Effectiveness of control measures of *Mikania micrantha* on grassland: a case study from grassland in Sauraha area of Chitwan National Park

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The spread of *Mikania micrantha* is causing a serious threat to native ecosystem in the tropical and sub-tropical parts of Nepal. The main objective of the study was to analyse the effectiveness of different control measures applied in the grasslands of Chitwan National Park (CNP) by comparing number and coverage of *M. micrantha* and native grass species. The three experimental sites were grassland of the CNP. These sites were delineated from Etrex 30, Global Positioning System (GPS) and GIS 10.3.2 in April, 2013. A block with size of 100 m x 100 m was separated by fire line on all sides for each treatment in each site. Systematic sampling with random start was used to establish sample plots within each block. Six sample plots were established in each block. The size of each plot was 2 m x 0.4 m (0.8 m^2). The distance between one sample plot to another sample plot was 40 m. Three treatments applied in three blocks of each site were controlled fire, manual cutting and control (no treatment).Seedlings of *M. micrantha* and native grasses were counted and their coverage assessed in each plot. The coverage and number of native grass species were higher in controlled fire plot than in manual cutting and control plots. The study concludes that controlled fire is better than manual cutting and control treatments for the management of grassland. This study will help to different stakeholders to control its outreach, make polices, proper management of grasslands that are being affected by the invasion of *M. micrantha*.

Key words: Control measures, grassland, *Mikania micrantha*, National Park, native grass species

Mikania micrantha, a perennial vine native to tropical, central and South America, is a pest in plantation crops and commercial forests, from Mauritius to West Africa and across Asia (Hills, 1999). It is one of the top 100 worst weeds in the world (Holm *et al.*, 1977). It is a fast growing, perennial climber, commonly called mile-a minute weed, because of its vigorous and rampant growth habit. It has been reported to grow to 27 mm a day (www.issg.org/database). *M. micrantha* is listed as one of the worst invaders (Holm *et al.*, 1977; Lowe *et al.*, 2000). It has been called a plant-killer since it causes native species to disappear and homogenize the invaded landscape (Zhang *et al.*, 2004). In Nepal, *M. micrantha* was first reported in 1963 in the eastern part (Tiwari *et al.*, 2005) and spreading towards the western part, which now recorded in 20 Terai districts of Nepal (Rai *et al.*, 2012 a). Likewise, *M. micrantha* is assessed as one of the six high risk posed invasive alien species in Nepal (Tiwari *et al.*, 2005) and later on, it is considered to be the most problematic in terrestrial ecosystem in eastern and central Nepal (Poudel *et al.*, 2005). In Chitwan National Park (CNP), *M. micrantha* was found to be the most serious weed among the eight invasive species in terrestrial ecosystem (Sapkota, 2006).

Since 1960s, various attempts have been made to control *M. micrantha* by applying mechanical, biological and chemical methods (Bogidarmanti, 1989). In practice, spraying chemicals may be the easiest way to control *M. micrantha*. However, the possibility of environmental contamination and public health risks, if chemicals are used to control the widespread weed *M. micrantha*,is of

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great concern. Using biological control may have a risk that the agent may convert into invasive itself in long-term. Herbicides are effective in controlling this weed but they cause serious environmental problems (Zhang *et al.*, 2004).

Consecutive cutting of the vines (mechanical technique) is found appropriate to control the growth of *M. micrantha*, without having any ecological negatives (Kuo *et al.*, 2002). Mechanical control is very labour intensive and uneconomical. The manual operation is becoming quite popular to control the growth of *M. micrantha* in many Asian countries. To control the *M. micrantha*, these options are suitable (i) the government can implement a large-scale control programme due to availability of cheap labour, (ii) local forest users are managing about one-fourth of the country's total forests, so they can participate in the *M. micrantha* cutting operation, and (iii) manual cutting has no side effects, so they are the causes for appropriateness for manual cutting in Nepal. Uprooting, cutting and burning by local forest user groups failed to produce the expected results in the buffer zone of the CNP, Nepal (Rai *et al.*, 2012a). Employing regular cutting operations can modify understorey shade enhancing regeneration of native species, which is a desirable condition to constrain proliferation of *M. micrantha*. Competitiveness of *M. micrantha* was reduced by periodic cuttings regardless of canopy openness, but native ground cover should be retained (Rai *et al.*, 2012b). In order to improve native ecosystem, targeting only to eliminate invasive species would not work properly, hence it needs to be addressed by an effective management strategy. Thus, manual cutting could be an appropriate strategy; however, it demands significant amounts of labour and time (Rai *et al.*, 2012b).

Control burning is considered as one of the cheapest and most effective ways to rejuvenate pasture and rangeland. Fire can improve wildlife habitat, decrease hazardous fuels by reducing litter accumulation, and decrease undesirable woody shrubs and "invader" plants. At the same time, fire improves the productivity and nutritive quality of forage grasses (Kjellsen and Higgins, 1990). The Grassland Conservation Council supports a balanced approach to restoring and maintaining grassland with prescribed fire is an important tool for restoring and maintaining grassland. Increasingly, prescribed fire is major aspect of using fire as a habitat restoration tool; its role in the management of invasive plants, which can include annuals, perennials and woody species. Managing invasive plants focuses on the use of fire (DiTomaso *et al.*, 2006).

Despite there have been various efforts to control the *M. micrantha*, there is lack of information to put forward the proper control mechanism of the most problematic terrestrial invasive species of the country. This paper analyses the effectiveness of different control measures applied in the grasslands of the CNP through comparison of number and coverage of both invasive (*M. micrantha*) and native grass species. Even though, the survey was carried out after short period (5 months) of treatments applied, this study attempts to answer two research questions: i) it considers which control measure is most appropriate to control *M. micrantha* in grassland ? and ii) which control measure will promote native grass species most ?

Materials and methods

Study site

The study was carried out at Sauraha area in eastern sector of the Chitwan National Park (Latitude: 27°35' North and Longitude: 84°29' East) (Fig. 1). Permanent plots were established by National Trust for Nature Conservation (NTNC) for using and estimating the effectiveness of different control measures of *M. micrantha* in the grasslands located at Padampur and Icharni islands near to Rapti and Dungre rivers. This area has monsoon dominated sub-tropical climate with average monthly maximum temperature 24°C–38°C, monthly minimum temperature 11°C–26°C, average rainfall 2,437 mm/year and relative humidity 89–98% (Thapa, 2011) and comprises the grassland habitat with major native tree and grass species *Clerodendrum infortunatum* (Bhant), *Trewia nudifloria* (Gutel), *Saccharum spontaneum* (Kans), *Imperata sp.* (Siru), etc. Table 1 depicts the description of treatments applied in the experimental sites.

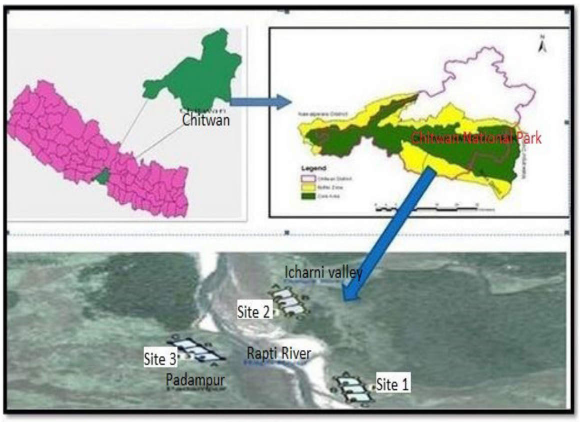

Fig. 1: Study area

Table 1: Description of treatments applied

Treatment name	Description
Controlled fire	Controlled burning was carried out within the block in April and then the block was protected from fire and grazing.
Manual cutting	All vegetation (*i.e.* both *M. micrantha* and native grasses) within the block were removed from ground level by manual cutting in April and the area was protected from fire and grazing.
Control (no treatment)	Treatment was not applied within the block and it was also protected from fire and grazing throughout the period.

Design for application of treatments

The three experimental sites were delineated from Etrex 30, Global Positioning System (GPS) and GIS 10.3.2 in April 2013. Within each experimental site, three blocks were designed for three different treatments (Table 1). Each block was comprised of 1 ha (100 m x 100 m) and it was separated by fire line on all sides. The three different treatments in each block were applied as shown in figure 1. Systematic sampling with random start was used to establish sample plots where six sample plots of size 2 m x 0.4 m were designed in each block having same treatment. The plot to plot distance was 40 m and the plot layout is shown in figure 2. Thus, number of replication and total number of sample plots for each treatment were 3 and 18, respectively.

Data collection

Number of *M. micrantha* seedling and native grass were counted and their coverage was assessed through visual examination in each sample plot. The treatments were applied in April, 2013 and the inventory was carried out after five months *i.e.* in September.

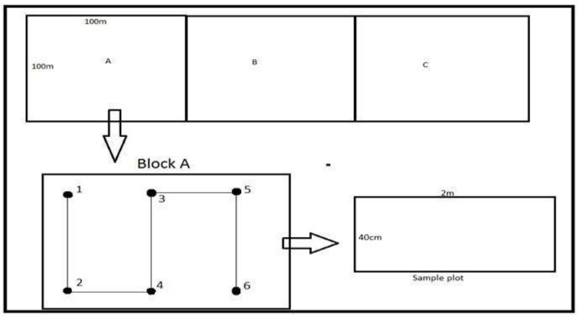

Fig. 2: Experimental design and lay-out of sample plots

Data analysis

The data were analysed by assessing average number and coverage of both invasive (*M. micrantha*) and native grass species. One way ANOVA followed by post hoc Least Significant Difference(LSD) at 5% level of significance was used to compare the effect of different treatments on the variables considered in this study.

Results and discussion

Effects on regeneration of *M. micrantha*

Summary statistics of number of *M. micrantha* seedlings and its coverage in different blocks are presented in table 2. Zero value of *M. micrantha* in minimum value column suggests that there was at least one plot without any *M. micrantha*. The number of *M. micrantha* seedlings was found the least in controlled fire block (7.9 per plot) followed by manual cutting (19.6 per plot) and the highest in control block (30.1 per plot).

Coverage of the *M. micrantha* seedlings also followed the same pattern as that of number *i.e.* the least in controlled fire plot followed by manual cutting and the highest in control plot.

Analysis of variance (ANOVA) showed that the effect of treatments on number of *M. micrantha* seedlings was significant and least significant

Table 2: Descriptive statistics related to number and coverage of *M. micrantha*

Treatment	Total number of plots (N)	Number per plot				Coverage (%)			
		Mean	St. dev.	Min.	Max.	Mean	St. dev.	Min.	Max.
Controlled fire	18	7.9	12.7	0	43	10.0	23.4	0	90
Control	18	30.1	32.0	0	106	23.9	27.8	0	90
Manual cutting	18	19.6	30.7	0	124	19.4	29.4	0	90

difference (LSD) test revealed that the number of *M. micrantha* seedlings in controlled fire block was significantly lower than in control block (p=0.016, n=18) (Table 3). The difference between the average number of seedlings of *M. micrantha* in control and controlled fire blocks (-22.7) suggests that the regeneration of *M. micrantha* can be reduced by 73.8% by controlled fire. Similarly, it can be reduced by 34.9% in manual cutting block. The coverage of *M. micrantha* was 58% less in controlled fire and 18.8% less in manual cutting than that of the control block. However, one way ANOVA at 5% level of significance failed to reveal a significant difference in coverage of *M. micrantha* among the blocks (p= 0.299).

Table 3: Statistics of LSD test on number of *M. micrantha* **seedlings**

Treatment		Mean difference	p-value
Controlled fire	Control	-22.7*	0.016*
	Manual cutting	-11.7	0.193
Control (no treatment)	Controlled fire	22.2*	0.016*
	Manual cutting	10.4	0.245
Manual cutting	Controlled fire	11.7	0.193
	Control	-10.4	0.245

* *significant at 5 % level of significance*

Rai *et al.* (2012b) concluded that manual cutting could be an appropriate strategy to maintain the native ecosystem in an invaded area by constraining the growth of *M. micrantha* but in case of grassland it seems different. The lowest number and the least coverage of *M. micrantha* in controlled fire block suggest that controlled fire is more effective than manual cutting in controlling *M. micrantha* in grassland. Similarly, more coverage and number of *M. micrantha* vines in control (no treatment) block could be due to its vigour growth in natural situation (Kuo *et al.*, 2002).

Effects on regeneration of native grass

The summary statistics of number and coverage of native grass in all blocks are presented in table 4. In contrast to *M. micrantha*, the number of native grasses were found the highest in controlled fire block (513.7 per plot) followed by manual cutting block (279.1 per plot) and the lowest in control block (243.7 per plot). One way ANOVA at 5% level of significance revealed that the difference in number of native grass species among the three blocks was significant and then LSD test was also performed. The number of native grasses in controlled fire block was more than double (2.1 times) as compared to the control block and the difference was significant (p=0.031, n=18) (table 5). Similarly, regeneration of the native grass was 1.1 times higher in manual cutting than in control block. The difference between the manual cutting and the control block was not significant at 5% level of significance, but significant at 10% level of significance (p= 0.059, n=18).

Table 4: Descriptive statistics of number and coverage of native grass

Treatment	Total number of plots (N)	Number (per plot)				Coverage (%)			
		Mean	St. dev.	Min.	Max.	Mean	St. dev.	Min.	Max.
Controlled fire	18	513.7	491.3	5	1780	67.6	32.9	5	99
Control	18	243.7	246.3	16	941	56.1	30.5	6	98
Manual cutting	18	279.1	312.8	22	1277	50.4	29.2	10	98

The coverage of native grasses was found the highest in firing block (67.6%) followed by control block (56.1%) and the lowest in manual cutting (50.4%). Analysis of variance failed to show significant effect of treatments in coverage of the native grasses (p=0.569).

Table 5: Statistics of LSD test on number of native grass

Treatment		Mean difference	p-value
Controlled fire	Control	270.1	0.031**
	Manual cutting	234.7	0.059*
Control (no treatment)	Controlled fire	-270.1	0.031**
	Manual cutting	-35.4	0.772
Manual cutting	Controlled fire	-234.7	0.059*
	Control	-10.4	0.245

**significant at 10% level of significance*
*** significant at 5% level of significance*

According to Bot and Benites (2005), fire is considered as the best management tool for grassland management which promotes native grass species. In initial phase, burning destroys the litter layer and so diminishes the amount of organic matter returned to the soil. And, our results also support it. The finding of this study is in line with many literatures like grassland management with prescribed fire by Stubbendieck *et al.* (2007) and grasslands: benefits of management by fire by Kjellsen and Higgins (1990) which states about fire and its importance in grassland management as well as positive effects of fire in regeneration on grassland.

Conclusion

This study has compared the effectiveness of treatments applied to control *M. micrantha* invasion in the grasslands of Chitwan National Park. Controlled fire was found better than the manual cutting to control invasion of *M. micrantha*. Controlled fire not only constrains the growth of *M. micrantha* but also promotes the growth of native grass species. Therefore, we concluded that controlled fire could be an appropriate strategy to maintain the *M. micrantha* invaded grassland in the CNP. Since the present study was based on one-time data and few treatments, further study with the data from different seasons of the year and with various treatments would be useful.

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