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Management strategies for rehabilitation of *Lantana* infested forest pastures in Shivalik foothills of Jammu & Kashmir

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ABSTRACT

A study on rejuvenation of wild sage (*Lantana camara L.*) infested forest pastures in Shivalik foot-hills of Jammu & Kashmir was conducted from April 2006 to December 2008. The study included manual cuttings of *Lantana* bushes*;* manual cuttings followed by application of 1% glyphosate on its regenerated growth of 30 cm in height; and manual grubbings. These were followed by either no plantation of grasses, planting either of hybrid napier and *Setaria* cuttings. Results of the study revealed that the fresh bio-mass of *Lantana* bushes recorded a sizeable reduction ranging from 66 to 99% under different treatments over its initial average fresh bio-mass value of 28 kg/25 m^2. Likewise, a significant reduction in the number of *Lantana* bushes per unit area to the extent of 67-99% over its initial average value of 6 bushes/25 m^2 was also recorded with grubbing and the herbicide applied treatments. Application of glyphosate 30 cm regenerated growth of *Lantana* bushes and grubbing treatments followed by planting either of hybrid napier and *Setaria* were found equally effective in rehabilitation of *Lantana* infested forest pastures as both of these grasses provided good soil cover and recorded higher forage yields under these treatments *i.e.* hybrid napier 1.81 to 2.07 t/ha and *Setaria* 0.98 to1.02 t/ha.These two treatments were also found significantly superior to the repeated *Lantana* cutting treatments and decreased fresh *Lantana* bio-mass by 94.20 to 99.03% over its initial bio-mass value. However, between these two most effective treatments *i.e.* the management of *Lantana* bushes with the application of glyphosate followed by planting of either hybrid napier and *Setaria* grasses were found economically superior, with a net saving of rupees 6,640/ha, over the grubbings of *Lantana* followed by planting either of these grasses .

Key words: Economics, Forest pastures rehabilitation, Grubbing, Glyphosate, *Lantana camara,* Manual cutting, Perennial grasses

The expansion of human population has enforced man to exhaustively exploit the natural resources including forest pastures and grasslands. Over-exploitation of such valuable resources is rendering large area as wasteland year after year which is an alarming signal for the sustenance of these resources. These resources cater the fodder need of more than 90 per cent of the livestock population in India (Anonymous 1995). Among the various pests which affect the productivity of a land, weeds wage a hidden war for plant essentials and interfere with the growth of plants and obstruct the activities of animals and human beings. Perennial weeds because of their immense capacity of reproduction, higher rate of dispersal and adaptation to adverse conditions have infested the land that are not under cultivation. Hilly regions which have more such land due to typical physiographic conditions are more infested by these weeds. The areas which used to support large livestock population have got invaded by uneconomic vegetation i.e. weeds. The perennial weeds infesting these lands resulted into shrinkage of the area for animal grazing and grass production (Angiras 1999).

Jammu & Kashmir, a North-Western hill state of India occupies 2, 22,236 sq km with an altitude range of 307 to 4,700 meter above mean sea level. The physiographic features of Jammu & Kashmir State can be compared to a threefold plateau on the basis of altitudinal variations for Shivaliks, middle Himalaya and the Greater Himalaya ranging from 307 to 615, 921 to 1,228 and 4,300 to 4,700 meters above mean sea level, respectively. The state is agrarian in character and about 75% of its population is engaged in various agriculture and live-stock related pursuits. However, the distribution of cultivable waste land and forest cover in the three regions vary. Out of a total sub-tropical area of about 585 thousand hectares in J&K around 268 thousand hectares is uncultivated (Anonymous 2008) and which probably has been under the threat by the invasion of aggressive native as well as exotic weed

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species, particularly exotic *Lantana camara* which is making inroads in forest pastures and grasslands. Out of total weed invaded area of sub tropical belt of Jammu region, probably a sizeable portion is heavily infested with exotic weed species and amongst them *Lantana* has been found to take hold of most of the area under natural forests as under canopy weeds. The alarming situation arising out of such invasions particularly by the *Lantana camara*, an obnoxious weed which is a wild shrub and does not grow on lands which are under frequent tillage but establish itself on non-cultivated areas has almost dwindled the ecology of the forest ecosystems turning the lush green productive and economically viable forest pastures into unproductive degraded lands which needed a scientific intervention. Thus, keeping this in view, a study on the management of *Lantana* invaded forest pastures of Shivalik foot-hills was carried out from April, 2006 to December, 2008 with the objectives of finding out the most effective and economical technique for rejuvenation of these land pockets rendering their ability to at least provide some forage for local consumption and meanwhile not having much competition with native vegetation like those of the endemic types which face extinction due to biotic environmental stress.

MATERIALS AND METHODS

The study site falls in forest area near village Janglote 8 km away from district headquarter Kathua of Jammu & Kashmir state. The experimental study to restore the forage productivity of forest pastures was conducted from April, 2006 to December, 2008. The soil of the experimental site was sandy loam in texture (sand=49.02%, silt =22.08% and Clay =28.0%), acidic in reaction (pH=6.4) and high in organic carbon (0.90%), medium in available nitrogen (416 kg /ha), phosphorus (15.8 kg/ha) and potassium (152.5 kg/ha). The experiment consisted of nine treatments *viz.*, T_1= 3- *Lantana* cuttings during the year each at 4 months interval to allow the natural native flora to come up, T_2 = 3- *Lantana* cuttings during the year each at 4 months interval and planting of hybrid napier (*NB-21*) cuttings, T_3= 3- *Lantana* cuttings during the year each at 4 months interval and planting of *Setaria sphacelata* cuttings, T_4 = 3- *Lantana* grubbings during the year each at 4 months interval to allow the natural native flora to come up, T_5 = 3- *Lantana* grubbings during the year each at 4 months interval and planting of hybrid napier (*NB-21*) cuttings, T_6 = 3- *Lantana* grubbings during the year each at 4 months interval and planting of *Setaria sphacelata* cuttings, T_7 =Cutting of *Lantana* bushes followed by application of glyphosate 1.0% just before rainy season on about 30 cm regenerated growth of *Lntana* to allow the natural native flora to come up, T_8 = Cutting of *Lantana* bushes followed by application of glyphosate 1.0% just before rainy season on about 30 cm regenerated growth of *Lantana* and planting of hybrid napier (*NB-21*) cuttings, T_9 = Cutting of *Lantana* bushes followed by application of glyphosate 1.0% just before rainy season on about 30 cm regenerated growth of *Lantana* and planting of *Setaria sphacelata* cuttings was laid out in a randomized block design in three repeats. For grubbing treatments, *Lantana* bushes were first cut near the ground level and then grubbing of its roots was done. In case of herbicidal treatments, the *Lantana* bushes were first cut just near the ground surface in the month of April, allowed its regrowth to occur up to about 30 cm in height and then herbicide (glyphosate 0.1%) was applied . About 15-20 cm deep holes were made with the help of screw auger at a spacing of 60 x 40 cm and stem cuttings of perennial grasses *viz.*, hybrid napier (*NB-21*) and *Setaria sphacelata* were planted during the rainy season in the treatment plots where grass cover was to be provided to the soil to suppress the further reoccurrence of the *Lantana* bushes. A uniform dose of 40 kg of N/ha was applied to all the treatments as top dressing. Re-planting of grass cuttings was done in the gaps occurred due to mortality of grass cuttings in February. The grasses were allowed to grow and establish till rainy season of 2008 and thereafter they were harvested and recorded. Treatment wise study of fresh above ground biomass of the introduced grasses was carried out to evaluate their establishment and effectiveness in checking the reoccurrence of the *Lantana* bushes about two years after imposition of the treatments. The weight of above ground biomass of *Lantana* bushes per unit area was assessed by weighing total above ground biomass obtained after cutting from a unit area both at the start as well as completion of the study. Fodder estimation per unit area was also done to work out the fodder output of each grass under each treatment. The economics of all the treatments was worked out on the basis of total man days involved for their respective operations as well as costs of the inputs as given in Table 2. The identification of the effective technique for rejuvenation of *Lantana* invaded forest pastures was done on the basis of higher fodder output and grass cover to the soil with relatively less expenditure incurred for the management of this weed. Identification of grasses was done keeping in view their aggressiveness in establishment under the prevailing conditions by suppressing this weed.

RESULTS AND DISCUSSION

Effect on forage yield

The results of the study (Table 1) revealed that both the introduced grasses *i.e.* napier and *Setaria* as well as native regenerated flora differed significantly in their forage yield and hybrid napier recorded highest forage yield ranging from 1.21 to 2.07 t/ha under different treatments

and this was followed by *Setaria* (0.62 to 1.02 t/ha) and natural native flora (1.68 to 2.10 t/ha). It was observed that all the treatments performed better in respect of their forage yields except natural flora under herbicidal treatment. The significant differences in production of different grasses were due to the differences in their respective potential of forage production. Moreover, the probable reasons for higher forage yield of napier and *Setaria* under grubbing and herbicidal treatments might be due to less competitive congenial conditions created under these treatments for the growth and establishment of these introduced grasses. Less forage production from natural native flora can be attributed to its slow growth and establishment as compared to hybrid napier and *Setaria* coupled with non- selective nature of the herbicide used which might have eliminated most of the native flora initially. Sood and Sharma (1993) also reported that the production of different forages was largely governed by their respective production potentials.

Effect on *Lantana* plants

Significant differences in fresh biomass production of *Lantana* bushes were recorded under various strategies adopted for management of this weed at the completion of the study. Treatment T_8 *i.e.* cutting of *Lantana* bushes followed by application of glyphosate 1% on about 30 cm regenerated growth of the weed and planting of hybrid napier thereafter was found to be significantly superior to all the other treatments and lead to almost complete eradication of *Lantana* plants as it recorded quite less biomass (1.12 kg/25 m^2) . Treatment T_1 *i.e.* only cutting of *Lantana* bushes to facilitate the natural native flora to come up and establishment, recorded the highest biomass of *Lantana* (3.22 kg/25 m^2). Highest per cent fresh bio-mass reduction was recorded with herbicide applied treatments ranging from 98.17 to 99.03% followed by grubbing (97.80 to 98.17%) and cutting (66.0 to 75.83%) treatments, irrespective of whether the grasses are introduced or regenerated species of native grasses. A significant reduction to the tune ranging from 67-99% over the initial average values of number of *Lantana* bushes per unit area was also recorded in the treatments where *Lantana* was controlled either by grubbing or by the application of herbicides**.** Better control of *Lantana* under herbicidal treatments can be attributed to the potential efficacy of the applied herbicide in suppressing this weed. Significant superiority of the herbicidal treatments followed by napier planting over *Setaria* and natural native flora, however, shall be ascribed to the fact that napier grass was found to be more aggressive in growth which lead to its early establishment under the Shivalik foot-hill situations. Similar observations with regard to establishment of different grasses were also made by Thakuria and Singh (1990).

Economics

The economic analysis of various treatments as innovative interventions (Table 2) indicated that the herbicidal control was found economically superior than manual grubbing as well as cutting of the wild sage, irrespective of the agrostological interventions in these treatments . However, the application of glyphosate 1.0% on

Table 1. Fresh *Lantana* biomass, per cent biomass reduction, number of *Lantana* bushes, forage yield and cost of management under different *Lantana* management techniques.

Treatment	Fresh biomass kg/25 m^2	% biomass reduction	Number of *Lantana* bushes/25 m^2	Forage yield (t/ha)	Management cost (₹/ha)
T_1= Three *Lantana* cuttings	3.20 (9.50)	66.0	2.971 (8)	0.21	10,500
T_2= T_1 + Hybrid napier planting	2.77 (6.75)	75.8	2.426 (5)	1.25	18,300
T_3= T_1 + *Setaria* planting	2.80 (7.00)	75.0	2.633 (6)	0.62	18,300
T_4= Three grubbing	1.58 (3.50)	94.2	1.715 (2)	0.23	15,010
T_5= T_4 + Hybrid napier planting	1.22 (0.50)	98.2	1.414 (1)	1.81	22,850
T_6= T_4 + *Setaria* planting	1.27 (0.60)	97.8	1.000 (0)	0.98	22,850
T_7= *Lantana* cutting+1% glyphosate on 30 cm regrowth	1.23 (0.50)	98.2	1.414(1)	0.17	7,460
T_8= T_7 + Hybrid Napier planting	1.12 (0.25)	99.0	1.414 (1)	0.21	16,210
T_9 = T_7 + *Setaria* planting	1.31 (0.47)	98.6	1.244 (0.67)	0.10	16,210
LSD (P=0.05)	0.51	9.7	0.61	0.003	-

Data are subject to square root transformation $\sqrt{x+1}$ and original values are given in parenthesis

Initial population of *Lantana* bushes = 6 bushes/25 m^2; Fresh biomass of *Lantana* before imposition of treatments = 28 kg/25 m^2.

Table 2. Details of expenditure incurred on different operations/inputs under various treatments

Treatment	Operations/inputs	Quantity/ha	Unit	Rate (₹/unit)	Cost of operations/ inputs (₹/ha)	Total Expenditure (₹/ha)
T_1	a) Manual cutting of *Lantana* bushes					
	-- I cutting	60	Mandays	70	4,200	
	-- II cutting	50	Mandays	70	3,500	10,500
	-- III cutting	38	Mandays	70	2,660	
	b) Fertilizer urea	40	kg	6.00	240	
T_2	a) Manual cutting of *Lantana* bushes					
	-- I cutting	60	Mandays	70	4,200	
	-- II cutting	45	Man days	70	3,150	
	-- III cutting	28	Mandays	70	1,960	
	b) Planting material cuttings	55,500	Hyb. Napier	0.06	3,330	18,300
	c) Carriage of planting	--	--	--	–	
	d) Planting of hybrid napier cuttings	70	Mandays	70	4,900	
	e) Fertilizer urea	40	kg	6.00	240	
T_3	Similar to T_2 treatment except for planting of *Setaria* instead of hybrid napier					18,300
T_4	a) Grubbing of *Lantana* bushes					
	-- I cutting	110	Mandays	70	7,700	
	-- II cutting	79	Mandays	70	4,830	15,010
	-- III cutting	32	Mandays	70	2,240	
	b) Fertilizer urea	40	kg	6.00	240	
T_5	a) Grubbing of *Lantana* bushes					
	-- I grubbing	110	Mandays	70	7,700	
	-- II grubbing	63	Mandays	70	4,410	
	-- III grubbing	25	Mandays	70	1,750	
	b) Planting material cutting				3,330	22,850
	c) Carriage of planting material	-	-	-	520	
	d) Planting of hybrid napier cuttings	70	Mandays	70	4,900	
	e) Fertilizer Urea	40	kg	6.00	240	
T_6	Similar to T_5 except for planting of *Setaria* instead of hybrid napier					22,850
T_7	a) Manual cutting of *Lantana* bushes	60	Mandays	70	2,600	
	b) Herbicide glyphosate 1.0%	5.2	Litres	500	2,600	
	c) Herbicide application	6	Mandays	70	420	9,560
	d) Fertilizer urea	40	kg	6.00	240	
T_8	a) Manual cutting of *Lantana* bushes	60	Mandays	70	4,200	
	b) Herbicide glyphosate 1.0%	5.2	Litres	500	2,600	
	c) Herbicide application	6	Mandays	70	420	
	d) Planting material cutting	55,500	Napier	0.06	3,330	16,210
	e) Carriage of planting material	--	--	--	520	
	f) Planting of hybrid napier cuttings	70	Mandays	70	4,900	
	g) Fertilizer urea	40	kg	6.00	240	
T_9	Similar to T_8 except for planting of *Setaria* instead of hybrid napier					16,210

Various expenditures incurred during the study were calculated on the prevailing market rates of different inputs

about 30 cm regenerated growth of *Lantana* followed by the planting of either hybrid napier and *Setaria* cuttings were found to be economically better with a net saving of about ₹ 6,640 over all the others similar treatment combinations of grubbings of *Lantana* bushes, respectively. The results are in conformity with the findings of Kumar and Sood (1998). They have also reported relatively differential response of such like treatments with respect to their economics.

The introduction of improved grass species like napier and *Setaria* after herbicidal (glyphosate 1.0%) control of *Lantana* had a pronounced effect on the elimination of this hardy obnoxious weed. The present study thus envisages that the *Lantana* infested forest pasture land pockets can be successfully and economically rejuvenated and converted into highly productive pastures through cutting of *Lantana* followed by application of 1% glyphosate at about its 30 cm regenerated growth and planting either of napier and *Setaria* cuttings.

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