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WEED CONTROL EFFICACY AND CROP TOLERANCE OF NOVLECT IN RICE

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Abstract

This research was conducted to evaluate the effectiveness of Novlect (2.13% florpyrauxifen-benzyl and 10.65% cyhalofop), for controlling multiple weed species in rice field. The study included eight treatments: the Novlect premix at three different rates T1, T2 and T3 (1000, 1250, 1500 ml/ha), a sole herbicide T4 (Loyant), three tank mix combinations T5, T6 and T7 (On-duty + Basagran; Nominee + Basagran; Solito + MCPA), and a weedy control plot (T0). Results showed that Novlect at all rates (T1, T2 and T3) effectively controlled weeds such as *Leptochloa chinensis* (L.) Nees, *Echinochloa crus-galli* (L.) P.Beauv., *Cyperus* spp., *Monochoria vaginalis* (Burm.f.) C.Presl, *Ludwigia octovalvis* (Jacq.) P.H. Raven, *Bacopa rotundifolia* (Michx.) Wettst, *Sphenoclea zeylanica* Gaertn. compared to other applied sole and tank mix herbicide. It caused minimal and recoverable injury to rice at 10-20 days after seeding (DAS). Novlect can be applied between 10-20 DAS, aligning with common practices among farmers for direct-seeded rice.

Introduction

The production of rice is the primary source of food and income for over a billion people worldwide. Rice is the second most significant staple crop due to its affordability, nutritional value, and ability to meet the average caloric needs of an individual (Motmainna *et al*. 2024). Rice is grown in over 100 countries globally, spreading around 162 million hectares. The weed problem is a major contributor to yield loss in rice production (Motmainna *et al*. 2021a). Weeds are becoming more challenging to control, and the emergence of resistant weeds is fast becoming a major problem (Hasan *et al*. 2024a).

New technologies need to be introduced for the improvement of rice production. The Herbicides Resistance Action Committee has recommended the use of herbicide premixes as part of the weed management tools that can delay the development of resistant weeds (Dilipkumar *et al*. 2020). Novlect (GF-3480) is a premix of 2.13% w/w florpyrauxifen-benzyl and 10.65% w/w cyhalofop developed by Corteva Agriscience LLC (Ghani *et al*. 2024). It contains RinskorTM active (florpyrauxifen-benzyl), a new active ingredient belonging to the new arylpicolinate herbicide known as 6-APs of synthetic auxin herbicides (Velásquez *et al*. 2021). It has a broad-spectrum activity on most of the important grasses, sedges, and broadleaf weed species with utility in water-seeded, dry direct-seeded, and transplanted rice. It is recommended as a post-emergence application with use rates depending on the target weed species and geography (Gao *et al*. 2022). The new and unique mode of action of RinskorTM provides an alternative weed management tool for the control of ALS (Acetolactate synthase), ACCase (Acetyl- coenzyme A carboxylase), and HPPD (Hydroxyphenylpyruvate dioxygenase), quinclorac, propanil, glyphosate, and triazine target site-resistant species (Duy *et al*. 2018). Novlect also includes Cyhalofop, a well-known molecule

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that has been widely used in Malaysia. This is a selective grass-type herbicide for control of *Echinochloa crus-galli* (L.) P.Beauv. and *Leptochloa chinensis* (L.) Nees with no broadleaf or sedge activity (Zhang *et al*. 2022). It is an ACCase inhibitor with greater selectivity making it applicable in a wide application window.

Herbicides used in combinations often possess different modes of action, and mixtures might respond in one of three ways: synergistic, antagonistic, or additive/neutral (Barbieri *et al*. 2022). Interactions between different groups of herbicides can lead to better management of rice weeds. Keeping this in view, this trial was laid out to evaluate the mixing compatibility, the effective use rates, and the optimal spraying window of Novlect against rice weeds.

Materials and Methods

The study was conducted in Bumbung Lima, Kepala Batas, Penang, Malaysia. *Oryza sativa* (L.) was cultivated by the direct-seeding (DSR) method with a 160 kg/ha seeding rate. The size of the plot was 4 m × 5 m. To reduce possible spray drift, trial plots were divided by a levee with 1 m interrow space. Water was drained from the field prior to application, post-emergence foliar application was made to expose weeds, and re-flooded within 24 hrs after application. Herbicides were applied using a Motorized Knapsack with a spray volume of 200 l/ha at two application windows, 2-3 leaf stage (10-15 DAS) of *Echinochloa crus-galli* and 3-4 leaf stage (15-20 DAS) of *E. crus-galli* to determine the best application timing for Novlect. Novlect and Loyant were applied at 10-15 days after seeding and 15-20 DAS, and the tank mix herbicides were applied at 7 and 10 DAS. The rice production was conducted using local farming practices and management. Detailed information regarding the herbicides that were use is provided in Table 1.

Table 1. Details of herbicide application with spraying window.

Treatment	Active compound	Rate (ml/ha)
T_0: Untreated (Control)	-	-
T_1: Novlect	Florpyrauxifen-benzyl + Cyhalofop	1000
T_2: Novlect	Florpyrauxifen-benzyl + Cyhalofop	1250
T_3: Novlect	Florpyrauxifen-benzyl + Cyhalofop	1500
T_4: Loyant	Florpyrauxifen-benzyl	1000
T_5: On-duty + Basagran	(Imazapic + Imazapyr) + (Bentazone + MCPA)	140g + 1000
T_6: Nominee + Basagran	Bispyribac-sodium + (Bentazone + MCPA)	200 + 1000
T_7: Solito + MCPA	(Pretilachlor + Pyribenzoxim) + MCPA	1250 + 1000

Crop injury observation was made at 1, 3, 7, 14, 21, and 28 days after application (DAA). Crop injury was measured in terms of visible phytotoxicity on rice seedlings by % of injury (0 - 100%) as compared to the untreated plot (Hasan *et al*. 2021). Weed control evaluation was made at 14, 28, 42, and 56 DAA. The dry weight of each species was observed at 56 DAA. The weed control efficiency (WCE) was calculated according to Hasan *et al*. (2023). The experiment employed a randomized complete block design with four replications. The collected data were statistically analyzed by using ARM8 and StatMart software owned by Corteva Agriscience.

Results and Discussion

Based on the result presented in Table 2, Novlect is highly effective against a wide spectrum of rice weeds. Novlect showed numerically higher control percentages when applied at 10-15 DAS, however they are not significantly different from each other, which indicated that Novlect can be equally effective when applied at both application windows. The incorporation of

cyhalofop in Novlect offered enhanced control efficacy that markedly differs from Loyant (florpyrauxifen-benzyl alone) against *Leptochloa chinensis*. Novlect (florpyrauxifen-benzyl + cyhalofop) at 1250 ml/ha provided 97.75-98% control on *L. chinensis* as compared to Loyant at 1000 ml/ha providing 82.13-86% control. Previous studies reported resistance biotypes of *L. chinensis* on multiple active ingredients in Kedah and made recommendations to use combinations of herbicides with different modes of action for effective control of *L. chinensis* (Ruzmi *et al*. 2017). Novlect also showed very good control on *Echinochloa crus-galli* with control percentage ranging between 94.25-99.63%, higher than the best available standard, tank mix of On-duty + Basagran (91.63%), Nominee + Basagran (92.88%) and Solito + MCPA (93.75%). Ghani *et al*. (2024) reported the highest weed control efficacy of Novlect on *E. crus-galli*.

Table 2. Control efficacy of Novlect against common weeds species as compared to the commercial standards on direct seeded rice.

Treatment	*Leptochloa chinensis*		*Echinochloa crusgalli*		*Cyperus diformis*		*Cyperus iria*		*Fimbristylis miliacea*	
	10-15/7	15-20/10	10-15/7	15-20/10	10-15/7	15-20/10	10-15/7	15-20/10	10-15/7	15-20/10
	Days after seeding (DAS)									
T_0	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
T_1	94.50d	93.00d	97.13bcd	94.25cd	95.75de	90.00c	97.00cde	97.25d	82.25bc	75.00b
T_2	98.00d	97.75d	98.50c	97.25d	97.88de	97.75c	98.50e	97.50d	85.00bc	84.50bcd
T_3	98.88d	98.38d	99.63d	98.75d	99.75e	98.25c	100.00e	98.25d	90.63cd	93.00d
T_4	86.00c	82.13bc	97.63bcd	94.75cd	98.13de	97.50c	98.25de	99.50d	80.00b	83.25bcd
T_5	91.88cd	92.88d	91.63b	89.25cd	89.63c	89.25c	89.13c	85.75c	94.38d	88.75cd
T_6	86.38c	89.75cd	92.88bc	85.75c	92.25cd	92.00c	90.50cd	90.50c	95.75d	90.00d
T_7	63.13b	79.25b	93.75bcd	74.50b	75.00b	73.75b	52.50b	68.25b	88.75cd	76.25bc

Table 2. Continue.

Treatment	*Monochoria vaginalis*		*Ludwigia octovanvis*		*Bacopa rotundifolia*		*Sphenoclea zeylanica*	
	10-15/7	15-20/10	10-15/7	15-20/10	10-15/7	15-20/10	10-15/7	15-20/10
	Days After Seeding (DAS)							
T_0	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a
T_1	98.50bcd	94.75c	96.38bc	94.88cd	97.88c	96.00d	94.50c	97.63c
T_2	99.63d	98.50c	98.13c	97.50d	98.88c	99.38d	97.50c	98.50c
T_3	100.00d	99.13c	99.13c	99.38d	100.00c	100.00d	99.00c	100.00c
T_4	98.88cd	98.88c	99.13c	97.88d	98.88c	99.75d	97.00c	97.63c
T_5	94.88bc	94.13c	95.75bc	86.25bc	74.38b	80.00c	78.75b	87.25bc
T_6	97.00bcd	94.13c	92.00b	93.13cd	75.63b	76.25bc	78.25b	90.00bc
T_7	94.13b	82.88b	92.75b	78.50b	68.75b	65.63b	76.25b	76.25b

Value noted in percentage (%). Means denoted by similar letters do not exhibit significant differences (P=0.05, Student-Newman-Keuls).

Application of Novlect at 1000-1500 m/ha at 10-20 DAS (no significant difference between the two application windows) provided effective control on both *Cyperus iria* L. (97.25-100.0%) and *Cyperus diformis* L. (90-99.75%) numerically higher if not similar to the other comparative treatments available in the market. *C. iria* has been identified as one of the most important weed species in Seberang Perai, Muda and Seberang Perak (Ruzmi *et al*. 2017). The control of *Fimbristylis miliacea* was relatively lower (75-93%) as compared to other weed species and significantly lower than other treatments, as such shall not be included in the label recommendation.

Novlect also showed excellent control on broadleaf species when applied at rate 1000-1500 ml/ha) between 10-20 DAS exhibiting control between 94.5-100% control on multiple species (*Monochoria vaginalis* (Burm. f.) C.Presl, *Ludwigia octovalvis* (Jacq.) P. H. Raven, *Bacopa rotundifolia* (Michx.) Wettst., *Sphenoclea zeylanica* Gaertn.). This product showed a significant difference in control efficacy as compared to the common farmer practice mixtures (T_5, T_6 and T_7). Several species of broadleaf weeds have been recorded to have resistance to some groups of herbicides; *S. zeylanica* (Synthetic auxins; O/4), *B. rotundifolia* (ALS inhibitor; B/2), *Sagittaria guyanensis* Kunth (ALS inhibitor; B/2), *Limnocharis flava* (L.) Buchenau (ALS inhibitor; B/2, Synthetic auxins; O/4) (Roma-Burgos *et al*. 2018). This could be the contributing factor to the lower efficacy in T_5-T_7.

A visual evaluation of a few chosen herbicides on rice was conducted at 1, 3, 7, 14, 21, and 28 DAA in both application windows (Table 3). At 3, 7, and 14 DAA, all herbicides showed notable ($p < 0.05$) injury levels on rice in comparison to the untreated plots (T_0). Novlect at the rate of 1000 and 1200 ml/ha showed no significant difference statistically with Untreated at 3, 21 and 28 DAA when applied at 10-15 DAS. At 7 DAA, the tank mix of Nominee + Basagran (6.88 and 6.25%) and Solito + MCPA (11.88 and 10.63%) showed comparatively higher injury symptoms for both application windows. All herbicides were applied at the rates and times recommended by the manufacturers; thus rice plants might not have been injured. Herbicide phytotoxicity can be affected by various parameters, including crop growth stage, application rate, soil moisture content, and other environmental factors. These factors might affect the absorption, transport, and metabolism of the herbicide (Motmainna *et al*. 2021b, Hasan *et al*. 2022, Islam *et al*. 2024). An increased concentration of herbicides causes changes in plant development, physiology, and metabolism, leading to phytotoxicity and reduced yield (Hasan *et al*. 2024b, Motmainna *et al*. 2023, 2025).

Table 3. Crop tolerance and phytotoxicity of Novlect on rice crop.

10-15/7 Days after seeding (DAS)							
Treatment	1 DAA	3 DAA	7 DAA	14 DAA	21 DAA	28 DAA	Yield kg/ha
T_0	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	2450a
T_1	0.00a	0.63a	1.88ab	3.13ab	0.00a	0.00a	8287cd
T_2	0.00a	0.63a	5.00ab	3.13ab	0.63a	0.00a	8575cd
T_3	0.00a	3.13ab	6.25b	6.88bc	2.50a	0.00a	8775d
T_4	0.00a	1.88a	4.38ab	4.38abc	0.00a	0.00a	8188cd
T_5	0.00a	3.75ab	4.38ab	3.13ab	0.63a	0.00a	7737bc
T_6	0.00a	6.88bc	6.88bc	4.38abc	3.13a	0.63a	7875cd
T_7	1.88b	8.13b	11.88bc	8.13c	8.13b	3.13b	6913b

Table 3. Continue.

15-20/10 Days after seeding (DAS)							
Treatment	1 DAA	3 DAA	7 DAA	14 DAA	21 DAA	28 DAA	Yield kg/ha
T_0	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	2375a
T_1	0.00a	1.88ab	1.25ab	1.25ab	0.00a	0.00a	7913c
T_2	0.00a	3.13ab	3.13abc	1.25ab	0.00a	0.00a	8400c
T_3	0.00a	3.75ab	5.00bc	2.50ab	0.00a	0.00a	8550c
T_4	0.00a	3.75ab	3.63abc	1.88ab	0.00a	0.00a	8000c
T_5	0.00a	3.13ab	5.00bc	3.13ab	0.63a	0.00a	7325bc
T_6	0.00a	6.25cd	6.25cd	5.00bc	0.63a	0.00a	7413bc
T_7	2.50b	9.38d	10.63d	8.13c	6.25b	3.13b	6200b

Value noted in percentage (%). Means denoted by similar letters do not exhibit significant differences (P=0.05)

Rice grain yield (kg/ha) obtained from both application windows showed that all the herbicidal weed management practices (sole, premix and tank mix combinations) significantly influenced the yield of rice (Table 3). The maximum grain yield (8775, 8550 kg/ha) was recorded from the T_3 (Novlect: 1500 ml/ha) treatment and the lowest grain yield (2450, 2375 kg/ha) from T_0. Weed free conditions increased the availability of nutrients, space and light to the rice crop due to the absence of crop weed competition, which resulted in increased yield. Similar findings were reported by Awan *et al*. (2015). The tank mix of Solito + MCPA exhibited the lowest grain yield compared to other treated herbicides. These results are in close conformity with those reported by Kushwaha *et al*. (2018), who observed that the highest yield, net return and benefit were obtained with ready-mix application among the tested herbicide treatments.

Based on overall observation on control efficacy, crop response and yield performance, application of Novlect can be made from 10-20 days after seeding for direct seeded rice, which coincides with the most common practice of farmers in Malaysia. Application of Novlect in this window will ensure the elimination of a broad spectrum of weeds from the field during the critical period. Novlect effectively control sedges, broadleaves, and grasses weed species. This product is an effective alternative tool for weed management practice should it be properly applied as per the herbicide resistance management recommendations.

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