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Full Length Research Paper

Identification of resistant biotypes of *Leptochloa chinensis* in rice field and their control with herbicides

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Weed populations of sprangletop (*Leptochloa chinensis*) such as Kampung Permetang (KP), Kampung Pida-Tiga (KPT), Sungai Baru (SB1 and SB2), Kampung Pida-Empat (KPE), Singkir Yan (SY), Tanjung Dawai (TD), Dulang Besar (DB) and Kampung Bahagia (KB1 and KB2) were collected from paddy (*Oryza* sp.) growing areas in Kedah, Malaysia to identify resistant biotypes and their method of control. Weed biotypes were evaluated against all varying rates of propanil, quinclorac and cyhalofop-butyl. Except SY, all weed populations showed resistance against propanil at the rate of 5500 ml a.i. ha^{-1}, on the contrary all weed populations appeared as susceptible against higher rates of propanil (11000 ml a.i. ha^{-1}) except SB2 and KB1. All populations except KP and SB1 were resistant against cyhalofop-butyl at rates of 800 and 1600 ml a.i. ha^{-1}. Kampung Bahagia (KB2) against cyhalofop-butyl at rates of 800 and 1600 ml a.i. ha^{-1} appeared as resistant and susceptible, respectively. Resistant biotypes were two times strongly resistant to propanil while one time strongly resistant to cyhalofop-butyl, respectively, than susceptible biotypes. Regardless of rates, quinclorac was ineffective against any of the biotypes. Resistant biotype SB2 was controlled by combined application of propanil and cyhalofop-butyl at rates of 5500 and 800 ml a.i. ha^{-1}.

Key words: *Leptochloa chinensis*, paddy, herbicides, sprangletop.

INTRODUCTION

Rice is one of the most important source of world's food supply (Hakim et al., 2010) and the third most important essential crop after oil palm and rubber in Malaysia (MOA, 2003). Transplanting of rice seedlings is a traditional practice of rice cultivation and it has been replaced by direct seeding because of high production cost especially labor (Tabbal et al., 2002; Tomita et al., 2003; Savary et al., 2005). Direct seeding of rice has been practiced in Malaysia since 1980 (Azmi et al., 2007) but its major bottlenecks is the easy infestation of weed (Hill et al., 1994) which has influence on yield, quality (Ionnis and Kico 2005) and price in rice growing countries in South East Asia (Azmi and Baki, 2002). Weed is a serious pest of rice and annual worldwide rice yield loss by weed is 15 - 21% (Oerke et al., 1994). A crop loss due to weed competition varies with the duration of weed infestation of the crop. The crop is likely to experience yield reduction, unless weeds are kept free during a part of its growing period (Azmi et al., 2007). The problem of weed competition with rice is of great economic importance in the country because it causes a 10 - 35% reduction in grain yield (Karim et al., 2004) and totally uncontrolled conditions can reduce grain yields of rice by 42 - 100% (Begum, 2006). Successful weed control is one of the major requirements for economical rice production (Azmi and Mortimer, 2000) which needs sustainable technology (Renner et al., 1999). Use of

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Abbreviations: KP, Kampung Permetang; **KPT,** Kampung Pida-Tiga; **SB1 and SB2**, Sungai Baru; **KPE,** Kampung Pida-Empat; **SY,** Singkir Yan; **TD,** Tanjung Dawai; **DB,** Dulang Besar, **KB1 and KB2,** Kampung Bahagia; **RI,** resistance index.

Table 1. *L. chinensis* seeds collected from rice field in Kedah, Malaysia.

Location	Abbreviated form
Kampung Permetang	KP
Kampung Pida-Tiga	KPT
Sungai Baru	SB1 - SB1
Kampung Pida-Empat	KPE
Singkir Yan	SY
Tg. Dawai	TD
Dulang Besar	DB
Kampung Bahagia	KB1 - KB1

herbicides is one of the most dependable and cheaper method of weed control which can greatly influence sufficient sustainable food production for humans (Abeysekera and Wickrama, 2005). Herbicides application has to be simplified for successful weed management in cropping systems where farmers do not face the struggle of adopting other practices such as grazing, burning, grow cover crops followed by fallow in order to keep weed densities at standard levels (Hill et al., 1994). Timely weed control can greatly influence rice yield and can save 25 to 89% yield loss (Yu et al., 2007). Year after year, farmers are getting most profitable crops on the same piece of land by application of herbicides and pesticides throughout the world (Tomita et al., 2003). The intensive use of herbicides has been shown as an effective tool to control weed in rice field since the last few decades but repeated use of same herbicides in the same field over time may raise serious drawback especially weeds used to acquire resistance to herbicides (Azmi and Baki, 2002). The frequent use of same type of herbicides (Christoffers, 1999) and limited knowledge of growers are the main causes of resistance of different weed species (Heap, 1999). Use of single or mixture of multiple herbicides is a great concern of rice growing farmers (Heap, 1997).

In Malaysian agriculture, 18 herbicide resistance weed species have been recognized since 1980 (Azmi and Baki, 2002). Information regarding rice field and occurrence of weed species which is herbicides resistant or not is still insufficient (Azmi and Mortimer, 2000). Methods, rate and time of application is very important to control weeds in rice fields. Improper and misuse of herbicides cannot control weed species and conesquently weed species are getting more resistant to herbicides (Azmi et al., 2007). *Leptochloa chinensis*, *Echinochloa crusgalli*, *Fimbristylis miliacea*, *Echinochloa colona*, *Cyperus iria*, *Sphenoclea zeylanica*, *Cyperus deformis*, *Oryza sativa* spontanea, *Scirpus grossus* and *Jussia linifolia* were the most frequent species covering more than 50% fields in rice growing areas in Malaysia (Begum et al., 2005). Sprangletop is an abundant and seasonal grass weed which is extensively disseminated in the rice growing regions in the world (Abeysekera and Wickrama, 2005) and ranked third in rice weed ecosystems in Malaysia (Begum et al., 2005). Rice yield would be drastically hindered until this prolific weed could not be controlled. Therefore, this study was initiated to determine herbicide resistant biotypes of sprangletop and to find out efficient methods of control by using optimum rates of herbicides alone or in combination.

MATERIALS AND METHODS

Study site and treatments

Weed seeds were collected from 10 random locations. For each location, randomly, five spot were selected to collect seeds from rice fields in Kedah (6°20'N, 100°22'E), Malaysia where different kinds of herbicides are being applied by farmers since 1990. The collected seeds were abbreviated as per locations and presented in Table 1. Seeds were stored in Weed Science Laboratory, Faculty of Science and Technology, National University of Malaysia. Before anticipation of experiment, germination test was carried out in the laboratory. Plastic pot was used to conduct experiment at green house and pot (15 by 20 cm) was filled with 500 g air-dried and sterilized clay loam soil. The duration of sunshine hour was more than 12-h. Day night temperature at greenhouse was ranged from 27 to 31 and 20 to 24°C, respectively. Screening experiment was conducted to identify resistant and susceptible biotypes, then further experimentation was carried out with resistant biotypes against variable concentrations of propanil (zepronex (R) 35% w/w; quinclorac (facet (R) 21.9% w/w and cyhalofop-butyl (clincer (R) 10.1% w/w. Finally levels of herbicide alone or mixed with others were tested to control resistant biotypes. Weed seeds were sown in pot as per treatment and after germination, only three weed seedlings were transplanted to each pot as per treatment for testing of herbicides. Normal irrigation water was applied to saturate up to field capacity for proper germination and growth of plants.

Identification of resistant and susceptible biotypes

Propanil at rates of 5500 (recommended rate) and 11000 ml a.i. ha^{-1}, quinclorac at rates of 300 (recommended rate) and 600 ml a.i. ha^{-1} and cyhalofop butyl at rates of 800 (recommended rate) and 1600 ml a.i. ha^{-1} were evaluated against weed populations to find resistant and susceptible biotypes. Non-treated control treatment was included against herbicides. The experiment was performed in a factorial completely randomized design with three replications. Details of herbicides application method, visual assessment evaluation and data collection procedures were described by Motior et al., (2010). Table 2 showed visual score indices which was used as an alternative and quicker method to determine resistance or susceptibility.

Effect of levels of herbicides on resistant and susceptible biotypes

Resistant and susceptible biotypes were determined from screening test and out of 10 tested weed population; only SB1 and SB2 were selected as susceptible and resistant against varying levels of propanil and cyhalofop-butyl, respectively. Although SB1 biotypes showed resistance against recommended and double doses of

Table 2. Visual evaluation indices of *L. chinensis*.

Physical status of weed plants	Visual score	Remarks
Green shoot and leaves	1	Highly resistant
Green shoot and leaves light green colour	2	Resistant
Green shoot and pale yellow colour leaves	3	Partial resistant
Partial control (dead)	4	Susceptible
Completely control (dead)	5	Strongly susceptible

Scoring indices: 1 = Green shoot and leaves; 2 = green shoot and leaves light green colour; 3 = green shoot and pale yellow colour leaves; 4 = partial control (dead) and 5 = completely control (dead).

quinclorac, this biotype along with SB2 was further tested against different concentrations of quinclorac for confirmation of resistance or susceptibility. Both resistant and susceptible biotypes were tested against propanil at rates of 0, 1375, 2750, 5500, 11000, 22000 and 44000 ml a.i. ha^{-1}; quinclorac at rates of 0, 75, 150, 300, 600, 1200 and 2400 ml a.i. ha^{-1} and cyhalofop-butyl at rates of 0, 200, 400, 800, 1600, 3200 and 6400 ml a.i. ha^{-1} respectively. The experiment was arranged in a factorial completely randomized design with three replications. Details of herbicides application method and data collection procedures were described by Motior et al., (2010). The consistency of fresh weight data and visual assessments showed accuracy for subsequent assay and fresh weight reduction up to 85 - 90% was considered as susceptible biotypes while 0 - 5 and 50% reduction assessed as resistant and partial resistant, respectively (Moss, 1999).

Effect of herbicides on resistant biotype

After the completion of dose response experiment, resistant biotype SB2 was further evaluated to control application of propanil at rates of 5500 (recommended rate) and 11000 ml a.i. ha^{-1}, quinclorac at rates of 300 (recommended rate), 600 ml ha^{-1} and cyhalofop-butyl at rates of 800 (recommended rate), 1600 ml ha^{-1} alone or mixture of all. In addition, non treated weed plant was also included as control. The experiment was arranged under completely randomized design with four replications. Herbicides application method and data collection procedures were described by Motior et al., (2010).

Statistical analysis

The effective dose (ED_{50}) was determined by using the shoot fresh weight fitted against rates of propanil, quinclorac and cyhalofop-butyl. The ED_{50} was estimated by log logistic model (Seefeldt et al., 1995) to compare the susceptibility of biotypes against herbicides. The dose was expressed in ml ha^{-1}. Statistical analysis system was used for data analysis and following the analysis of variance procedures, differences among treatment means were determined using the least significant difference (LSD) comparison method (SAS, 1999).

RESULTS AND DISCUSSION

Identification of resistant and susceptible biotypes

The result obtained from visual observation suggests that Kampung Pida-Tiga (KPT) population obtained visual score 1 and 5 by application of propanil at rates of 5500 and 11000 ml a.i. ha^{-1}, respectively. Plants of Kampung Permetang (KP), Dulang Besar (DB) and Kampung Bahagia (KB2) population's recorded visual score 2 and 5 by use of propanil at rates of 5500 and 11000 ml a.i. ha^{-1}, respectively. Plants of Sungai Baru (SB1), SB2, Kampung Pida-Empat (KPE), Tanjung Dawai (TD) and Kampung Bahagia (KB1) population's possessed visual score 3 and 4 or 5 by application of propanil at rates of 5500 and 11000 ml a.i. ha^{-1}, respectively. Plants from Singkir Yan (SY) population obtained visual score 5 by both rates of propanil (Table 3). All populations except TD plants obtained poor score by application of quinclorac at rates of 300 and 600 ml a.i. ha^{-1}, respectively. Plants from DB obtained 1 and 2 by recommended and double rates, respectively. Plants from SY and TD population's recorded visual score 1 by cyhalofop-butyl at rates of 800 and 1600 ml a.i. ha^{-1}, respectively. Plants from KP, SB1 credited visual score 5 by recommended and double rates while SB2 and KPT scored 2 and 3 by both rates of cyhalofop-butyl, respectively. Weed populations of KPE, DB and KB1 obtained 2 and 3 by recommended and double rates, respectively. On the other hand, KB2 population plants treated with cyhalofop-butyl at both recommended and double rates obtained 2 and 5 (Table 3), respectively.

The application of herbicides showed significant influence on fresh weight of weed biotypes (Figure 1). Regardless of herbicides concentrations and weed populations, non treated control plants produced higher fresh weight. Maximum fresh weight was obtained by KB1 followed by KB2, SY and SB2; and minimum fresh weight was recorded by TD, DB followed by KPT among control plants. The fresh weight of weed ranged from 0.21 to 1.22 g $plant^{-1}$ by propanil at rates of 5500 and 11000 ml a.i. ha^{-1}, respectively. The weed biotypes of KPT and SY produced the highest and lowest fresh weight by propanil at the rate of 5500 ml a.i. ha^{-1}. On the other hand, SB2 and KPT recorded maximum and minimum fresh weight by propanil at the rate of 11000 ml a.i. ha^{-1}. Intermediate fresh weight was obtained from other populations (Figure 1a). The highest reduction (85 - 89%) of shoot fresh

Table 3. Visual assessment of *L. chinensis* as affected by herbicides.

Source of weed population	Herbicide (ml a.i. ha^{-1})					
	Propanil		Quinclorac		Cyhalofop-butyl	
	†5500	††11000	†300	††600	†800	††1600
KP	2	5	1	1	5	5
KPT	1	5	1	1	3	3
SB 1	3	5	1	1	5	5
SB 2	3	4	1	1	2	2
KPE	3	5	1	1	2	3
SY	5	5	1	1	1	1
TD	3	5	2	3	1	1
DB	2	5	1	2	2	3
KB 1	3	4	1	1	2	3
KB 2	2	5	1	1	2	5

†, Recommended rate; ††, double rate; scoring indices: 1 = green shoot and leaves; 2 = green shoot and leaves light green colour; 3 = green shoot and pale yellow colour leaves; 4 = partial control (dead) and 5 = completely control (dead).

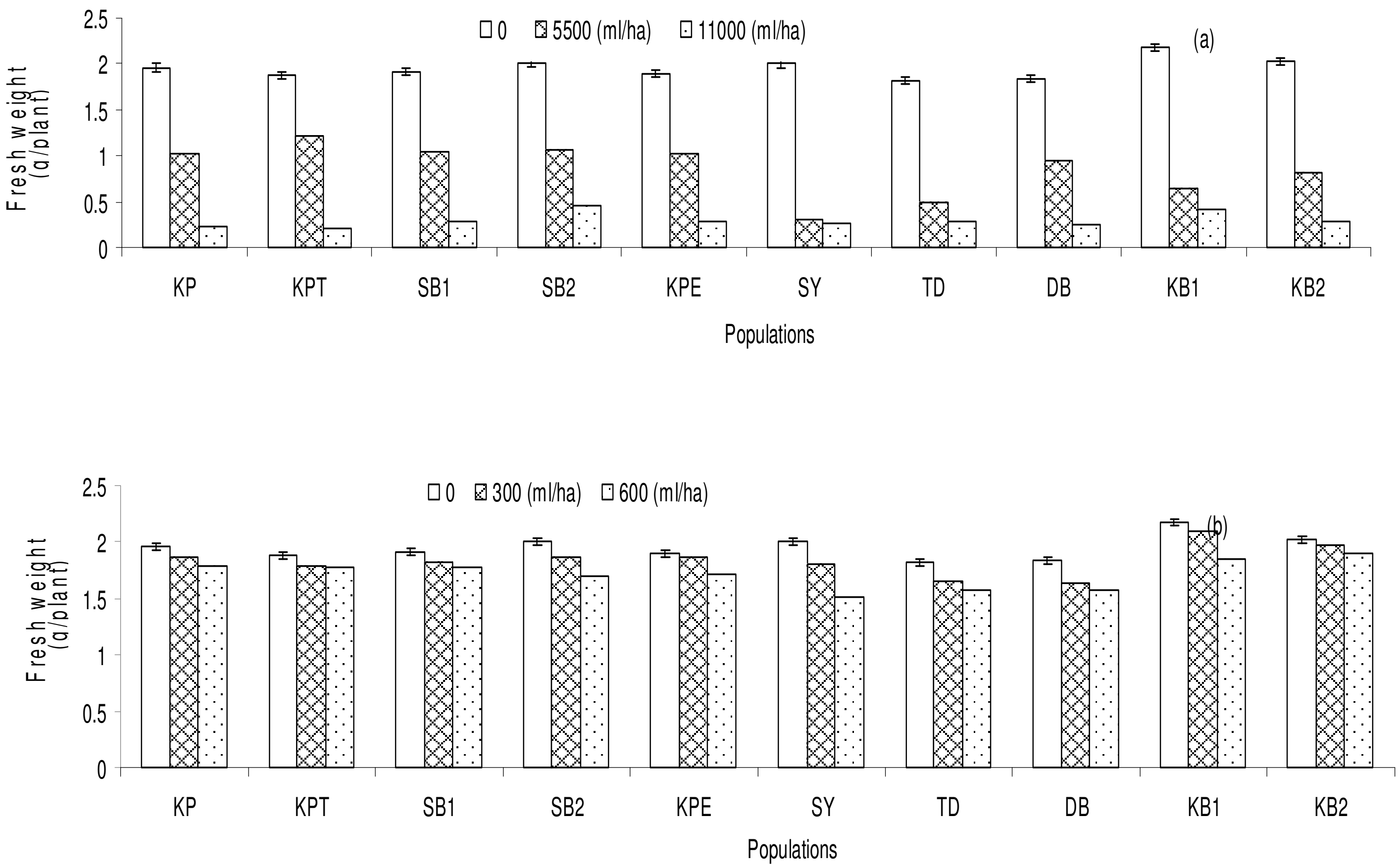
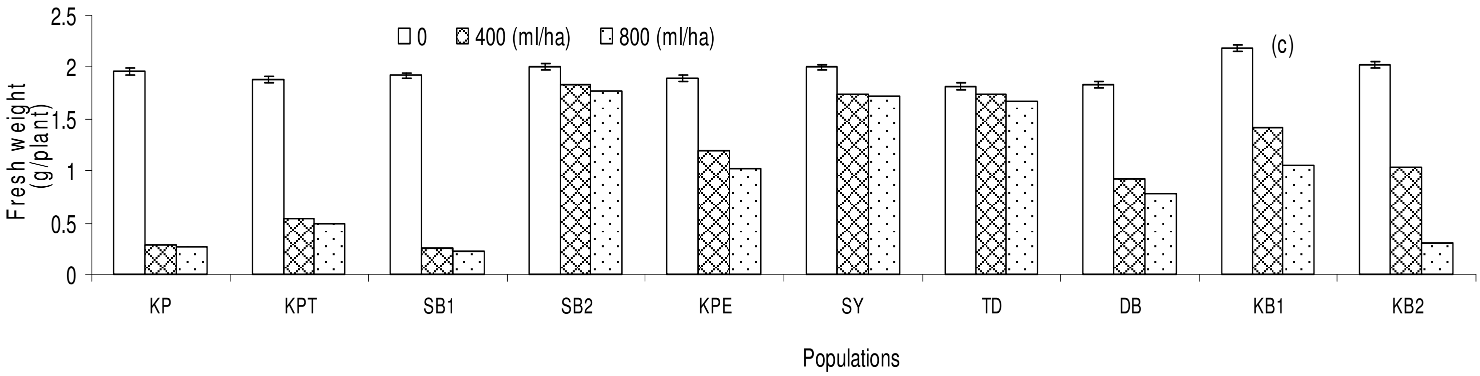


Figure 1. Shoot fresh weight as affected by (a) Propanil, (b) quinclorac and (c) cyhalofop-butyl (error bar indicates LSD at 0.001).

weight was obtained from SY with propanil at the rate of 5500 ml a.i. ha^{-1} and KP and KPT at the rate of 11000 ml a.i. ha^{-1} (Figure 2a). The fresh weight was sharply decreased, because of photosynthetic activities supposed



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to be inhibited by application of propanil (Daniell et al., 2006). Barnyard grass shoot fresh weight was reduced (78 - 85%) by use of propanil at the rate of 10.4 kg ha^{-1} (Ionnis and Kico, 2005). The greater fresh weight was produced by KP, KPT, SB1, SB2, KPE, DB and KB2. The shoot fresh weight reduction was poor over control plant and the lowest scoring suggests that all are considered highly resistant biotypes to propanil (Figure 2a). The highest visual score, lower fresh weight and maximum rate of reduction in the shoot fresh weight clearly indicated that SY was placed under susceptible biotype.

The shoot fresh weight ranged from 1.90 to 2.10 g plant^{-1} by application of quinclorac at rates of 0.30 and 0.60 kg a.i. ha^{-1}, respectively (Figure 1b). The shoot fresh weight was not reduced over control plants which indicated that all population was resistant to quinclorac (Figure 2b). Fresh weight varied from 0.25 to 1.83 and 0.27 to 1.77 g plant^{-1} by cyhalofop-butyl at rates of 800 and 1600 ml a.i. ha^{-1}, respectively. The higher fresh weight was produced by SB2 by both rates followed by SY and TD plant. The lower fresh weight was produced by SB1 and KP by both rates of cyhalofop-butyl (Figure 1c). The shoot fresh weight reduction of SB1 and KP was higher over control plants by both rates of cyhalofop-butyl (Figure 2c). Weed populations of KP, SB1 and KB2 were represented as susceptible biotypes while KPT, SB2, KPE, SY, DB and KB1 showed resistance against cyhalofop-butyl. The higher fresh weight, lower reduction rate of shoot weight and lower visual scoring showed resistance while lower fresh weight, higher reduction rate along with higher scoring showed susceptibility of weed biotypes. Similar findings were obtained in *Echinochloa crus-galli* (Motior et al., 2010). The results of the present study showed that shoot fresh weight had positive correlation with visual scoring indices. The superior shoot fresh weight had lower scoring while inferior shoot fresh weight and higher scoring indices would be the selection indices of resistance and susceptible biotypes. Therefore fresh weight data can be used to verify the accuracy of the visual evaluation and the consistency of results between subsequent assays.

Effect of levels of herbicides on resistant and susceptible biotypes

The shoot fresh weight of both resistance and susceptible biotypes were decreased along with increased concentration of propanil. A sharp decline was observed in the case of susceptible biotype compared to resistant biotype. The susceptible biotype SB1 had 85% reduction of shoot fresh weight at recommended rates (5500 ml a.i. ha^{-1}) of propanil (Figure 3a). No significant difference was observed among recommended (5500 ml a.i. ha^{-1}) and double (11000 ml a.i. ha^{-1}) rates of propanil in respect of susceptible weed biotypes which suggested that no distinct difference in phytotoxicity was observed by propanil among both rates. In case of resistant biotype SB2, shoot fresh weight reduction was only 48% by use of propanil at the rate of 5500 ml a.i. ha^{-1} and of course reduction rate was also higher with higher rate of propanil but it was lower compared to susceptible biotype. Fresh weight reduction of susceptible biotype had 92% at the highest dose of propanil (44000 ml ha^{-1}); on the contrary, resistant biotype had a bit lower (Figure 3a). No significant reduction of shoot fresh weight was observed by quinclorac for both susceptible and resistant biotypes (Figure 3b). The shoot fresh weight of susceptible biotype had no significant ($P > 0.05$) difference by application of cyhalofop-butyl at rates of 800 and 1600 ml ha^{-1}, respectively. It clearly indicated that no appreciable difference was found in respect of plant toxicity by application of cyhalofop-butyl at both rates. The shoot fresh weight of susceptible biotype had 87% at recommended rates (800 ml a.i. ha^{-1}) while resistant biotype had no significant effect even with higher rates of cyhalofop-butyl (Figure 3c).

Quadratic equation provided the best fit for regression

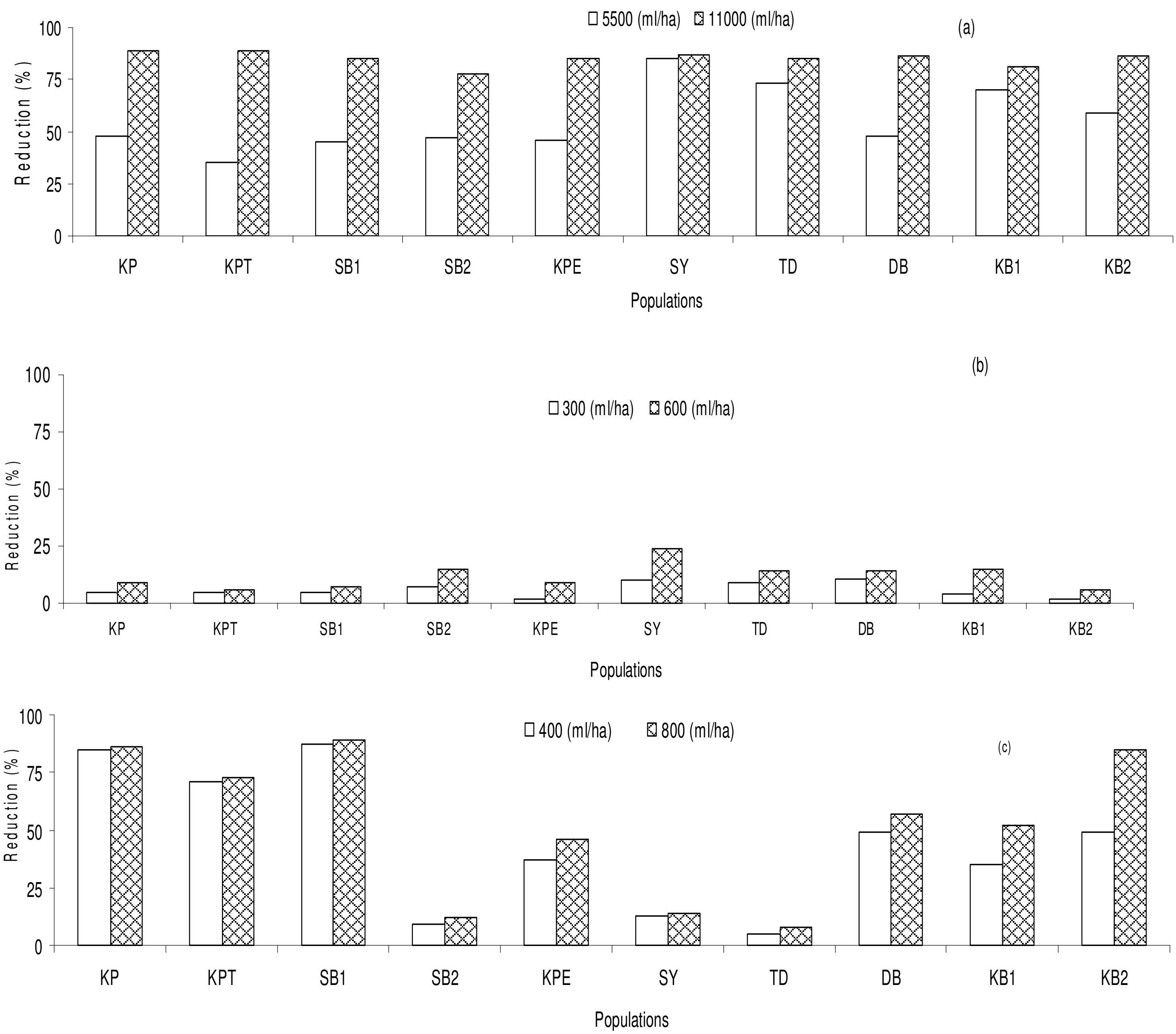

Figure 2. Shoot fresh weight reduction as affected by (a) propanil, (b) quinclorac and (c) cyhalofop-butyl.

analysis regarding fresh weight response to propanil, quinclorac and cyhalofop-butyl (Table 4). Slopes of the regression equations showed that fresh weight of resistant biotype SB2 had less reduction rate of shoot fresh weight, whereas the susceptible biotype SB1 had faster reduction rate by use of propanil. Poor reduction rate was observed in resistant biotypes compared to susceptible biotypes by use of cyhalofop-butyl; on the contrary, severely poor reduction rate was noticed for both susceptible and resistant biotypes in case of quinclorac application. Our findings precisely suggest that the resistant biotype had the highest growth rate and these results coincided with the finding of Ionnis et al. (2000) and Motior et al., (2010). They reported that the propanil-resistant biotypes of barnyard grass had higher growth rate than a susceptible biotype. Propanil-resistant junglerice had also greater leaf area, more dry matter accumulation, taller height (Fischer et al., 1993) and reduced ecological fitness compared with susceptible biotypes (Radosevich and Holt, 1984).

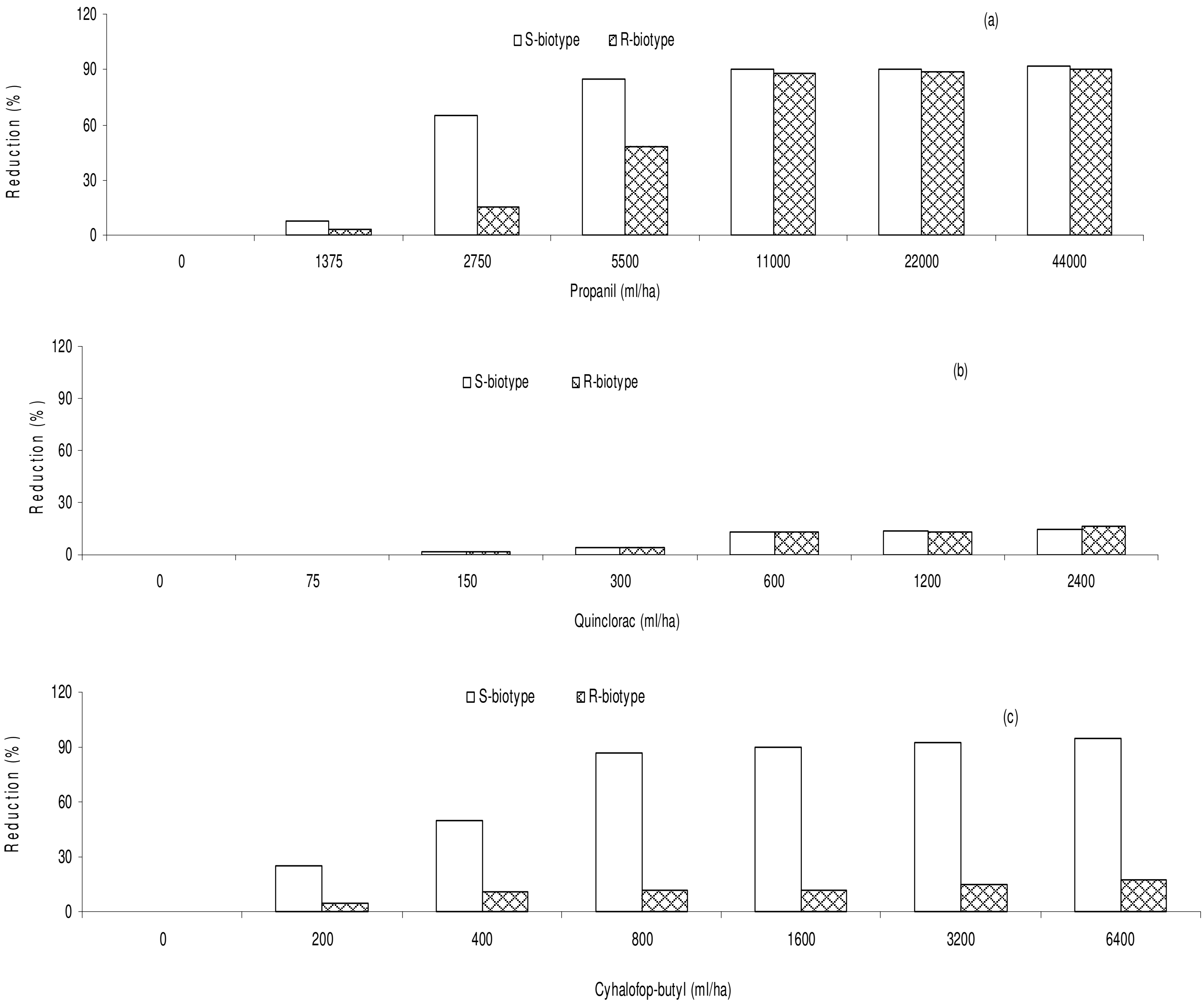

Figure 3. Shoot fresh weight reduction of SB2 – R. biotype as affected by propanil, quinclorac and cyhalofop-butyl.

Table 5 presented dose response curves (Figure 4) which shows the resistance index (RI). The ratio between ED_{50}-R and ED_{50}-S was 5.16 and 2.23, respectively and RI was 2.31 (Table 5). According to RI, the resistant biotypes was more than two times stronger to propanil than the susceptible biotype. The dose response curves of cyhalofop-butyl (Figure 5) also showed that the RI between ED_{50}-R and ED_{50}-S was 0.35 and 0.33, respectively and RI was 1.06 (Table 5) which indicated that the resistant biotypes were more than one time strongly resistant to cyhalofop-butyl than the susceptible biotype. The effective dose (ED_{50}) values clearly emphasized on herbicides concentrations which can reduce shoot weight about 50% relative to untreated controls. The ED_{50} was derived from nonlinear regression analysis that indicated response of propanil and cyhalofop-butyl with six levels against resistant and susceptible populations, respectively. No response curve was obtained from quinclorac due to no shoot reduction rate which was recorded during experimentation. The ED_{50} values varied from 2230 to 5160 ml ha^{-1} of propanil and 330 to 350 ml ha^{-1} of cyhalofop-butyl for the most susceptible to the

Table 4. Regression equation and coefficients of determination (R^2) for the relationship between herbicides concentration and shoot fresh weight of resistant SB2 and susceptible SB1 biotypes.

Herbicides	Regression equation [a]	R^2
Propanil for R biotype	$Y = 2.2088 - 0.1718X + 0.0029X^2$	0.9173
Propanil for S biotype	$Y = 1.7465 - 0.1528X + 0.0027X^2$	0.6811
Quinclorac for R biotype	$Y = 2.2636 - 0.8258x + 0.2314X^2$	0.9272
Quinclorac for S biotype	$Y = 2.258 - 0.4515X + 0.1273X^2$	0.9262
Cyhalofop-butyl for R biotype	$Y = 2.1529 - 0.2776X + 0.0298X^2$	0.9069
Cyhalofop-butyl for S biotype	$Y = 1.7109 - 1.0261X + 0.1233X^2$	0.7539

[a]Y, Shoot fresh weight; X, herbicides in kg ha^{-1}

Table 5. ED_{50} estimates from dose response curves for shoot fresh weight.

Herbicides	ED_{50} (ml a.i. ha-1)		Resistance Index
	R	S	
Propanil	5160	2230	2.31
Cyhalofop-butyl	350	330	1.06
Quinclorac	370	-	-

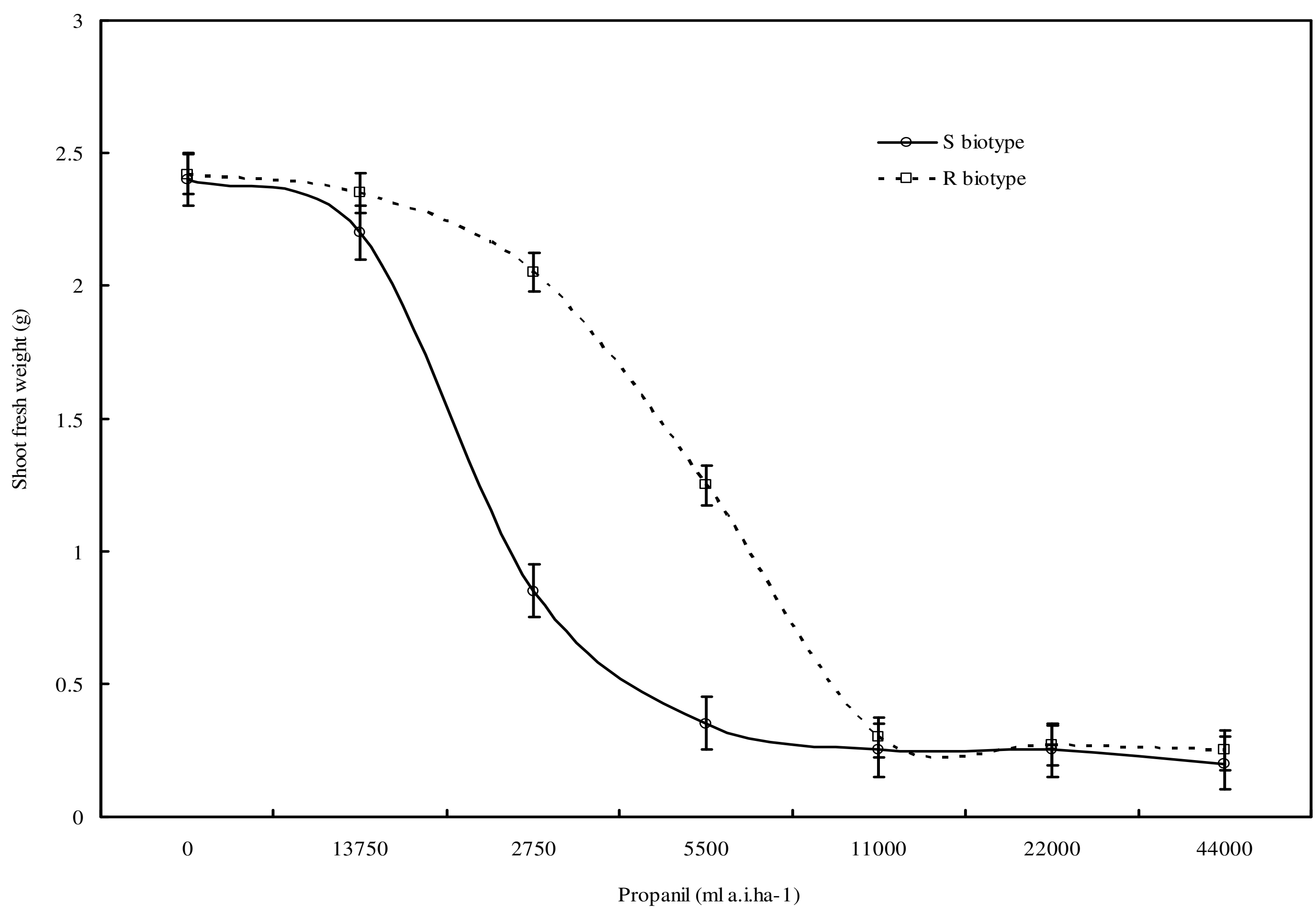

Figure 4. Effect of propanil concentrations on the shoot fresh weight of *L. chinesis* (error bar indicates ± S. E.).

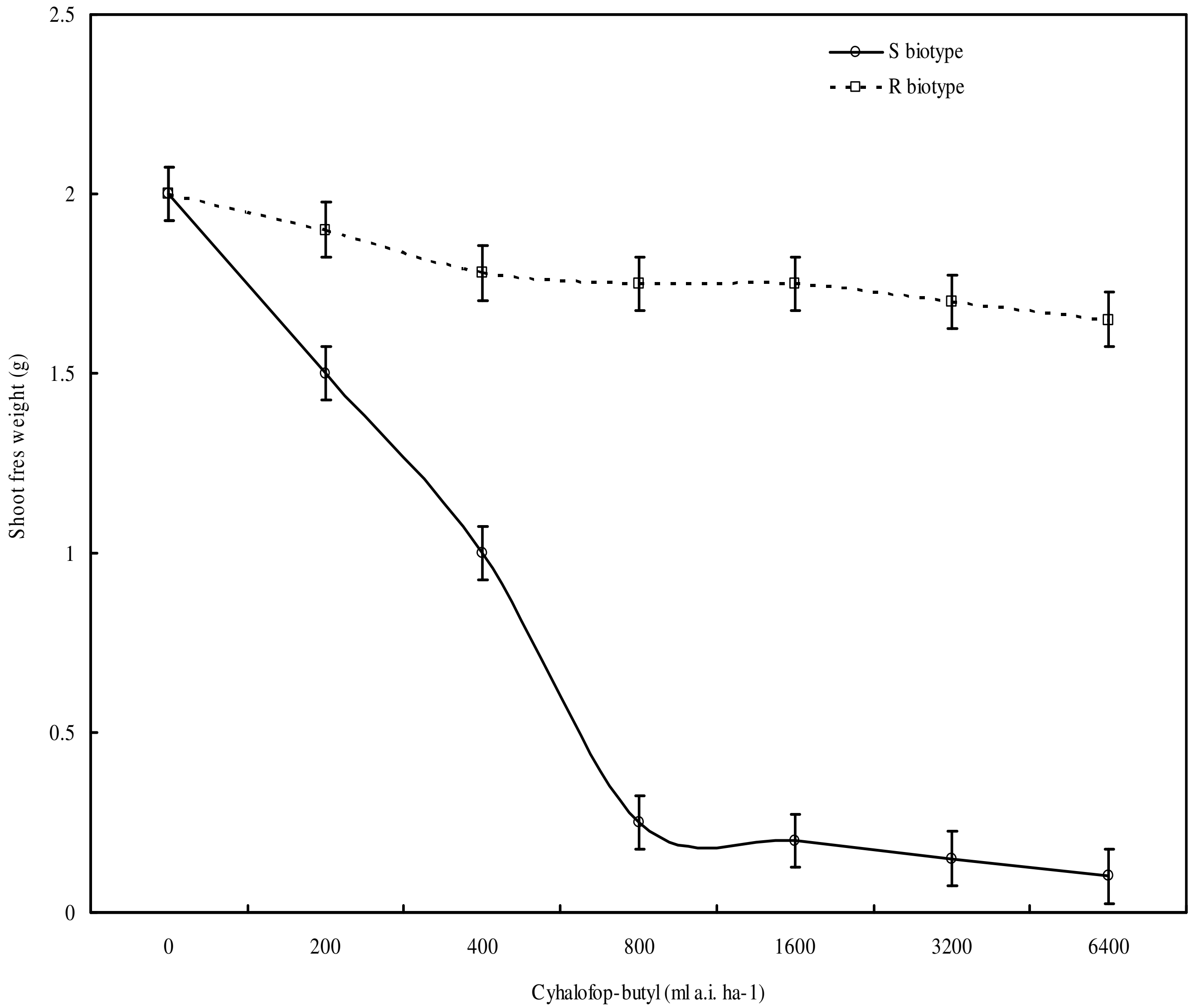

Figure 5. Effect of cyhalofop-butyl concentrations on the shoot fresh weight of *L. chinesis* (error bar indicates ± SE).

most resistant populations, respectively.

Effect of herbicides on resistant biotype

Herbicides had significant influenced on shoot fresh weight (Table 6). The resistant biotype was effectively controlled by application of recommended or double rates of propanil + cyhalofop-butyl while recommended rate of propanil + quinclorac and quinclorac + cyhalofop-butyl failed to show any positive response to control resistant biotype. Post-emergence application of propanil mixed with quinclorac, thiobencarb or pendimethalin was very effective to control resistant and susceptible biotypes while quinclorac mixed with pendimethalin or thiobencarb was effective as pre-emergence application (Baldwin et al., 1995). Baltazar and Smith (1994) reported that resistant barnyard grass biotypes could not be control with 6.0 to 8.0 kg ha^{-1} of propanil when weed plant was at two to three leaf stage in Arkansas. Similar findings were illustrated by Ionnis et al. (2000) and they found that resistant biotypes of barnyard grass were not controlled by application of propanil at rates of 2.6 or 5.2 kg ha^{-1}. Our finding conforms with the findings of Abeysekera and Wickrama (2005) and they mentioned that *L. chinensis* was successfully controlled by mixture of propanil, clomozone and cyhalofop. Combined effect of thiobencard, pendimethalin, molinate or quinclorac was able to control propanil-resistant barnyard grass than the single effect of propanil (Baltazar and Smith, 1994; Crawford and

Table 6. Effect of herbicides on the fresh weight and reduction in shoot of resistant biotype.

Herbicides rate	Shoot fresh weight (g)	Shoot reduction (%
Control	1.89 a	-
Propanil R + Quinclorac R	1.21 c	36
Propanil R + Cyhalofop-butyl R	0.26 d	86
Quinclorac R + Cyhalofop-butyl R	1.32 b	30
Propanil R + Quinclorac R + Cyhalofop-butyl R	0.23 d	88
Propanil D + Quinclorac D	1.13 c	40
Propanil D + Cyhalofop-butyl D	0.19 de	90
Quinclorac D + Cyhalofop-butyl D	1.13 c	40
Propanil D + Quinclorac D + Cyhalofop-butyl D	0.15 e	92

R, Recommended; D, double.

Jordan, 1995). In this study, a positive response was observed when propanil, quinclorac and cyhalofop-butyl at recommended or doubles rates were applied combined to control resistant biotype of sprangletop. Regarding economic points of view, the results revealed that propanil at the rate of 5500 ml a.i. ha^{-1} and cyhalofop-butyl at the rate of 800 ml a.i. ha^{-1} is effective to control resistant biotypes of *L. chinensis.*

Conclusion

The shoot fresh weight and reduction rate along with visual assessment scores can be utilized as a good index to determine resistant and susceptible biotype. The ED_{50} values and regression analysis revealed that resistant biotype was two times strongly resistant to propanil while more than one time resistant to cyhalofop-butyl, respectively, than susceptible biotype. This study also advocate that combined application of propanil (5500 ml a.i. ha^{-1}) and cyhalofop-butyl (800 ml a.i. ha^{-1}) is effective to control resistant biotype of *L. chinensis*.

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