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Plant Pathology

Differential Response of Trifloxystrobin in Combination with Tebuconazole on Growth, Nutrient Uptake and Yield of Rice (*Oryza Sativa* L.)

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Abstract

The present investigation was carried out at Tamil Nadu Agricultural University to evaluate the influence of trifloxystrobin in combination with tebuconazole (*Nativo*) on the nutrient uptake, yield attributes and yield of rice. Foliar spray of *Nativo* was taken up at 50-55 days after sowing (DAS) and 70-75 DAS and observations were recorded at panicle initiation (60-65 DAS), flowering (80-85 DAS) and maturity (100-105 DAS) stages. The result indicated that *Nativo* significantly improved the root length, total dry matter production (TDMP) and nutrient uptake, but inhibited the shoot length. Among the different concentrations, *Nativo* @ 400 g ha^{-1} performed better by increasing the fertility co-efficient, 1000 grain weight, panicle length and the grain yield in rice.

Highlights

- Different doses of *Nativo* were given as foliar spray at 50-55 DAS and 70-75 DAS in rice.
- Among the concentrations applied, *Nativo* @ 400 g ha^{-1} exhibited higher root length, dry matter production, nutrient uptake and thereby, grain yield.

Keywords: Rice, trifloxystrobin, tebuconazole, nutrient, TDMP, yield

Introduction

Rice culture plays a dominant role in national agriculture sustaining the livelihood of considerable per cent of the population. India, the second largest rice growing country has a cultivation area of about 44.6 million hectares with a production of 104.32 million tonnes and average productivity of 2.34 tonnes per hectare. Various biotic and abiotic stresses limit the productivity of rice across diverse crop growing areas. The interference of plant diseases results in significant losses in the productivity and quality of products obtained.

Fungicides remain a vital solution to the effective control of plant diseases, which are estimated to cause yield reductions of almost 20 percent in major food and cash crops worldwide. After the launching of modern agrochemicals containing antioxidant compounds such as fungicides belonging to strobilurins (trifloxystrobin, azoxystrobin, pyraclostrobin, kresoxim methyl etc.), and triazoles (propiconazole, epoxiconazole, tebuconazole, penconazole, etc.), the concept of disease control gained new perspectives, especially when considering the advantages by the positive physiological effects on the

plants. *Nativo* 75 WG is a water dispersible granular formulation containing 25 per cent w/w trifloxystrobin and 50 per cent w/w tebuconazole and proved to be effective in management of blast disease in rice (Debashis *et al*., 2012). Trifloxystrobin belongs to the strobilurin group of fungicide which is a mesostemic and broad-spectrum fungicide with preventive and specific curative activity. In addition to the fungicidal effect of strobilurins on the metabolism of pathogenic fungi, positive influences on host physiology and, consequently, on yield formation have been recognised in cereals (Beck *et al*., 2000). These changes in the metabolism and physiology have been studied intensively and are ultimately referred to as "the greening effect". This comprises of increased dry matter, enhanced chlorophyll content, higher amount of protein and delayed senescence. The use of stobilurins is an alternate approach to increase and stabilize yield in crop plants. Tebuconazole is a systemic triazole fungicide which is used widely in agricultural practices and reported to kill the target organisms by disrupting the membrane functions through sterol biosynthesis inhibition. Previous studies have revealed that morphological and physiological changes associated with triazole treatment in various plants, include an increase in root length, decreased internodal elongation, increased chlorophyll levels, enlarged chloroplasts, thicker leaf tissue, increased root to shoot ratio, increased antioxidant potentials and enhancement in alkaloid production (Jaleel *et al*., 2008). *Nativo* (trifloxystrobin+tebuconazole), a proprietary product of Bayer CropScience is reported to cause physiological changes in crops and influence the crop yield. With this background, a detailed investigation was made to assess the impact of *Nativo* on the growth, nutrient uptake and grain yield of rice.

Materials and Methods

The field experiments in rice (var. ADT 43) were conducted at Wetland, Tamil Nadu Agricultural University, Coimbatore during *Kharif* (June 2011 to September 2011) and *Rabi* (November 2011 to February 2012) with four replications in factorial randomized block design using season as one factor and treatments as second factor. SRI (System of Rice Intensification) method of cultivation was followed and recommended package of practices were adopted. The treatment includes untreated control (T_1), foliar spray of *Nativo* 75 WG @ 350 g ha^{-1} (T_2), 400g ha^{-1} (T_3), 800g ha^{-1} (T_4) and *Carbendazim* @ 1000 g ha^{-1} (T_5) at 50-55 DAS and 70-75 DAS.

The observations on growth parameters such as shoot length (cm $plant^{-1}$), root length (cm $plant^{-1}$) and total dry matter production (g $plant^{-1}$) were recorded in five plants per replication. The soil samples and dried plant samples were collected and determined for nitrogen, phosphorus and potassium content from triple acid extract and soil extract respectively (Piper, 1966). The total nitrogen content in plant samples were estimated by Microkjeldhal method as proposed by Humphries (1956), phosphorus by colorimetric method (Piper, 1966) and potassium by flame photometer (Piper, 1966). The total NPK uptake at different stages were worked out by summing up the uptake in different parts of the plant after multiplying the total dry matter of the plant parts with the corresponding NPK content and expressed as kg ha^{-1}.

The yield components such as number of panicles $hill^{-1}$, number of spikelets $panicle^{-1}$, number of filled grains $panicle^{1}$, 1000 grain weight, length of panicle (cm), grain and straw yield per hectare was recorded during harvest and fertility co-efficient (%) were calculated by the ratio of filled grains to the total number of spikelets in the primary panicles in each hill. Harvest index was computed as given below and expressed in percentage.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Results and Discussion

Application of fungicide has been found to influence the plant growth in various crops. Significant reduction in shoot length was observed by foliar spray of *Nativo* (trifloxystrobin + tebuconazole) irrespective of the seasons (Table 1). The reduction could have resulted due to inhibition of cell expansion as reported by Gopi *et al*. (1999) in cowpea. From the present study, a maximum reduction of 3.18 percent was recorded in *Nativo* 75 WG @ 800 g ha^{1} and the reduction in shoot growth by triazole occurs primarily as a consequence of reduced internodal elongation due to lack of sufficient quantity of gibberellins.

Root length of rice plant treated with fungicide (*Nativo*) showed a significant increase in root length at both the seasons of study (Table 2). The treatment, T_4 (*Nativo* 75 WG @ 800 g ha^{-1}) recorded highest root length at 60-65 DAS (22.29) and 80-85 DAS (26.95) and lowest root length was registered in treatment T_1 (18.30, 23.15). The increase in root length may be due to inhibition of gibberellic acid (GA) synthesis causing reduced shoot length (Sankhla and

Davis, 1999) and increased partitioning of assimilates towards roots. The increased root length by fungicide treatment may facilitate the water and nutrient absorption from the soil, which are the crucial factors for determining crop growth.

Translocation of assimilates to the growing reproductive parts is a major factor in crop production, which can be influenced by the physiological effects of fungicide. Fungicide (*Nativo*) as foliar spray increased total dry matter production (TDMP) significantly when compared with control (Fig.1). The maximum TDMP was observed in *Nativo* 75 WG @ 400g ha^{-1} (61.40) and the minimum in control (56.20) at 100-105 DAS. The increment was related to the ability of triazoles to enhance the levels of cytokinin (Grossmann *et al.*, 1994) and as a consequence, increased cell division and dry weight (Gopi *et al.*, 2007).

Both pre-planting and post-experimental soil samples were collected and analyzed for NPK (Table 3). The initial soil sample did not show any significant difference in available NPK. In postharvest soil samples, N, P and K content were found to reduce considerably compared to the initial soil sample. Considering the effect of fungicide levels, irrespective of both the seasons, the increase in fungicide concentration reduced the available N, P and K compared to untreated control. The available N in the final soil sample was considerably low compared to initial soil sample. The effect of fungicide levels showed an evident variation compared to untreated control, the maximum available N (229.20) in T_1 and the lowest in T_3 (214.36). Considering the effect of fungicide concentration on P content, the fungicide spray at two different stages significantly reduced the soil P compared to control, the maximum P in T_1 (12.98)

Table 1: Effect of trifloxystrobin in combination with tebuconazole on shoot length (cm $plant^{-1}$) of rice

Treatments	Shoot length (cm $plant^{-1}$)								
	60-65 DAS			80-85 DAS			100-105 DAS		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	64.85	61.91	63.38	87.67	84.46	86.07	90.23	86.15	88.19
T_2	62.42	59.76	60.99	86.52	84.24	85.38	88.07	85.94	87.01
T_3	61.75	58.23	60.14	84.10	82.11	83.11	87.69	83.06	85.38
T_4	59.58	56.83	58.21	83.81	80.97	82.39	87.06	82.39	84.73
T_5	63.90	61.34	62.67	85.37	83.12	84.25	88.51	85.27	86.89
Mean	62.50	59.65	61.08	85.49	82.98	84.24	88.31	84.56	86.44
	T	S	T x S	T	S	T x S	T	S	T x S
SEd	1.174	0.742	1.660	1.309	0.828	1.851	1.219	0.771	1.724
CD (P:0.05)	2.4081	1.523	0.002	2.6857	1.699	3.798	2.5020	1.582	3.538

Table 2: Effect of trifloxystrobin in combination with tebuconazole on root length (cm $plant^{-1}$) of rice

Treatments	Root length (cm $plant^{-1}$)								
	60-65 DAS			80-85 DAS			100-105 DAS		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	18.31	18.29	18.30	23.42	22.88	23.15	22.38	20.73	21.56
T_2	21.58	19.00	20.29	25.68	25.11	25.40	23.48	22.72	23.10
T_3	22.19	20.37	21.28	26.18	25.36	25.77	24.43	23.57	24.00
T_4	22.80	21.78	22.29	27.09	26.81	26.95	25.23	25.48	25.36
T_5	20.80	21.57	21.19	26.30	25.96	26.13	24.05	25.19	24.62
Mean	21.14	20.20	20.67	25.73	25.22	25.48	23.91	23.54	23.73
	T	S	T x S	T	S	T x S	T	S	T x S
SEd	0.119	0.075	0.168	0.147	0.093	0.207	0.136	0.086	0.193
CD (P:0.05)	0.2437	0.154	0.345	0.3009	0.190	0.425	0.2798	0.177	0.396

Table 3: Effect of trifloxystrobin in combination with tebuconazole on available soil nitrogen, phosphorous and potassium content (kg ha^{-1}) of rice at initial and final stages

Treatments	Available nitrogen (kg ha^{-1})						Available phosphorus (kg ha^{-1})						Available potassium (kg ha^{-1})					
	Initial			Final			Initial			Final			Initial			Final		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	278.39	271.50	274.94	234.62	223.78	229.20	16.62	15.79	16.21	12.74	13.23	12.98	513.06	509.38	511.22	454.05	456.25	455.15
T_2	275.27	270.26	272.76	226.12	212.85	219.49	17.01	13.89	15.45	11.80	12.42	12.11	533.36	511.75	522.56	449.32	454.41	451.87
T_3	279.69	268.76	274.22	222.30	206.43	214.36	16.76	14.46	15.61	11.54	12.03	11.78	518.64	516.74	517.69	442.29	453.77	448.03
T_4	278.37	269.04	273.70	227.90	216.80	222.35	16.63	14.77	15.70	12.14	13.18	12.66	526.37	503.03	514.70	450.72	446.58	448.65
T_5	277.66	270.68	274.17	224.07	208.37	216.22	16.35	13.63	14.99	12.22	12.96	12.59	517.10	515.87	516.48	449.80	456.21	453.00
Mean	277.87	270.04	273.96	227.00	213.65	220.32	16.67	14.51	15.59	12.09	12.76	12.43	521.71	511.36	516.53	449.23	453.44	451.34
	T	S	T x S	T	S	T x S	T	S	T x S	T	S	T x S	T	S	T x S	T	S	T x S
SEd	1.227	0.699	1.735	0.083	0.048	0.117	0.356	0.206	0.504	0.092	0.053	0.130	2.677	1.546	3.786	5.76	3.33	8.14
CD (P:0.05)	NS	NS	NS	0.168	0.098	0.239	NS	NS	NS	0.186	0.108	0.264	NS	3.145	NS	NS	NS	NS

and the lowest in T_3 (11.78). Though the available K content was reduced by the fungicide application, there was no significant difference among the treatment at final stage.

Nitrogen uptake by the plants showed significant increase over the growth period. The effect of fungicide (*Nativo*) on nitrogen uptake was highest in the treatment T_3 (*Nativo* 75 WG @ 400 g ha^{-1}) followed by T_2 (*Nativo* 75 WG @ 350g ha^{-1}). Available nitrogen content in soil (Table 2) was maximum (229.20) in control and minimum (214.36) in T_3. This show that maximum uptake of nitrogen from soil was favoured by *Nativo* 75 WG @ 400 g ha^{-1} and less uptake by control plants. The present findings are strongly supported by the findings of Han and Yang (2009) that uniconazole increased the uptake of nitrogen in wheat. A maximum enhancement of 17.53 per cent could be observed in rice and the increment in nitrogen uptake (Fig.2) by application of different levels of trifloxystrobin combined with tebuconazole may be attributed to enhanced

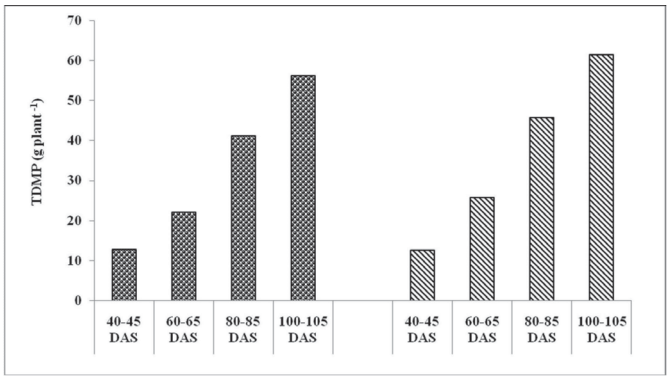

Fig. 1: Effect of trifloxystrobin in combination with tebuconazole on total drymatter production (TDMP) of rice

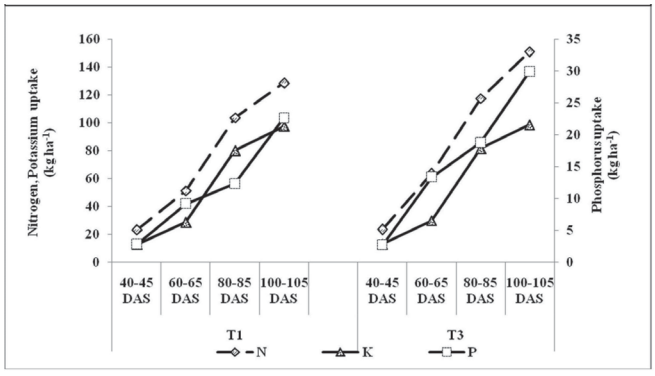

Fig. 2: Effect of trifloxystrobin in combination with tebuconazole on nitrogen, phosphorus and potassium uptake of rice

cytokinin and this increase in cytokinin levels was associated with stimulated chlorophyll biosynthesis (Fletcher *et al*., 2000).

Root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation in legumes, crop quality, and resistance to plant diseases or abiotic stress are the attributes associated with phosphorus nutrition. The effect of fungicide (*Nativo*) on phosphorous uptake showed significant increase irrespective of the seasons over the growing period. Among the treatments, T_3 showed significant increase in phosphorous uptake (32.4 per cent) by the plant compared to other treatments (Fig.2). The increment in phosphorus uptake due to fungicide application was earlier reported by Schweiger *et al.* (2001) in peas. In general, plants appear to be remarkably efficient in their internal recycling of phosphorus. Phosphorus uptake by the plants was increased due to the enhanced activity of acid phosphatase (Djanaguiraman, 2003), by solubilising organic phosphates in the rhizosphere (Goldstein *et al*., 1989). The analysis of data did not show any significant variation, between the treatments on potassium uptake (Fig.2). Contrary to the results, significant increase in potassium uptake was observed by Mohamed *et al*. (2011) in tomato in response to triazole application.

Yield (Table 4a, b) is the manifestation of morphological, growth, physiological and biochemical parameters. Among the fungicide treatments, *Nativo* 75 WG @ 400g ha^{-1} was observed to have maximum number of panicles (25.03) than other treatments and the lowest in T_1 (19.78). *Nativo* 75 WG @ 400g ha^{-1} proved to be superior by having maximum fertility co-efficient (86.4) followed by *Nativo* 75 WG @ 350g ha^{-1} (85.9) and the lowest in untreated control (84.2). The data on 1000 grain weight and panicle length revealed that, though *Nativo* 75 WG @ 400g ha^{-1} showed higher mean value (18.13) on 1000 grain weight and higher panicle length (20.88), compared to other treatments, there was no significant difference between them. Foliar spray of *Nativo* 75 WG @ 400g ha^{-1} resulted in higher grain yield (6.73), while the untreated control registered the lowest yield (5.76). *Nativo* 75 WG @ 400g ha^{-1} significantly increased the economic yield to an extent of 16.81 per cent in rice. The harvest index followed the similar trend as of grain yield and the fungicide treatment *Nativo* 75 WG @ 400 g ha^{-1} registered the maximum harvest index (42.00), followed by T_2 (41.42) and the lowest in T_1 (38.87). Similar evidences were also reported by Bag (2009) in rice and Ijaz (2012) in mustard. The

Table 4a: Effect of trifloxystrobin in combination with tebuconazole on yield and its components of rice

Treatments	No. of panicles hill^{-1}			No. of spikelets panicle^{-1}			Filled grain panicle^{-1}			Fertility coefficient (%)		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	21.06	18.49	19.78	157.9	149.2	153.6	135.1	123.7	129.4	85.5	82.9	84.2
T_2	24.63	22.18	23.40	182.5	168.1	175.3	159.2	142.1	150.6	87.2	84.5	85.9
T_3	26.14	23.92	25.03	187.5	177.2	182.4	164.5	150.9	157.7	87.7	85.2	86.4
T_4	22.73	20.15	21.44	171.3	163.9	167.6	147.7	137.4	142.6	86.2	83.8	85.0
T_5	22.40	19.82	21.11	169.8	158.5	164.1	146.1	132.1	139.1	86.1	83.3	84.7
Mean	23.39	20.91	22.15	173.8	163.4	168.6	150.5	137.2	143.9	86.6	84.0	85.3
	T	S	T x S	T	S	T x S	T	S	T x S	T	S	T x S
SEd	0.096	0.060	0.135	0.729	0.461	1.030	0.622	0.393	0.879	0.370	0.234	0.524
CD (P:0.05)	0.196	0.124	NS	1.495	0.946	NS	NS	0.807	NS	0.760	0.481	NS

Table 4b: Effect of trifloxystrobin in combination with tebuconazole on yield and its components of rice

Treatments	Panicle length (cm)			Straw yield (t ha^{-1})			Grain yield (t ha^{-1})			Harvest Index (%)		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
T_1	20.80	19.59	20.20	9.12	8.98	9.05	5.82	5.71	5.77	38.96	38.87	38.91
T_2	21.19	20.00	20.59	9.31	9.19	9.25	6.58	6.50	6.54	41.41	41.43	41.42
T_3	21.47	20.29	20.88	9.36	9.21	9.29	6.86	6.59	6.73	42.29	41.71	42.00
T_4	19.81	18.61	19.21	9.13	9.03	9.08	6.51	6.41	6.46	41.62	41.52	41.57
T_5	20.20	18.97	19.58	9.16	9.01	9.09	6.33	6.01	6.17	40.87	40.01	40.44
Mean	20.69	19.49	20.09	9.22	9.08	9.15	6.42	6.24	6.33	41.03	40.71	40.87
	T	S	T x S	T	S	T x S	T	S	T x S	T	S	T x S
SEd	0.087	0.055	0.123	0.040	0.025	0.056	0.027	0.017	0.039	0.177	0.112	0.251
CD (P:0.05)	0.179	NS	NS	NS	NS	NS	0.056	0.036	0.080	0.364	0.230	NS

increase in yield by *Nativo* 75 WG @ 400 g ha^{-1} was due to the changes in growth and nutrio-physiological processes such as inhibition of shoot length, higher root length, enhanced TDMP and increased NPK uptake. The increment of these parameters significantly increased the accumulation of dry matter in reproductive parts and promoted fertility coefficient and, in turn the yield and harvest index of rice.

Conclusion

The present study demonstrated the additive effect of trifloxystrobin and tebuconazole in improving the growth and yield, and concluded that foliar spray of *Nativo* 75 WG @ 400g ha^{-1} during 50-55 days after sowing and 70-75 days after sowing was found to be optimum in improving the yield in rice.

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