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Evaluation of Synthetic Herbicide Imazapic Isopropylamine 262.5 g/L + Imazapyr Isopropylamine 87.5 g/L for Weed Management in Tea Lands

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ABSTRACT

Experiments were conducted to determine the bio-efficacy of synthetic chemical named Mayoral SL (Imazapic isopropylamine 262.5 g/L + Imazapyr isopropylamine 87.5 g/L) against common weed species in tea lands. Three rates of Mayoral at 0.5, 0.75 and 1 L/ha in 500 L of water were tested as a post emergent non-selective herbicide in comparison with Glufosinate ammonium (15% Basta) at 1.3 L/ha and Glyphosate 36% at 2 L/ha and untreated control. Experimental Design was RCBD (Randomised Complete Block Design) with three replicates. Fresh weight (FW) and dry weight (DW) / 1.5 m^2 of weeds were measured. Visual scores were performed on each plot to record weed injury rate as percentage of dead plants (DP) to that of untreated control. The data were analyzed using SAS package following ANOVA. Mayoral resulted in a significant control up to 12 WAA (Weeks After Application) in all three regions, compared to untreated control. Mayoral at 0.75 and 1 L/ha and standard herbicides, Glufosinate ammonium and Glyphosate showed comparable control of weeds up to 8 WAA in the Up-Country and in the Mid and Low-Country, 12 WAA. The most promising weed control was achieved with Mayoral at 1 L/ha.

Keywords: Bio efficacy of herbicides, maximum residue limits (MRL), mayoral, tea,

INTRODUCTION

Tea industry plays a significant role in Sri Lankan economy because it is the main foreign exchange earner in agriculture sector. Sri Lanka produced 303.8 million kg in the year 2018 securing Rs 249.34 billion (FOB = Rs 820.75) and cost of production of tea was recorded as Rs 475.29 (Anon, 2018).

Weed competes with tea and the cost of weeding is in the range of 6-8% of the total cost of field operations. It is also accounted for 4-5% of the total cost of production of made tea and second only to plucking and fertilizer application. Weed infestation in tea lands contributes for reducing the tea crop harvest which was recorded to be in the range of 5-15% for seedling tea and 5-9% for vegetative propagated (VP) tea, when weeding was delayed by 4-6 months (Wettasinghe, 1971). Further, weeds interfere with cultural practices reducing worker productivity, and adversely affect growth of young tea and quality of made tea.

In the recent past, there was an issue of weed management in tea lands owing to restrictions of import and banning of some commonly used weedicides. Although the Tea Research Institute of Sri Lanka (TRISL) has recommended Integrated Weed Management (IWM) strategy to manage weeds effectively at a lower cost, the banning of popular weedicides such as Glyphosate, resulted in some issues in weed management in tea lands. Estimated crop loss was around 33 Mn kg (Shyamalie, 2015; De Silva, 2018) of tea at national level, assuming 100% absence of weed control scenario in mature tea which reflects the magnitude of the economic impact and loss of export earnings as a result of heavy weed infestation. Therefore, proper weed management is important in tea lands and the chemical weeding using herbicide is the most convenient and effective method under IWM strategies (Prematilake, 2003).

At present, Glyphosate, a post emergent herbicide ban is lifted temporarily. However, MCPA was temporarily banned by TRISL due to detection of residues in made tea above MRL (Maximum Residue Limits) standards. Oxyfluorfen and Diuron (80% WP) have been recommended by TRISL as pre-emergent herbicides. Accordingly, only a limited number of herbicides are available for weed management in tea lands. For the recommendation of herbicide, MRL standards of Japan and EU to be satisfied (De Silva 2015). Hence, the objective of this study was to evaluate the efficacy of new herbicide formulation having post-emergent action, in comparison with standard herbicides recommended by Tea Research Institute of Sri Lanka and to study the susceptible weed species to the new herbicide formulation.

MATERIALS AND METHODS

Product details

Mayoral herbicide contains Imazapic isopropyl ammonium 262.5 g/L and Imazapayr isopropylammonium 87.5 g/L SL. It is a non-selective weed killer controlling broad-leaved weed species and grasses. Imazapic and Imazapyr are branched chain amino acid synthesis inhibitors and have a systemic and contact action by disruption of protein synthesis which leads to interference in DNA synthesis and cell growth. Its' LD_{50} (oral) value for mammal is > 5,000 mg/kg and it belongs to World Health Organization toxicity class III. Photodegradation in aqueous solution is two days. No toxic to bees as indicated in literature. Mayoral belongs to EU (+ve) list and MRL specified as 0.01 ppm for Imazapic. No MRL is specified for Imazapyr.

Experimental site

Three experimental sites were selected from different elevations. Up-Country experimental site was located at St. Coombs estate (WU2a) at an elevation of 1394m amsl, Mid-Country site was at New Peacock tea estate, Pussellawa (WM2a) at an elevation of 950m amsl and Low-Country site was at St. Joachim estate, Ratnapura (WL1a) at an elevation of 30 m amsl. The trials were conducted from November 2018 to August 2019. No repeated trials conducted for the above trials.

The experimental design was Randomized Complete Block Design (RCBD) with three replicates. 2.5 m × 2.5 m plots were demarcated and each replicate were separated by guard rows. These sites were free from any herbicide application within last six months and treatments were applied when the weeds were in an active growth stage. Herbicide applied on days with favorable weather condition and knapsack spray machine was used with flood jet nozzle under 1 bar pressure.

Treatments

T1 - Mayoral at 0.5 L/ha (10 mL/10 L)
T2 - Mayoral at 0.75 L/ha (15 mL/10 L)
T3 - Mayoral at 1 L/ha (20 mL/10 L)
T4 - Glyphosate 36% at 2 L/ha (40 mL/10 L)
T5 - Glufosinate Ammonium (15%) at 1.3 L/ha (26 mL/10 L)
T6 - Untreated Control

Existing weed species in Up-Country trial

Ageratum spp. (Hulanthala), *Commollina diffusa* (Girapala), *Crassocephalum crepidioides* (Kadupahara), *Erigeron sumatrensis* (Sudana), *Polygonum nepalense* (Lime weed), *Phyllantus debilis* (Sudu pitawakka), *Spermacoce hispida* (Getakola)

Existing weed species in Mid-Country trial

Ageratum spp. (Hulanthala), *Comollina diffusa* (Girapala), *Centella aceatica* (Gotukola), *Crassocephalum crepidioides* (Kadupahara), *Drymaria cordata* (Kukulupala), *Erigeron sumatrensis* (Sudana), *Polygonum nepalense* (Lime weed), *Phyllantus debilis* (Sudu Pitawakka), *Spermacoce hispida* (Getakola)

Existing weed species in Low-Country trial

Ageratum spp. (Hulanthala), *Anredera cordifolia* (Wal Nivithi), *Caladium bicolor* (Wal Alakola), *Comollina diffusa* (Girapala), *Cleome viscose* (Walaba), *Crassocephalum crepidioides* (Kadupahara), *Desmodium trifolium* (Heen undupiyaliya), *Erigeron sumatrensis* (Sudana), *Oldenlandia corymbose* (Wal Pathpadagam), *Polygonum nepalense* (Lime weed), *Phyllantus debilis* (Sudupitawakka), *Scoparia dulcis* (Wal Kotthamalli), *Spermacoce hispida* (Getakola), *Asystasia gengetica* (Puruk)

Weed growth assessment

Pre-assessment of weeds

Weed samples were collected using a Quadrat (30cm x 30cm) by randomly placing on each plot before imposition of treatments from three elevations. The available weed species were identified. Then the samples were oven dried at 85°C for 16 hrs for dry weight measurements.

Visual assessments

Visual observation was made for weed injury and the weed injury percentage in comparison with untreated control was estimated accordingly, at bi-weekly interval until 8 WAA of herbicide. Visual scores for weed injury was assigned as 100% for completely killed of common weeds while zero for non-killed weeds in comparison with those in untreated control.

Weed dry weight assessment

Weeds were removed one quarter plot, marking out randomly of each plot at monthly intervals at all three sites to assess the changes in weed biomass after chemical application. Weed samples were obtained at 2, 4, 8 and 12 WAA of herbicides. The samples were oven dried at 85^0C for 16 hrs and dry weight was recorded.

Statistical analysis

The parametric data were analysed using one-way ANOVA procedure and the mean separation was performed using Statistical Analysis System (SAS) Version 9.1. The percentages of dead weeds were analysed using "Probit analysis" of visual scores.

RESULTS AND DISCUSSION

Dry Weight of weeds in Up-Country

Pre-assessments of dry weight of weeds in all plots were not significantly different. Weed Dry weight was very significantly lower ($p<0.01$) in all chemically treated plots when compared to that of untreated control at all phases except 2 WAA with Mayoral. The weed dry weight was significantly lower with Mayoral 1 L/ha and standard treatments of Glyphosate and Gufosinate ammonium which were comparable when compared to that of Mayoral at 0.5 and 0.75 L/ha, at 4 WAA.

Furthermore, the same with Mayoral 0.75, 1 L/ha and above standard treatments were comparable and they were significantly lower (0.0001) than that of Mayoral at 0.5 L/ha, 8 WAA. However, the weed dry weight with all tested rates of Mayoral and with standard treatments was very lower and comparable, 12 WAA (Figure 1). From 4 - 12 WAA, all tested herbicides thus showed significantly a lower weed dry weight than untreated control (Figure 1). In the Up-Country tea lands Mayoral at the rate of 0.75 and 1 L/ha was thus more promising in weed control.

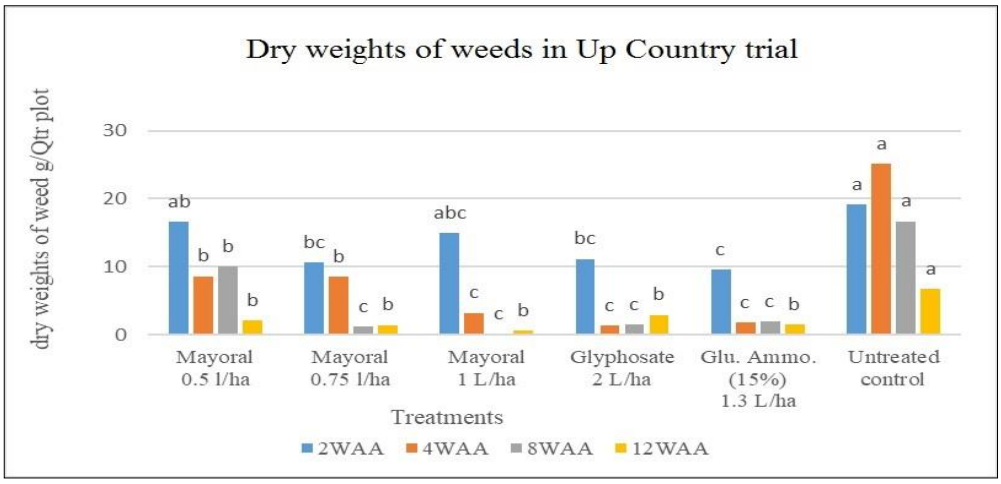

Figure 1. Dry weight of weeds as affected by different herbicide treatments in the Up-Country

Weed dry weight in Mid-Country

Pre-assessments of dry weight of weeds in all plots were not significantly different. Weed dry weight was significantly lower in all chemically treated plots than that of untreated control from 4 WAA onwards and it was in chemical treatments was comparable, 2 WAA. Whereas, weed dry weight under Mayoral 0.75 and 1.0 L/ha and standard treatments were significantly lower than that of Mayoral 0.5 L/ha 4 WAA. Furthermore, weed dry weight was significantly lower with all three rates of Mayoral than that of

Glyphosate and Glufosinate ammonium, both 8 and 12 WAA (Figure 2).

Thus, Mayoral at 0.75 L to 1 L/ha were found to be more effective in controlling weeds in the Mid-Country.

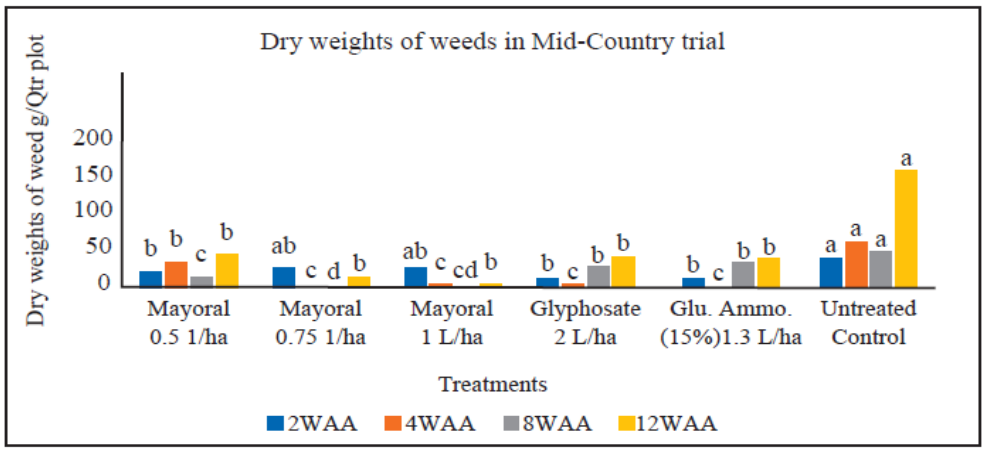

Figure 2. Dry weight of weeds as affected by different herbicide treatments at New Peacock Estate, Pussellawa in the Mid-Country

Weed dry weight in Low-Country

Pre-assessments of dry weight of weeds in all plots were not significantly different. The weed density in Low-Country experiment was comparatively higher when compared with the Up and Mid-Country (Figure 3).

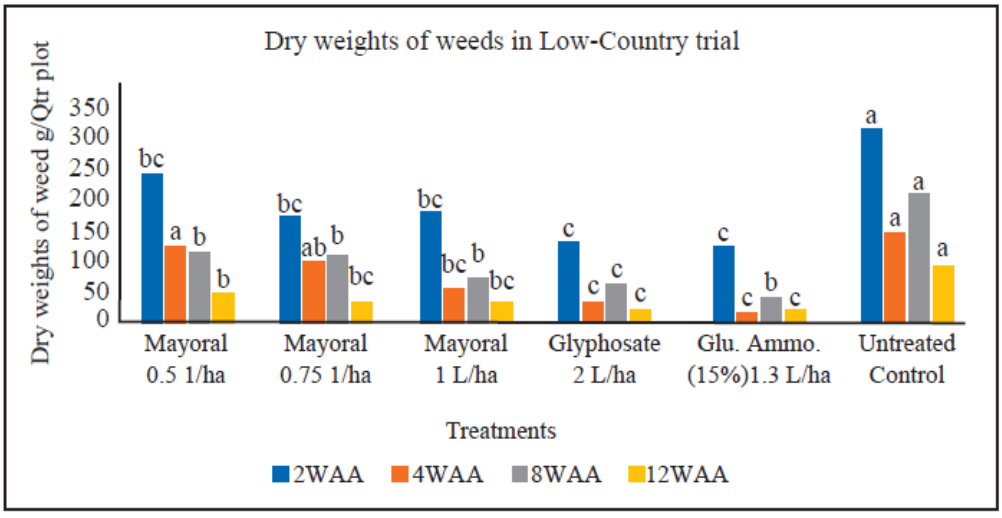

Figure 3. Dry weight of weeds as affected by different herbicide treatments in the Low-Country

Weed dry weight was significantly lower in all chemically treated plots compared to that of untreated control at all phases except for Mayoral 0.5 and 0.75 L/ha, 4 WAA. All tested Mayoral rates were poorly performed compared to two standard treatments at 2 and 4 WAA.

Mayoral at 1 L/ha, and standard treatments had similarly performed reporting a lower dry weight though not significant, compared to Mayoral at 0.5 and 0.75 L/ha, 8WAA. However Mayoral at 1.0 and 0.75 L/ha and standard treatments showed better performance having significantly a lower weed dry weight

compared to 0.5 L/ha Mayoral, 12 WAA. Hence, Mayoral at 1.0 and 0.75 L/ha have shown promising results in weed control under Low-Country conditions as well (Figure 3).

Evaluation of weed injury percentage under Up-Country conditions

Figure 4 shows that there was a significant difference in visual score percentages in all tested herbicide treatments compared with untreated control up to 8 WAA.

Weed injury score percentage was more or less and same in standard treatments and Mayoral at 1 L/ha at all phases except in few cases and significantly higher ($p<0.0001$) when compared to Mayoral 0.5 and 0.75 L/ha. Glyphosate showed less efficacy in weed control in comparison to Mayoral 1L/ha particularly at 6 and 8 WAA (Figure 4).

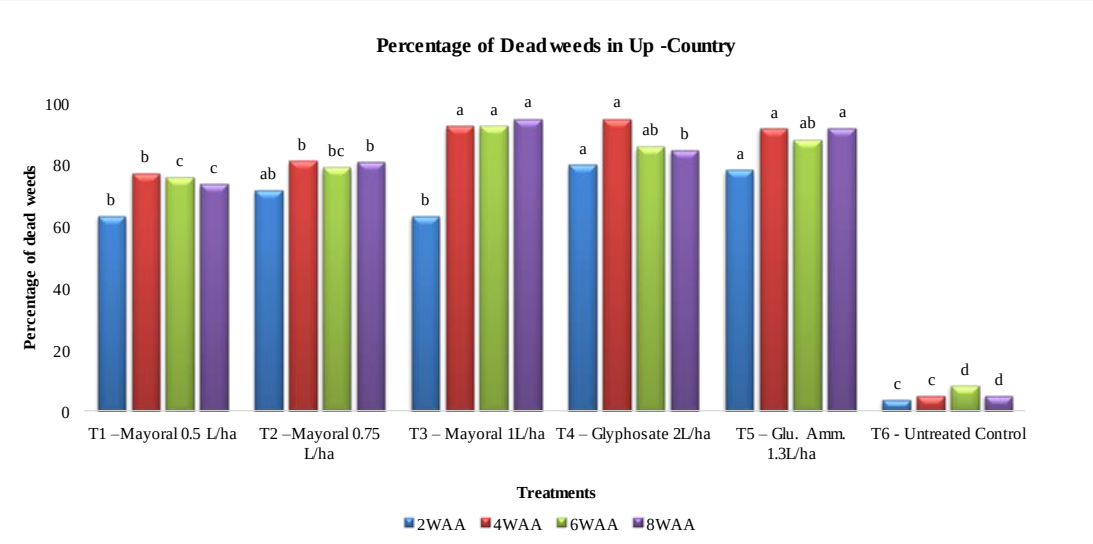

Figure 4. Weed injury percentage based on visual scorning under Up- Country conditions

Probit analyses of weed injury percentage under Up-Country conditions

Probit analyses (Table 1) also confirmed the comparison of visual scores of percentage death of weeds. Over a period of 2-8 WAA weed control under all tested herbicides were significantly higher than that of untreated control and performed well indicating positive results. In comparing with Glyphosate 4 WAA, the rate 1 L/ha Mayoral was equally performed indicating positive and negative values of the confident limits and 8 WAA all the rates performed well (Table 1). In Comparing with Glufosinate ammonium at 4 WAA, only 1 L/ha Mayoral was equally performed but not at 8 WAA (Table 1).

Table 1. Probit analyses of visual scores (ratio to untreated control) of Mayoral with Glyphosate and Glufosinate ammonium in the Up-Country

Treatments	Untreated control (T6)	With Glyphosate		With Glu. ammonium	
	Up to 8 WAA	4 WAA	8 WAA	4 WAA	8 WAA
T1: Mayoral 0.5 L/ha	<0.0001 (+ve)	0.0001 (-ve)	<0.0001 (+ve)	0.0001 (-ve)	<0.0001 (-ve)
T2: Mayoral 0.75 L/ha	<0.0001 (+ve)	0.0001 (-ve)	0.0264 (+ve)	0.0038 (-ve)	0.0026 (-ve)
T3: Mayoral 1 L/ha	<0.0001 (+ve)	0.2257 (+ve, -ve)	0.0108 (+ve)	0.1281 (+ve, -ve)	0.0826 (-ve)
T4: Glyphosate 2 L/ha	<0.0001 (+ve)				
T5: Glufosinate Ammonium 1.3 L/ha	<0.0001 (+ve)				

Evaluation of weed injury percentage under Mid-Country conditions

Figure 5 shows the dead weed percentage was significantly higher with Glufosinate ammonium compared to that of Mayoral and Glyphosate, 2 and 4 WAA. Whereas, Mayoral at 0.75 and 1 L/ha and Glufosinate ammonium performed a comparable weed death percentage, 6 WAA, but Mayoral 0.75 L/ha and Glyphosate reported a higher weed damage, 8 WAA (Figure 5).

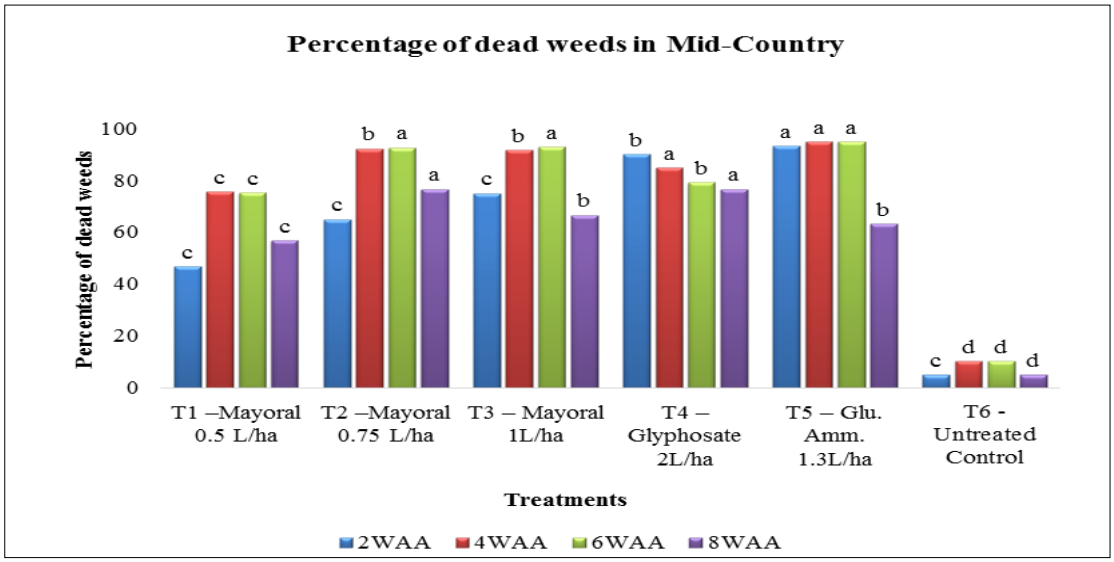

Figure 5. Weed injury percentage based on visual scores under Mid-Country conditions

Probit analyses of visual scores in Mid-Country

Probit analyses in Table 2 shows the comparison of weed injury percentage based on visual scores. Weed growth under all tested herbicides were significantly different from untreated control and performing well indicating positive values up to 8 WAA (Table 2).

In comparing with Glyphosate, at 4 and 8 WAA, Mayoral at 0.75 and 1 L/ha performed better than Glyphosate indicating +ve values of the confident limits. When compared with Glufosinate ammonium (4 and 8 WAA) the activity of these two rates 0.75 and 1 L/ha of Mayoral were similar to Glufosinate ammonium (Table 2).

Table 2. Probit analyses of visual scores (ratio to untreated control) of Mayoral with Glyphosate and Glufosinate ammonium in the Mid-Country

Treatments	Untreated control (T6)	With Glyphosate		With Glu. Ammonium	
	Up to 8 WAA	4 WAA	8 WAA	4 WAA	8 WAA
T1: Mayoral 0.5 L/ha	<0.0001 (+ve)	<0.0001(-ve)	0.0259 (+ve, -ve)	0.0001 (-ve)	<0.0001 (-ve)
T2: Mayoral 0.75 L/ha	<0.0001 (+ve)	0.0042 (+ve)	<0.0001 (+ve)	0.2014 (+ve, -ve)	0.2473 (+ve, -ve)
T3: Mayoral 1 L/ha	<0.0001 (+ve)	0.0105 (+ve)	<0.0001 (+ve)	0.1107 (+ve, -ve)	0.3071 (+ve, -ve)
T4: Glyphosate 2 L/ha	<0.0001 (+ve)				
T5: Glu.Ammonium 1.3 L/ha	<0.0001 (+ve)				

Evaluation of weed injury percentage under Low-Country conditions

Application of Mayoral at the rate of 0.75 – 1 L/ha showed similar percentage of dead weeds at 4 WAA and 8 WAA in comparison with standards treatments 4 WAA (Figure 6). When compared with the untreated control at 8 WAA of herbicides percentage of dead weeds was significantly high.

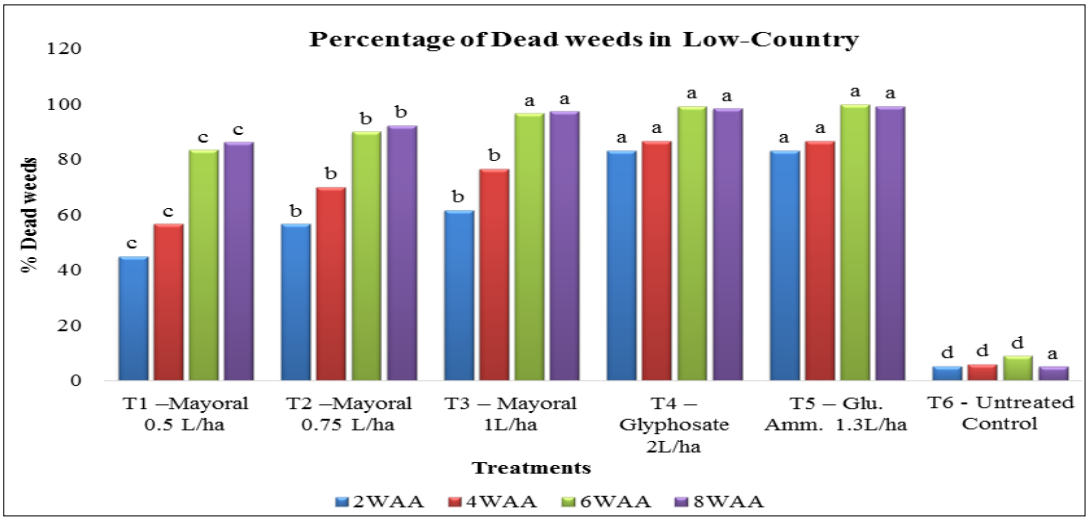

Figure 6. Weed injury percentage based on the visual scoring under the Low-Country conditions

Probit analyses of visual scores in Low-Country

Probit analyses (Table 3) shows the comparison of weed injury percentage. All tested herbicides were significantly different from untreated control and performed well indicating positive values up to 8 WAA (Table 3). At 4 WAA, Mayoral at 1 L/ha performed better than Glyphosate indicating +ve values of the confident limits. When comparing with Glufosinate ammonium at 4 WAA, Mayoral 1 L/ha was less effective than Glufosinate ammonium and however at 8 WAA, Mayoral 1 L/ha was comparable with Glufosinate ammonium (Table 3). A same trend was observed with visual scoring for weed injury as shown in Figure 6.

Table 3. Probit analyses of visual scores (ratio to untreated control) of Mayoral with Glyphosate and Glufosinate ammonium in the Low-Country

Treatments	Untreated control (T6)	With Glyphosate		With Glu. Ammonium	
	Up to 8 WAA	4 WAA	8 WAA	4 WAA	8 WAA
T1: Mayoral 0.5 L/ha	<0.0001 (+ve)	0.0001 (-ve)	0.0001 (-ve)	0.0001 (-ve)	<0.0001 (-ve)
T2: Mayoral 0.75 L/ha	<0.0001 (+ve)	0.0001 (-ve)	0.0001 (-ve)	0.0001 (-ve)	<0.0001 (-ve)
T3: Mayoral 1 L/ha	<0.0001 (+ve)	0.0275 (+ve)	0.3984 (+ve, -ve)	0.0151 (-ve)	0.0597 (+ve, -ve)
T4: Glyphosate 2 L/ha	<0.0001 (+ve)				
T5: Glufosinate Ammonium 1.3 L/ha	<0.0001 (+ve)				

CONCLUSIONS

All tested rates *i.e.* from 0.5 L to 1 L /ha of Mayoral (SL) gave reasonable weed control in comparison with untreated control. Overall results revealed that the effect of Mayoral (SL) at 1 L in 500 L/ha of water was comparable with standard treatments, Glyphosate and Glufosinate ammonium. Hence, Mayoral at the rate of 0.75 and 1 L/ha could be used for managing weeds successfully in up and Mid-Country for a period of three months depending on the weed density, in all three regions as an alternative to Glyphosate at 2 L/ha and Glufosinate ammonium at 1.3 L/ha in 500 l of water. However for *Commellina diffusa* (Girapala) in all three elevations and *Hedyotis* spp. (Getakola) in Low-Country elevation showed resistance to these herbicides. The formal recommendation of Mayoral herbicide for tea will be given after completing the MRL studies.

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