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Phytotoxicity of Triafamone 200 SC in transplanted rice and its residual effect on succeeding blackgram

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Abstract
A field study was conducted on clay loam soils at the Agricultural Research Station, Jangamaheswarapuram, Guntur District, Andhra Pradesh, India, during 2017-18 and 2018-19. The study aimed to assess the efficacy of Triafamone 200 SC herbicide in transplanted rice and its residual effects on succeeding blackgram. Among the treatments, T_{10} (Triafamone 200 SC @ 100 g a.i. ha^{-1} at 2-3 DAT) and T_5 (Triafamone 200 SC @ 100 g a.i. ha^{-1} at the 2-3 leaf stage) caused slight phytotoxicity, characterized by stunted Rice growth and yellowing of leaves, which was observed 7 days after application. However, plants recovered completely within a week. The weed-free treatment (T_{13}) recorded the highest grain yields of 5762 kg ha^{-1} and 6376 kg ha^{-1} in 2017-18 and 2018-19, respectively, followed closely by T_{12} (Two hand weedings), T_{10}, and T_5. The untreated control (T_1) yielded significantly lower at 3066 kg ha^{-1} and 3825 kg ha^{-1} during the respective years. The succeeding Blackgram crop showed no signs of phytotoxicity or adverse effects, including on germination, growth and yield.

Keywords: Weed management, Triafamone 200 SC, phytotoxicity, grain yield, residual effects, crop injury score

Introduction
Rice is one of the most vital crops cultivated in tropical regions, particularly in India, where it plays a key role in ensuring food security and nutritional sustenance. India is the second-largest rice producer globally, contributing significantly to the agricultural economy. As of recent reports, rice is cultivated on 43.8 million hectares in India, yielding 118.4 million tonnes with an average productivity of 2.7 t ha^{-1} (GOI, 2021) [2]. Andhra Pradesh, a major rice-producing state, accounts for 2.21 million hectares of rice cultivation, producing 8.23 million tonnes with a productivity of 3.73 t ha^{-1} (Reserve Bank of India, 2020) [7]. Labour shortages and the increasing costs of manual input have made traditional weed management practices inefficient, labour-intensive, and economically unfeasible for large-scale farming. Rapid industrialization and urbanization have further limited the viability of these conventional methods. Herbicides have emerged as a preferred solution due to their cost-effectiveness, efficiency, and ability to save time. Selecting suitable herbicides tailored to the specific weed flora is crucial for achieving optimal weed control (Jyothi Basu *et al.*, 2020) [3].
Herbicidal weed control plays a vital role in sustainable crop management, but residual effects on succeeding crops require careful evaluation. While herbicides can effectively manage weeds when applied at recommended rates, their persistence in the soil poses challenges for subsequent crops. Some herbicides degrade slowly, remaining active for weeks, months, or even years, potentially inhibiting plant growth (Rani *et al.*, 2021) [5]. To mitigate environmental and agronomic risks, optimizing herbicide use is crucial (Sridhara *et al.*, 2018) [8]. Herbicide residue analysis has become pivotal in ensuring environmental safety, with bioassay emerging as a practical and cost-effective method for evaluation.
In rice fallows, pulses such as Blackgram are sown via relay cropping, relying entirely on residual soil moisture and fertility. However, poor crop stand, weed competition, and terminal moisture stress often limit productivity. Given these challenges, this study was undertaken to assess the efficacy, phytotoxicity, and residual impact of Triafamone 200 SC in transplanted Rice and its influence on the subsequent Blackgram crop.

Materials and Methods

The field experiment was conducted on clay loam soils at the Agricultural Research Station, Jangamaheswarapuram, Guntur District, Andhra Pradesh, India, during the 2017-18 and 2018-19 cropping seasons. The study was designed to assess the efficacy of various weed management treatments in transplanted Rice. A total of 13 treatments were implemented and analysed, including herbicidal applications, manual weed control practices, and untreated controls. The treatments were arranged in a randomized block design with four replications.

A field experiment was conducted on clay loam soils of Agricultural Research Station, Jangamaheswarapuram, Guntur Dist. Andhra Pradesh, India for two consecutive years (2017-18 and 2018-19). There were nine treatments, as given here under.

Treatment	Dose (g a.i. ha^{-1})	Time of Application
$T_{1.}$ Untreated control	-	-
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed	30	2 to 3 leaf stage of weed
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed	40	2 to 3 leaf stage of weed
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed	50	2 to 3 leaf stage of weed
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed	100	2 to 3 leaf stage of weed
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15	2 to 3 leaf stage of weed
$T_{7.}$ Triafamone 200 SC) at 0-3 DAT	30	0 to 3 days after transplanting
$T_{8.}$ Triafamone 200 SC) at 0-3 DAT	40	0 to 3 days after transplanting
$T_{9.}$ Triafamone 200 SC) at 0-3 DAT	50	0 to 3 days after transplanting
$T_{10.}$ Triafamone 200 SC) at 0-3 DAT	100	0 to 3 days after transplanting
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750	0 to 3 days after transplanting
$T_{12.}$ Farmer practice (two hand weedings)	-	20 DAT and 40 DAT
$T_{13.}$ Weed free	-	-

Triafamone is classified as a keto sulfonanilide herbicide that is absorbed by plants through both leaves and roots. Once inside the plant, it rapidly undergoes conversion to an intermediate form via reduction of the keto group. In weeds, however, an additional metabolite is produced through N-demethylation, which effectively inhibits the enzyme acetolactate synthase (ALS), thereby disrupting weed growth.

The potential phytotoxic effects of herbicides on the rice crop were evaluated at intervals of 7, 14, 21, 28, and 35 days after application. A simple rating scale ranging from 0 to 10 (corresponding to 0% to 100% phytotoxicity) was employed for assessment, as described by Rao (2000) [6] and detailed below.

Effect	Rating	Description on crop	Phytotoxicity Rating Scale (PRS)
None	0	No injury, normal	0-00
Slight	1	Slight stunting injury or discolouration	1-10%
	2	Some stand loss, stunting discolouration	11-20%
	3	Injury more pronounced but not persistent	21-30%
Moderate	4	Moderate injury, recovery possible	31-40%
	5	Injury more persistent, recovery doubtful	41-50%
	6	Near severe injury, no recovery possible	51-60%
Severe	7	Severe injury, stand loss	61-70%
	8	Almost destroyed, a few plants surviving	71-80%
	9	Very few plants alive	81-90%
Complete	10	Complete destruction	91-100%

After harvest and threshing of crop, grain yield was recorded in net plot wise and converted to grain yield per hectare. The data of each year was analyzed separately.

Weed index indicates percent reduction in grain yield due to weed competition. The weed index was calculated by using the formula as suggested by Gill and Vijay Kumar (1969) [1].

$$\text{WI (\%)} = \frac{X - Y}{X} x100$$

Where,
X = Grain yield from weed free plot
Y= Grain yield from plots for which WI is to be calculated.

Results and Discussion

Crop Injury Score

Among the herbicides evaluated, T_{10} (Triafamone 200 SC @ 100 g a.i. ha^{-1} at 2-3 DAT) and T_5 (Triafamone 200 SC @ 100 g a.i. ha^{-1} at the 2-3 leaf stage of weeds) exhibited slight phytotoxic effects on rice. The observed phytotoxicity included stunted plant growth and yellowing of leaves that failed to fully expand, which appeared 7 days after application. However, these symptoms were temporary and disappeared within a week, with rice plants recovering completely. These results are consistent with the findings of (Jyothi Basu *et al.*, 2023) [4], showcasing similar observations of transient phytotoxic effects on rice crops. The temporary symptoms, such as stunted growth and leaf yellowing, align with previous studies, which highlight the reversible nature of herbicide-induced phytotoxicity, with plants recovering fully within a short duration.

Grain Yield (kg ha^{-1})

Grain yield in transplanted rice was significantly affected by weed management practices during both years of the study (Table 2**)**. The weed-free treatment (T_{13}) recorded the highest grain yields of 5762 kg ha^{-1} in 2017-18 and 6376 kg ha^{-1} in 2018-19, which were significantly higher than the rest of the treatments and comparable to two hand weedings (T_{12}). Treatments T_{10} (Triafamone 200 SC @ 100 g a.i. ha^{-1}

at 2-3 DAT) and T_5 (Triafamone 200 SC @ 100 g a.i. ha^{-1} at the 2-3 leaf stage of weeds) also recorded grain yields similar to T_{12}, demonstrating their effectiveness. In contrast, the untreated control (T_1) registered the lowest grain yields, with 3066 kg ha^{-1} in 2017-18 and 3825 kg ha^{-1} in 2018-19, which were significantly inferior to all herbicidal treatments. "The observed results corroborate the conclusions of (Jyothi Basu *et al.*, 2023) [4], emphasizing similar patterns in managing weeds and improving productivity."

Phytotoxicity Effect on Succeeding Crop

The succeeding blackgram crop exhibited no signs of crop injury or adverse effects due to herbicide application in the previous rice crop. Key growth parameters such as germination, plant height, branch formation, and crop yield were unaffected across all treatments (Table 3 and 4). These findings confirm that the herbicides, including Triafamone 200 SC, had no residual phytotoxic effects on the succeeding blackgram crop, making them suitable for sustainable rice-based cropping systems. Jyothi Basu *et al.*, 2020c [3] found similar findings, stating that herbicides applied to rice crops had no lasting effects on subsequent crops' growth and production. The findings align with those of (Jyothi Basu *et al.*, 2023b) [4], emphasizing the absence of long-term residual toxicity in the soil and its non-adverse effects on succeeding crops. These results demonstrate that the herbicides used left no significant residual impact, ensuring their suitability for sustainable crop rotations and subsequent legume cultivation. The results of this research correspond closely with the findings of (Jyothi Basu *et al.*, 2023) [4], underscoring analogous trends in herbicide efficacy and crop yield."

Table 1: Phytotoxic effect of Triafamone 200 SC on transplanted Rice as influenced by weed management practices during *Rabi* 2017-18 and *Kharif* 2018-19

Tr. No	Treatment	Time of Applcication	Dosage ha^{-1}		Phyto-toxicity Days after herbicide application									
					2017-18					2018-19				
			a. i. (g)	Formulation (ml)	7	14	21	28	35	7	14	21	28	35
$T_{1.}$	Untreated conrol	-	-	-	0	0	0	0	0	0	0	0	0	0
$T_{4.}$	Council Prime (Triafamone 200 SC)	2 to 3 leaf stage of weed	50	250	0	0	0	0	0	0	0	0	0	0
$T_{5.}$	Council Prime (Triafamone 200 SC)	2 to 3 leaf stage of weed	100	500	1	0	0	0	0	1	0	0	0	0
$T_{9.}$	Council Prime (Triafamone 200 SC)	0 to 3 days after transplanting	50	250	0	0	0	0	0	0	0	0	0	0
$T_{10.}$	Council Prime (Triafamone 200 SC)	0 to 3 days after transplanting	100	500	1	0	0	0	0	1	0	0	0	0

Table 2: Grain yield and weed index of transplanted Rice as influenced by weed management practices during *Rabi* 2017-18 and *Kharif* 2018-19

Treatments	Dose (g a.i. ha^{-1})	Grain yield (kg ha^{-1})		*Weed index (%)	
		2017-18	2018-19	2017-18	2018-19
$T_{1.}$ Untreated conrol	-	3066	3825	42.71 (46.0)	39.24 (40.1)
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed	30	3838	4459	34.87 (33.0)	33.12 (30.2)
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed	40	4251	4936	30.38 (26.0)	27.76 (22.6)
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed	50	4527	5178	27.42 (21.4)	25.01 (18.9)
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed	100	4651	5313	23.86 (18.5)	22.31 (16.7)
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15	4168	4898	31.44 (27.7)	27.63 (23.0)
$T_{7.}$ Triafamone 200 SC) at 0-3 DAT	30	4211	4672	30.51 (26.4)	30.73 (26.7)
$T_{8.}$ Triafamone 200 SC) at 0-3 DAT	40	4329	5037	28.56 (24.4)	25.61 (20.9)
$T_{9.}$ Triafamone 200 SC) at 0-3 DAT	50	4659	5276	24.10 (18.8)	23.57 (17.4)
$T_{10.}$ Triafamone 200 SC) at 0-3 DAT	100	4967	5518	21.01 (13.5)	19.91 (13.4)
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750	3797	4328	34.84 (33.3)	34.46 (32.2)
$T_{12.}$ Farmer practice (two hand weedings)	-	5342	5849	14.04 (7.4)	15.06 (8.2)
$T_{13.}$ Weed free	-	5762	6376	0.00 (0.0)	0.00 (0.0)
SEm $\pm$	-	242.27	335.92	3.04	3.04
CD (P = 0.05)	-	694.87	963.46	8.71	8.71

*Note: Data transformed to arc sine transformations. Figures in parenthesis are original values

Table 3: Phytotoxic symptoms and germination of succeeding blackgram as influenced by Triafamone 200 SC during *Rabi* 2017-18 and *Kharif* 2018-19

Tr. No	Treatment	Time of Applcication	Dosage ha^{-1}		Phyto-toxicity (Days after sowing)				Plant germination per 3 row at 20 DAS	
					2017-18		2018-19		2017-18	2018-19
			a. i. (g)	Formulation (ml)	20	Harvest	20	Harvest		
$T_{1.}$	Untreated conrol	-	-	-	0	0	0	0	48.1	47.5
$T_{4.}$	$T_{4.}$ Council Prime (Triafamone 200 SC)	2 to 3 leaf stage of weed	50	250	0	0	0	0	46.3	47.5
$T_{5.}$	Council Prime (Triafamone 200 SC)	2 to 3 leaf stage of weed	100	500	0	0	0	0	46.5	47.1
$T_{9.}$	Council Prime (Triafamone 200 SC)	0 to 3 days after transplanting	50	250	0	0	0	0	46.3	47.5
$T_{10.}$	Council Prime (Triafamone 200 SC)	0 to 3 days after transplanting	100	500	0	0	0	0	46.9	46.1

Table 4: Plant height (cm), braches (No. plant^{-1}) and seed yield (kg ha^{-1}) of blackgram as influenced by weed management practices in Rice-blackgram sequence during *Rabi* 2017-18 and *Kharif* 2018-19

Treatments	Dose (g a.i. ha^{-1})	Plant height (cm)		No. of Branches plant^{-1}		Seed yield (kg ha^{-1})	
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
$T_{1.}$ Untreated conrol	-	34.37	34.54	7.44	7.12	539	528
$T_{2.}$ Triafamone 200 SC at 2-3 leaf stage of weed	30	35.08	34.44	7.51	7.51	544	531
$T_{3.}$ Triafamone 200 SC at 2-3 leaf stage of weed	40	34.18	35.63	7.59	7.92	545	556
$T_{4.}$ Triafamone 200 SC at 2-3 leaf stage of weed	50	35.67	36.48	7.83	7.31	553	569
$T_{5.}$ Triafamone 200 SC at 2-3 leaf stage of weed	100	35.57	36.57	8.48	8.09	551	572
$T_{6.}$ Pyrazosulfuron ethyl 10% WP	15	35.97	36.16	7.18	7.33	564	543
$T_{7.}$ Triafamone 200 SC) at 0-3 DAT	30	34.40	36.82	7.97	7.70	556	544
$T_{8.}$ Triafamone 200 SC) at 0-3 DAT	40	32.37	36.45	7.29	7.28	614	539
$T_{9.}$ Triafamone 200 SC) at 0-3 DAT	50	33.81	35.57	8.32	8.19	560	572
$T_{10.}$ Triafamone 200 SC) at 0-3 DAT	100	35.74	34.87	8.03	8.01	556	567
$T_{11.}$ Pretilachlor 50% EC at 0-3 DAT	750	34.60	35.80	7.68	8.34	552	534
$T_{12.}$ Farmer practice (two hand weedings)	-	36.52	36.67	8.47	8.26	566	576
$T_{13.}$ Weed free	-	36.23	37.12	8.61	9.22	570	587
SEm±	-	0.84	0.67	0.35	0.46	23.49	14.25
CD (P = 0.05)	-	NS	NS	NS	NS	NS	NS

Conclusions

Triafamone 200 SC effectively managed weeds in transplanted rice, showing temporary phytotoxic effects that resolved within a week without impacting crop recovery. The highest grain yields were achieved under weed-free and hand-weeding treatments, with herbicidal treatments T_{10} (Triafamone 200 SC @ 100 g a.i. ha^{-1} at 2-3 DAT) and T_5 (Triafamone 200 SC @ 100 g a.i. ha^{-1} at the 2-3 leaf stage of weeds) performing comparably. The succeeding blackgram crop exhibited no residual phytotoxicity, confirming the herbicides' suitability for sustainable rice-blackgram cropping systems.

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