The Pharma Innovation Journal 2022; 11(8): 1253-1256

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(8): 1253-1256

www.thepharmajournal.com
Received: 15-05-2022
Accepted: 21-06-2022

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Fluxapyroxad 333 FS: A novel systemic fungicide for effective management of black scurf of potato

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Abstract
Black scurf of potato caused by the pathogen *Rhizoctonia solani* Kuhn (Teleomorph *Thanatephorus cucumeris* Donk) affects the potato crop globally. The pathogen poses a possible threat to rapidly expanding seed potato cultivation in the north plain. In cool and wet soil, the diseases cause significantly more damage. Boric acid and pencycuron are the two chemicals that are frequently used by Indian farmers to control the black scurf of potato. New molecule: Fluxapyroxad 333 FS was evaluated at the different concentrations for bio-efficacy and phytotoxicity against black scurf of potato for two cropping seasons (2020-21). Pooled Results of two years showed that all the concentrations of 0.08%, 0.1% and 0.12% tested statistically effective in percent reduction of disease severity over control (90.77, 92.43 % and 92.43 % respectively) and percent increase in yield (12.12, 14.02 % and 14.60 % respectively). The plant emergence percentage ranged from 92.30-94.01 at tested concentrations of Fluxapyroxad 333 FS. No adverse effect on plant emergence and phytotoxicity was observed in any tested concentration. Conclusively as per looking at percent efficacy, environmental concern, and resistance risk factor, Fluxapyroxad 333 statistically even at a lower concentration (0.08%), advocated for potato growers for healthy crop.

Keywords: Black scurf, *rhizoctonia* solani, fluxapyroxad and management

Introduction
Potato (*Solanum tuberosum* L) is the most important non-grain food crop of Jammu and Kashmir and the unique climate condition of the union territory to good opportunity to produce healthy crop but often the potentiality is limited by a number of biotic and abiotic factors. Among the biotic factors diseases *viz*. Black scurf of potato caused by *Rhizoctonia solani* Kuhn which was earlier considered a minor disease emerging as an insurmountable problem for disease free seed production and production.

Black scurf of potato caused by the pathogen *Rhizoctonia solani* Kuhn (Teleomorph *Thanatephorus cucumeris* Donk) affects the potato crop globally, in India diseases cause losses between 10-25 % (Sharma, 2015) [3]. Farmers suffer an economic loss of 5-7 percent as a result of the disease's defacing of the tuber and sclerotia deposition (Shekhawat *et al*., 1993; Singh and Shekhawat, 1994) [4]. The pathogen poses a possible threat to rapidly expanding seed potato cultivation in the north plain. In cool and wet soil, the diseases cause significantly more damage (Khurana *et al*., 1998; Arora, 2012) [1].

Various fungicides pencycuron, carboxin, validamycin, and thiophenate methyl, boric acid is being used in seed treatment to prevent yield losses and deactivate *R. solani* sclerotial propagules worldwide (Olaya *et al*., 1994). The repeated use of fungicides reduces their effectiveness and leads to the development of resistance in the pathogen population (Wharton *et al*., 2007). Thus, there is a strong need to search for non-hazardous and equally effective alternatives to commonly used fungicides. In view to avoid the development of resistance to extensively used fungicides, a new fungicide Fluxapyroxad 333 FS is a systemic fungicide and has been recently introduced in India by BASF Company.

A study was undertaken with new recently introduced BASF company fungicide - Fluxapyroxad 333FS against black scurf of potato under field conditions with the view to find out a safer and better alternative to control this disease.

Materials and Methods
The field experiment was conducted to evaluate the new fungicide molecules Fluxapyroxad 333FS (Systiva) against black scurf of potato at a plant pathology research farm, SKUAST-J,

Chatha during the 2019-20 and 2020-21 crop season. The experiment was laid out in plot size 2.5 x 2.0 m with three replication and the infected potato variety Kufri Khyati was planted. The experiment was conducted with three doses of fungicides *viz.* Fluxapyroxad (0.08%), Fluxapyroxad (0.1%) and Fluxapyroxad (0.12%). The untreated tubers were kept in control. The fungicide mancozeb (0.4%) was kept as a stranded check of the SKUAST university package and healthy check treatment was also kept for estimation of yield losses (Table 1).

Seed treatment

The fungicide mentioned above and Table (1) were evaluated as the dip method of seed treatment The fungicidal dip treatment was carried out on the sprouted tubers one day before planting For dip treatment hundred percent infested diseased seed tubers of cv. Kufri Khyati was dipped for 10 minutes and shade dried. Tuber dip treatment was carried out by dipping 6 kg of the seed tubers in 6 liter of fungicide solution for 10 minutes. The same solution can be used 15-20 times for seed treatment.

Planting, harvest and observation

The seed tubers after shade drying were planted at 60 x 15 cm spacing in a 2.5 x 2.0 m^2 plot. Each treatment was replicated three times in Randomized Block Design. The crop was raised following the standard agronomic practices of the region. Plant vigor was recorded at 30 days of planting and other phytotoxicity indices 10 plants/replication at 7 and 15 days after germination. The haulms were cut after 100 days of planting and the crop was harvested two weeks after dehaulming. A total of 120 tubers (40 tubers/replication) were taken randomly from each treatment at harvesting and data of disease incidence and percent diseases severity was recorded.

The disease severity was recorded on a 0-5 disease rating scale developed by Ahmad *et al*. (1995) whereas 0=healthy, 1= less than 1% tuber area affected, 2= 1-10% tuber area affected, 3=11-20% tuber area affected, 4=21-50 tuber area affected, 5= 51 % or more tuber area affected. Yield data was taken at the time of harvesting and converted into a hectares basis.

The plant vigor was recorded after 30 days of germination by observing plant health as per scale (Plant vigor - (1-5 rating scale) Plant vigor - (1-5 rating scale) (1=High vigor, 2=moderate high, 3=moderate, 4=moderate-low, 5=low vigor).

Results and Discussion

Fluxapyroxad 333 FS was found effective in improving plant health, percent disease control and yield over control in both seasons.

The data (Table 1 and 2) revealed that all the concentration of tested fungicides Fluxapyroxad 333 FS was found effective in reducing the disease severity significantly and enhanced the plant vigor and yield with respect to control or even near to healthy check. All the concentrations of tested fungicide Fluxapyroxad 333 FS improve the plant vigor as compared to control but maximum plant vigor 4. 4 and 4.10 were observed in Fluxapyroxad 333 FS 0.12 % in both the years with 31.07 percent improvement in plant health. Statistically similarly Fluxapyroxad 333 FS 0.1% and 0.08 % showed 26.79 and 29.8 percent improvement in plant vigor respectively over control. The standard check mancozeb showed 3.3 plant vigor and the control plot showed 2.95 plant vigor.

The pooled data of two years of plant emergence showed that maximum plant emergence of 94.01 percent was observed in Fluxapyroxad 333 FS 0.12 % concentration followed by statistically at par in 0.1 and 0.08% concentrations percent with 92.30 and 92.86 percent, respectively. Plant emergence (96.10 percent) was observed in the healthy check whereas in the control plot plant emergence was 76.67 percent.

As evident from the data all the concentrations of tested fungicides Fluxapyroxad 333 FS proved most effective over untreated control. All the doses tested showed statistically at pat 11.2 to 14.5 percent disease severity with 90.77 to 92.34 percent efficacy over control. In the control plot, the disease severity was recorded 37.50 percent. The least efficacy 20.74 percent was recorded in mancozeb @0.4%

The two-year pooled data of yield showed that yield in various treatments varied from 212 to 246.6 qt/hectare Among the Fluxapyroxad 333 FS tested concentration statistically at par yield 232.6 to 239.50 qt/hectare were recorded with 1.12 to 14.6 percent increase in yield as compared to control. The highest yield 246.6 qt/hectare was recorded in a healthy check.

Phytotoxicity observation Fluxapyroxad being a new fungicide, Phytotoxicity parameters *viz.*, Delay in emergence, adverse effect on plant and yield aerial tuber formation, effect on maturity period were also observed. There was no side effect was observed in the tested concentrations Table (3).

The study indicated the superior efficacy of Fluxapyroxad in controlling black scurf of potato and better efficacy of this fungicide may be attributed to its strong and specific action against *R. solani* and its longer persistent action on the pathogen.

Various workers reported the efficacy of different fungicides to combat the menace. Pencycuron was found effective in reducing the disease severity and reduction in stem grilling (Rauf *et al.*, 2007) [5]. Similarly, Khanna *et al.* (1991) reported the promising efficacy of carbendazim in reducing the potato black lack scurf severity. *In vitro* and *In vivo* efficacy of Carboxin 37.5 + Thiram 37.5 against black scurf disease was reported in Punjab state (Thind *et al*., 2002) [6]. Efficacy of Thifluzamide 24 % SC was well documented in reducing potato black scurf severity by Mehi *et al*. (2017).

General view of the trials

Fig 1: General field view of trails and harvested tubers

Table 1: Bio efficacy of Fluxapyroxad 333 FS against black scurf of potato under field condition during 2020 and 2021(Diseases parameters)

Tr. No.	Treatment	Disease incidence (%)			Diseases severity (%)			Percent efficacy over control		
		2019-20	2020-21	Mean	2019	2020	Mean	2019	2020	Mean
*T_1	Seed treatment with Fluxapyroxad 333 FS @0.08 %	18.5	10.5	14.5	4.0	2.5	3.2	87.30	94.25	90.77
*T_2	Seed treatment with Fluxapyroxad333 FS @0.1 %	17.5	7.5	12.5	3.5	1.75	2.62	88.9	95.97	92.43
*T_4	Seed treatment with Fluxapyroxad 333 FS @0.12 %	15.0	7.5	11.2	3.5	1.75	2.62	88.9	95.97	92.43
*T_5	Seed treatment with mancozeb 75% WP @ 0.4 % (Std. Check -M45)	57.50	75.00	66.20	23.50	36.50	30.00	25.39	16.09	20.74
T_{16}	Control	70.00	97.50	85.00	31.50	43.50	37.50			
T_{17}	Healthy Check	2..0	2.0	2.0	0.50	1.00	0.75	98.41	97.70	98.05
	CD (P=0.05)	19.9	12.6	16.2	9.5	6.6	8.05			
	SE(m)	7.01	4.4	5.7	3.3	2.2	2.75			

*Dip Treatment

Table 2: Bio efficacy of Fluxapyroxad 333 FS against black scurf of potato under field condition during 2020 and 2021(Health parmeters)

	Treatment	Plant Emergence (%)				Plant Vigor (%)				Yield (q/hac)			
		19-20	20-21	Mean	% Increase	19-20	20-21	Mean	(%) Improvement	19-20	20-21	Mean	% Increase
T_1	Seed treatment with Fluxapyroxad 333 FS @0.08 %	94.50	90.10	92.30	16.93	4.10	3.97	4.03	26.79	243.50	229.7	232.6	12.12
T_2	Seed treatment with Fluxapyroxad333 FS @0.1 %	95.63	90.10	92.86	17.47	4.33	4.00	4.16	29.08	245.50	230.0	237.75	14.02
T_3	Seed treatment with Fluxapyroxad 333 FS@0.12 %	95.70	92.33	94.01	22.61	4.47	4.10	4.28	31.07	246.50	232.50	239.50	14.60
T_5	Seed treatment with mancozeb 75% WP @ 0.4 % (Std. Check -M45 Univ)	83.31	80.00	81.66	6.50	3.57	3.03	3.30	10.60	222.70	201.70	212.2	3.67
T_{16}	Control	77.78	75.55	76.67		3.00	2.90	2.95	36.55	212.50	196.30	204.4	0.00
T_{17}	Healthy	98.87	93.33	96.10	20.21	4.77	4.53	4.65	36.50	253.30	238.70	246.0	16.91
	CD (P=0.05)	10.4	6.7			0.56	0.49	0.52		10.2	12.9	11.5	
	SE(m)	(0.19)	(2.3)			(0.19)	(0.16)	(0.17)		(3.9)	(4.4)	(4.1)	

Table 3: Evaluation of Fluxapyroxad 333 FS on Phytotoxicity parameters (Health traits)

S. N	Fungicide	Delay in emergence	Adverse effect on plant height	Delay in tuber initiation	Aerial tuber formation	Maturity period	Adverse effect on yield
T_1	Seed treatment with Fluxapyroxad 333 FS @0.08 %	No	No	No	No	Normal	No
T_2	Seed treatment with Fluxapyroxad 333 FS @0.1 %	No	No	No	No	Normal	No
T_3	Seed treatment with Fluxapyroxad333 FS @0.12 %	No	No	No	No	Normal	No

Conclusion

All the tested concentrations of Fluxapyroxad (0.08 %, 0.1% and 0.12 %) were found effective in reducing the percent disease severity and increase in plant health attributes. Moreover, no phytotoxicity was observed in any concentration tested and statistically, all the concentrations are at par in all aspects but in view to the environment concerned, risk of resistance development and cost benefit to the farmer, Fluxapyroxad brand name Systiva at concentration 0.08% advocated potato growers for effective management of diseases.

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