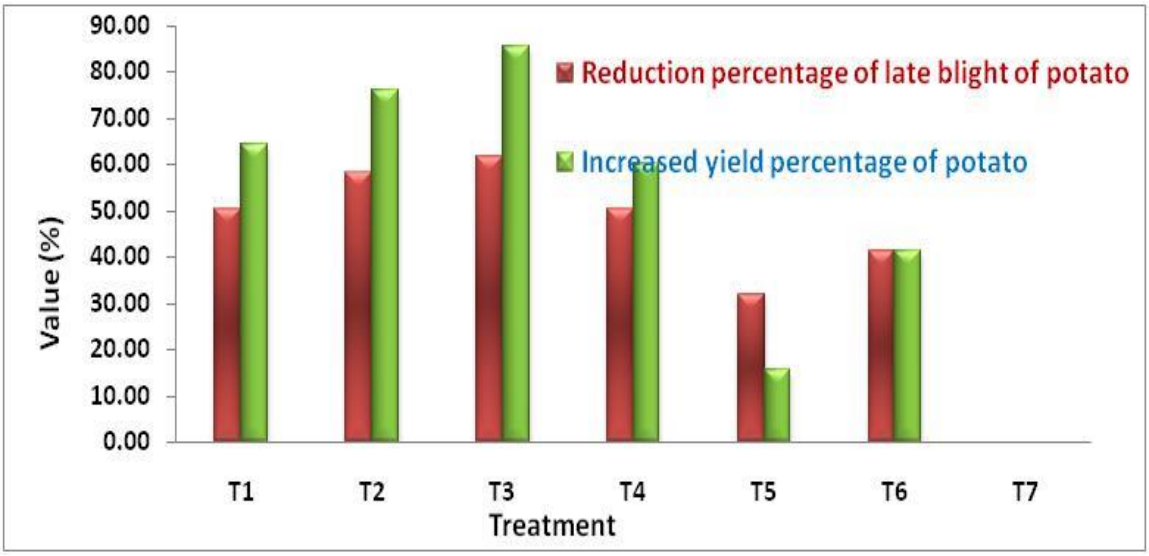

Fig 1: Effects of different treatments on the reduction percentage of incidence of late blight of potato and increased yield percentage of potato.

Table 1: Late blight incidence (in %) at 10 days interval (after appearance) and tuber yield

Treatments	Pre-treatment at 45 DAS	55 DAS	65 DAS	75 DAS	85 DAS	% reduction of disease incidence	Yield/plot (Kg/12m^2)	Yield /ha (q/ha)
T1	2.50	6.73	13.70	17.41	19.60	69.12	29.27	24.39
	(9.07)	(14.96)	(21.63)	(24.64)	(26.26)	(50.31)		
T2	2.52	6.36	10.90	13.21	14.17	77.68	31.42	26.18
	(9.00)	(14.57)	(19.25)	(21.28)	(22.09)	(58.21)		
T3	2.58	4.57	8.83	10.83	11.97	81.15	33.05	27.54
	(9.16)	(12.29)	(17.25)	(19.18)	(20.20)	(61.79)		
T4	2.52	8.88	14.67	17.95	19.51	69.27	28.57	23.81
	(9.05)	(17.29)	(22.48)	(25.05)	(26.20)	(50.43)		
T5	3.27	11.52	24.10	30.56	34.48	45.68	20.61	17.18
	(10.25)	(19.74)	(29.37)	(33.54)	(35.94)	(32.00)		
T6	2.67	10.67	19.16	23.92	26.68	57.98	25.17	20.98
	(9.20)	(18.98)	(25.91)	(29.19)	(31.03)	(41.29)		
T7	3.07	20.06	42.48	60.12	63.48	0.00	17.83	14.86
	(9.97)	(26.52)	(40.65)	(50.87)	(52.85)	(0.00)		
CD	NA	3.9	4.33	3.8	3.85	-	7.11	5.93
CV	20.81	12.21	9.33	7.26	6.98	-	14.90	14.90

Note: Bold values in parentheses are angular transformed, DAS=Days after sowing

Table 2: Phytotoxicity evaluation of test products on potato crop

Treatment	Dose/ha	Phytotoxicity parameters observed (mean observations recorded 1, 3, 7 and 10 days after each spray)					
		Leaf injury on tips/ surface*	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
Azoxystrobin 23% SC (Rainbow)	400 ml	0	Nil	Nil	Nil	Nil	Nil
Azoxystrobin 23% SC (Rainbow)	500 ml	0	Nil	Nil	Nil	Nil	Nil
Azoxystrobin 23% SC (Rainbow)	600 ml	0	Nil	Nil	Nil	Nil	Nil
Azoxystrobin 23% SC (Market sample)	500 ml	0	Nil	Nil	Nil	Nil	Nil
Hexaconazole 2% SC	3000 ml	0	Nil	Nil	Nil	Nil	Nil

Copper oxy chloride 50% WP	2500 gm	0	Nil	Nil	Nil	Nil	Nil
Untreated control (water only)	-	0	Nil	Nil	Nil	Nil	Nil
Azoxystrobin 23% SC (Rainbow)	1000 ml	0	Nil	Nil	Nil	Nil	Nil

*Based on 0-10 scale: 0 = no phytotoxicity, 1=1-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9==81-90%, 10=91-100%

Conclusion

We can conclude that potato plants treated with different fungicidal products responded well than un-treated plants. The better efficacy of the fungicidal products of Azoxystrobin 23% SC (Rainbow) to increase crop yield and disease management of late blight was observed over Azoxystrobin 23% SC (Market sample), Hexaconazole 2% SC and Copper oxy chloride 50% WP. Among the different doses of Azoxystrobin 23% SC (Rainbow), plants treated with dose @ 600 ml/ha was recorded highest yield and lowest late blight disease incidence closely followed by dose of 500 ml/ha. Hence the use of Azoxystrobin 23% SC @ 500 ml/ha is optimum for the control of late blight of potato crop.

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