POTENTIAL THREAT OF ALIEN INVASIVE SPECIES: *PARTHENIUM HYSTEROPHORUS* L. TO SUBSISTENCE AGRICULTURE IN ETHIOPIA

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ABSTRACT

Labeled as one of the world's most serious invasive plants, spreading over Australia, Asia, and Africa during the present century, recent unabated expansion of Parthenium hysterophorus (Asteraceae) was described in the western parts of Ethiopia. In a two-year survey, Parthenium hysterophorus has been found to spread vigorously in Ambo of Oromia Region, Ethiopia, mostly along the roadsides. Though literature survey indicated a serious problem of crop fields, range lands and other habitats, evidences from this survey indicate that in the study area it is spreading along the highway and still in the early stage of invasion. Population of this weed is rapidly expanding along the roadsides. Results indicated that there is enough knowledge and awareness among the agriculture workers but farmers and students lack adequate information. Absence of effective control measure in the region was noted and the needs of long term, well planned integrated control activities are suggested.

Key words: ***Parthenium hysterophorus*, alien invasive species, Ethiopia, Africa,**

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INTRODUCTION

Economy of all the developing African countries depends heavily on agriculture for sustaining growth and for reducing poverty. For example, in Ethiopia, agriculture accounts for 50% of GDP, 88% of export value and is a source of employment for more than 85% of the country's population of more than 70 million (Anon, 2007). Moreover, agriculture will remain a major source of economic growth for these countries in future. Agriculture sector in Ethiopia expected to have a growth rate of 8.1% in 2011/12 (African Economic Outlook, 2010). Especially, food security has a primary focus not only in Ethiopia but all over Africa and small farm systems providing food for more than 70% of the global population (World Economic and Social Survey, 2011). For example, most of agricultural producers of Ethiopia are subsistence farmers with small land holdings, the average Ethiopian farmer holds 1.2 hectares of land, with 55.13% holding less than one hectare. Thus, through strengthening these traditional small food production systems with modern knowledge, technology and economic support, the countries like Ethiopia can attain sustainable food production (World Economic and Social Survey, 2011). But these subsistence farmers in Africa are facing problems originating from degradation of natural environment and factors arising from external sources like climate change.Many farms in East and Southern Africa are particularly affected by infestations of invasive alien species like *Parenthenium hysterophorus* (Mcconnachie *et al.* 2010) where weeding often accounting for major labour cost in many rural small-scale farms (Akobundu, 1991).

Parthenium hysterophorus (Asteraceae) is an aggressive colonizing alien species of dry and disturbed land widely demonstrated to affect crop production, animal husbandry, human health and biodiversity (Evans, 1997) and now spreading in more than 20 countries of Africa, Asia and Oceania (Dhileepan and Strathie, 2009). The seeds being very small and light with short wing like structures are known to float in wind or carried easily by various vectors (Navie *et al.*, 1996; Auld *et al.*, 1983). Evidences indicate the long distance seed dispersal by motor vehicles or machinery or water and mud, movement of livestock, animal dung and grain seeds contributed to the spread (Gupta and Sharma, 1977, Frew *et al.*, 1996; Tamado, 2001). One of the biological characteristics contributing to the success of *P. hysterophorus* as an aggressive weed lies on its reproductive ability, four or more successive cohorts of seedlings were known in a single season (Pandey and Dubby, 1989). Under favourable conditions flowering can be initiated within four weeks of seed germination and plants continue to flower for extended periods upto 6-8 months (Jayachandra, 1971; McFadyen 1992) . All these indicate the weed's ability of presenting significant constraint on sustainable development, economic growth, poverty alleviation and food security (GISP, 2004). The recent growth of world trade system has reinforced the trend in the redistribution of IAS in general and *P. hysterophorus* in particular (McNeely, 2001; McNeely *et al.*, 2001; Perrings *et al.*, 2005). With improved road communication, the

opening of new markets and extension of trade has also contributed to the introduction and expansion of new species (Enserink, 1999; Cassey *et al.*, 2004; Semmens *et al.*, 2004).

Parthenium in Africa

Recent surveys detected severe negative impacts of *P. hysterophorus* where subsistence and pastoral agriculture are of crucial importance like countries in Ethiopia, Swaziland and SouthAfrica, the Ethiopian farmers refer to *parenthenium. hysterophorus* as '*klidnole'* (living alone) or '*feremsis*' meaning 'sign off' (and leave your farm), reflecting its economic importance. Even many farmers have been forced to abandon grazing and cultivated land invaded by *P. hysterophorus.* The world famous, Masai Mara ecosystem in Kenya, which hosts the largest wildlife migration known to man, is under attack from this noxious weed from Central America, became a serious concern. If left unchecked it could threaten the continued migration of millions of animals across the plains every year (IUCN, 2010).

Parthenium was first detected in Uganda in 2008 and a follow-up survey carried out in Eastern and Western Uganda in July/August 2010 for the distribution of the weed in Uganda detected this weed in several districts indicating recent spread to new locations (Mcconnachie *et al.;* 2010). In Tanzania, surveys conducted in 2010 along selected road networks found it in Kilimanjaro International airport area, near Arusha airport, and around Arusha town (Mcconnachie *et al.,* 2010). First recorded in South Africa in 1880, in KwaZulu-Natal province (Hilliard, 1977), becoming common and invasive after 1984. Wild and Barbosa (1967) reported the presence of *P. hysterophorus* in Mozambique, but not in Zimbabwe, but since 1982 found spreading relatively slowly around Harare in Zimbabwe (Mcconnachie *et al.,* 2010).

Parthenium in Ethiopia

First noticed in 1980s near food-aid distribution centers in Ethiopia (GISP, 2004), around Dire-Dawa in 1980's (Medehin, 1992; Frew *et al.,* 1996; Tamado, 2001), *P. hysterophorus* has been threatening the natural and agricultural ecosystems in Ethiopia by many authors (Table 1). this weed entered the country during theEthio-Somali war in 1976/77 through military vehicles (Frew *et al.,* 1996). The presence of the weed in Kenya and Somalia (Njorage, 1986) and the capacity of the seed to travel long distance through wind, water, and other means also suggested possible entry into Ethiopia from these neighboring countries.

Now, widely spread in the rangelands and in the cultivable fields of the Jijiga Zone (SERP, 1995; Frew *et al.,* 1996; Tamado and Milberg, 2000, Tamado, 2001), exerting harmful impacts on the composition, diversity and biomass production of the grass species in the range lands of Jijiga, Kebribeyah and Harshin districts of the Jijiga Zone and Somali Regional State of Ethiopia (Ayeles, 2007) and was reported *P. hysterophorus* as the second most frequent weed (54%). It is abundantly found in Gojjam, in south and north Gonder with the potential to spread to agricultural districts of Metama and Setit Humera and established in many districts of South, north, and central Tigray. In Alamata district, about 10,000 hectares of the land has been infested with *P. hysterophorus* (Bezabieh and Araya, 2002). In much of the low lands of Wello, this species has become the most dominant weed, a serious problem in the Regional State of Oromia although there is no actual survey data on the total area of land infested in the region. In the Adami Tulu-Jido Woreda , Central Rift Valley *P. hysterophorus* was found to be the most frequent and dominant species in road sides, grazing land and crop , especially the most abundant in road sides (49.1%). Field survey results showed that all the interviewed farmers were aware of *P. hysterophorus*, its ways of impacts on crops (Gebeyehu 2008), but little control measures adopted. Sorghum grain yield was reduced from 40 to 97% depending on the year and the location (Tamado *et al.,* 2002**),** a strong negative relationship between *P. hysterophorus* coverage and species diversity was noted (Nigatu et al, 2010). Also, high infestation of *P. hysterophorus* in sorghum fields around Kobo and in sorghum, maize and teff fields around Robit, Gobie, Woldiya, and Kombolcha both during the growing period and after harvesting time and in East Shewa (Wolenchitti, Wonji, Methara), also in the Afar region (Awash, Anano, and Miesso), and West and East Hararghe, heavy infestation of the weed was observed both during fallow and cropping seasons. In Hataye, Shewa Robit, Ambo, and Nazareth area, *P. hysterophorus* has been reported to enter crop fields (Taye Tessema, 2002), but from Sirinka to Mersa and Dessie, the weed was present on the narrow strip along the main road for several kilometers, in many Woredas of West Shewa: Shoboka, Tibe, Guder, and Wolliso, only localized infestation of parthenium weed was observed on roadsides and rarely in crop fields (Taye Tessema, 2002). However, it was not found in the fields of economically important crops like maize and wheat, also in the central farmlands of East Shewa: Dukem, Bishoftu, Modjo, and Koka widespread infestation occurs mostly on roadsides, wastelands, towns, villages and gardens. In Ziway, Awassa and Wolkite, the weed was observed only in the town along the road and near dwelling sites indicating its recent introduction into the area. Introduction in these area considered very recent, probably since 1997, for there had been

no *P. hysterophorus* observed in West Shewa region from 1995 – 1996 (Taye Tessema *et al.*, 1998) during which intensive qualitative and quantitative determination of weeds occurring in these areas took place.

The most current survey (Mcconnachie *et al.* 2010) indicated *P. hysterophorus* spreading to Southwestern Ethiopia, but its prevalence and distribution has not been assessed and documented as limited baseline distribution locality data were available from Ethiopia. In East Africa, countries with highly favourable Ecoclimatic Index (EI) for *P. hysterophorus* include Ethiopia, Uganda, Tanzania and Kenya and in fact roadside surveys conducted in 2006 and 2007 revealed a significant increase in the baseline distribution records for *P. hysterophorus* in Ethiopia, South Africa and Swaziland. In Ethiopia, *P. hysterophorus* was found widespread in the north, east and south-western regions surveyed, the extent of distribution being more widespread than previously recorded (Mcconnachie *et al.* 2010). High density of *P. hysterophorus* infestations were mostly observed on roadsides surveys in Ethiopia, South Africa and Swaziland, nearly a third of the localities encountered in Ethiopia were of low and medium density, possibly indicating early stages of invasion at those localities. *P. hysterophorus* was only found at a few localities in north-western Ethiopia, even though the model estimated a wider area with suitable EIs for the weed (Mcconnachie *et al.* 2010). This may indicate that the full extent of the distribution has probably not yet been achieved. Their CLIMEX model indicated additional areas that are highly climatically suitable for *P. hysterophorus* in Ethiopia, in the sub-Saharan region and in southern Africa, which also highlights the potential for future spread of *P. hysterophorus* in sub-Saharan Africa (Mcconnachie *et al.* 2010). However, the study indicated that the need of more field data to further validate the predictions. In Ethiopia, the region south-east and south-west of Dire Dawa (where *P. hysterophorus* was first recorded in the country) is estimated by the CLIMEX model to be most eco-climatically suitable for *P. hysterophorus*) (Mcconnachie *et al.* 2010). Moreover, roadside surveys are by no means provide a comprehensive assessment of distribution of a species. Many African countries do not have accessible road networks. Due to the lack of information on the distribution of *P. hysterophorus* in Western Ethiopia, the current survey was undertaken to facilitate improved knowledge and to provide a baseline to monitor spread of the weed and to provide site-specific information for control measures.

MATERIALS AND METHODS

The study site, Ambo ($37^0$48’59” to $37^0$54’15”E and $8^0$57’54” to $8^0$59’39”N), situated in the Oromia Regional State of Ethiopia, is a small city in western high land part of Ethiopia, 112 km from Addis Ababa (Fig 1). Altitude of the area ranges from 2060-2204 masl, with total annual rainfall ranging from 800 mm-1000 mm. The natural vegetation in the area has been much reduced, subsistence agriculture dominated by wheat, sorghum and teff, Most smallholder farms are located in the moisture reliable cereal-based highlands, which accounts for 59 percent of all farm area (Taffesse et al; 2010).

During September, 2010, road side verges of two km long, along both sides of the Addis Ababa – Ambo Highway, on the Eastern and Western ends of the city (2 km from City Center) were sampled for *P. hysterophorus* (Fig 1). At each city end along the roadsides, ten transects of 100 x 1m area were sampled at 50 m intervals, number of *P. hysterophorus* plants were counted on both the sides (north and south). In September 2011, the same transects used in 2010 were visually located and again counted for the weed. In addition, during 2011, sampling was done at 5 km distance on both the East and West side of the city, again on both north and south side verges, an area of 100x4 m were sampled for *P. hysterophorus* (Fig 1). Local farms (both east and west end 5 km off the city, were visited for observation and sampling, farmers were shown the live sample plants and asked for information regarding *P. hysterophorus*, local Agriculture Office and Agriculture Research Center were visited and information was collected from the officers/researchers.

RESULTS AND DISCUSSION

The survey established the presence of *P. hysterophorus* along the road sides of Ambo, city, the number of individuals increased more than tenfold from 2010 to 2011 in the observed transects (Table 1), the differences being highly significant for data collected for both sides of the road (Wilcoxon Rank Sum Test , $P = 0.001$). It was observed that the distribution of plants along the verges was highly heterogeneous, from no plants in some transects to more than several thousand per transect, this was found in both the years (Table1). These observations suggesting rapid increase in population size and that the species is in the invasion stage because the main roadside verges had more plants (average 435.5 per transect) than the side roads (mean 148.5 per transect) in 2011. This observation of presence of the weed only along roads, others also indicated the species coming through road transport, also reported a common roadside weed in the highlands (>1900 m) of the Eastern Ethiopia (Tamado and Milberg, 2000). Another interesting point emerging from the data (Fig 2) was the presence of more individuals of *P. hysterophorus* in the South side than in the North side of the road. This was true for both 2010 and 2011.

In the near end and far area from the City also show more plant along the South side than north side (Table 1). When Wilcoxon Rank Sum Test was made, the differences between plant numbers observed in the South and North sides of the Highway was significant for 2010 data (P> 0.01), 2011 data (P>0.05). This difference may be due to the wind direction, predominant wind direction from northeast prevails for most of the year so that the seeds carried by vehicles may be lodged to the southern side more than north side. The number of *P. hysterophorus* in transects sampled from the roadsides near (1 km) and far end (4 km) of City were different (Table 1). More plants were found near the city than far from the city, the difference highly significant (P>0.01 in the Rank Test). This also indicates the vehicles as carrier, they stop near the city center more and for longer periods. Visits to the crop fields (teff, wheat, pulse) and fallow lands around Ambo city (5/6 Km distances) by the authors indicated absence of *P. hysterophorus*. Further survey indicated the plant also occurring in the town of Holeta, about 100 km east of Ambo on roadsides growing only at irregular intervals.

It was noted that the city of Ambo is expanding fast and the areas with high infestation of *P. hysterophorus* were observed near these constructions sites, which probably enabled the weed to spread and establish rapidly. As reported recently (Mcconnachie *et al.* 2010) the rate and extent of spread of *P. hysterophorus* since introduction has been more noticeable in countries like Ethiopia and Swaziland than Kenya, South Africa and Zimbabwe, despite ecoclimatically suitable areas within the latter countries. This disparity has been ascribed to higher levels of land use related disturbances in Ethiopia and Swaziland. Processes such as overgrazing, agricultural expansion, and increased fuel wood extraction have certainly affected the vegetation of the region, with well-documented cases of local degradation reported (Mabbutt and Floret 1980; Lambin and Ehrlich 1997; Lindqvist and Tengberg 1993). It is very likely that the loss of vegetation cover and land use changes are likely to continue, driven by a rapidly growing population and development activities, also any prolonged droughts in the coming years with global climate change may trigger further deforestation, agricultural expansion and modifications in pastoral land use, thus contributing to rapid expansion of weeds like *P. hysterophorus.* Thus, agriculture in many countries in the tropics and sub-tropics currently facing extraordinary ecological challenges posed by the invasive species likely to be intensified in near future (Dukes and Mooney, 1999).

The survey of the stakeholders (Table 2) indicated that the personnel associated with agriculture are fully informed about the weed and have training/research experience. Some of them reported that the weed is reported in the crop fields by extension workers. However, there is apparent lack of activity to undertake control measures from any sources so far. Generally, the local farmers were found not to be aware about the potential threats originating from *P. hysterophorus,* only a few had heard about the weed from agriculture officers during a control campaign five/six years ago. This is contrary to other surveys done in the highly infested areas of Ethiopia, where the farmers were fully aware of the potential threat (Gebeyehu 2008). Among the university students from biology department (N=13) about half had knowledge about *P. hysterophorus,* but the local secondary school students had no idea at all. A complete understanding and awareness about environmental problem is necessary to achieve environmental protection and the stakeholders must be committed "to initiate action, based upon knowledge and understanding" (Madsen, 1996).

The extensive survey of published literature in this paper indicated a fairly wide research data and information available on this weed in Africa in general and specifically for Ethiopia. It is now more important that effective control measures be undertaken. There were some isolated programmes aimed at creating awareness and controlling the weed, for example, the GoE-UNEP/GEF project "Removing Barriers to Invasive Plants Management in Africa (RBIPMA)" organizing parthenium field day on October 19, 2008 at Welenchitti, Boset Woreda [http://www.eiar.gov.et/ias-news/76] or the Virginia State University implementing a USAID

IPM-CRSP "Management of the Invasive Plant, Parthenium in Eastern and Southern Africa**,**" 2005-2009 (http://www.vsu.edu/pages/5039.asp).

The results of this distribution survey added to the knowledge of current distribution of *P. hysterophorus* in the Western Ethiopian Highlands. The information that the weed is spreading rapidly indicates the urgency of control measures. The study also indicates the need of a baseline from which monitoring be done on the spread and abundance of *P. hysterophorus* in the future. Moreover, site-specific information is essential for the selection of appropriate management options and integrated control programmes. It is hoped that all the stakeholders including the government departments will undertake long term and appropriate activities with the participation of the local community to control *P. hysterophorus* before the problem becomes difficult to manage.

As mentioned above, this noxious weed has now been spreading in more than 20 countries of Africa, Asia and Oceania (Dhileepan and Strathie, 2009), for example, it has achieved major weed status in Pakistan during the last

15-20 years, rapidly spreading in rain fed districts of northern Punjab and other parts (Javaid et al, 2006; 2007; Javaid and Anjum, 2005, 2006). Also India, Bangladesh and other Asian countries have very similar problems with this invasive species. Few farmers and members of community are aware of the adverse effects of *Parthenium hysterophorus* on the productivity of crop plants, grazing animals and on ecosystem and biodiversity , also the rural people know little about the management and control of the weed (Kapoor, R.T, 2012, Gnanavel, 2013; Zuberi and Akter 2007; Akter and Zuberi. 2009; Salma Hossain and Zuberi, 2011). Thus, there is an urgent need of research, communication, awareness creation and programmes for management and control of the invasive weed.

CONCLUSION AND RECOMMENDATION

The results indicated that *P. hysterophorus* is spreading rapidly in the Highlands of Ethiopia. There is a need of a baseline data for monitoring on the spread and abundance and for the selection of appropriate management options and integrated control measures. All the stakeholders including the government departments, researchers and the local community should undertake long term and appropriate activities for the successful control of *P. hysterophorus*.

Table 1 ***Distribution of Parthenium hysterophorus along the roadside verges (Addis Ababa- Ambo Highway) in Ambo, Ethiopia in 2010 and 2011***

Distribution of Parthenium in 100x(1-4)m Transects along the roadside verges in Ambo										
	Location		Sides of Road	Number of transects with plants					Mean plants	Total number
Years	Road	Distance(Km)from city		Absent (0)	1-10	11-50	51-100	above	per transect	of transects
	Main		North	6	8	5	1	0	12.75	20
2010	Road	2	South	4	2	8	2	4	76.45	20
	Main		North	1	6	4	2	7	156.1	20
2011	Road	2	South	1	1	4	0	14	714.9	20
	Side									
2011	Roads	1 to 3	both	1	9	4	1	5	148.5	20
	Main	4km,East 100x4	North	5	4	0	0	1	41.8	10
2011	Road	m Transect	South	5	2	2	0	1	143.9	10
		4Km West	North	7	4	2	0	2	46.6	15
	Main	100x4 m								
2011	Road	Transect	South	8	1	3	1	2	86.27	15

Table 3. Level of information about *P.hysterophorus* and control activities among different stakeholders in Ambo

Information on *P.hysterophorus* among stakeholders						Control action		Control activity
Subjects	N	Nil	Know as alien	Know as harmful	Know as AIS	Nil	Once	Integrated/biocontrol
Agriculture officers	4	--	1	1	2	3	1	--
Research Institute personnel	3	--	1	--	2	2	1	--
Farmers-- East end	17	11	6	--	--	12	5	--
Farmers-- West end	9	6	3	--	--	9	--	--
University students	13	6	--	3	4	13	--	--
Secondary School students	15	12	3	--	--	--	--	--

*Numbers are individuals responding

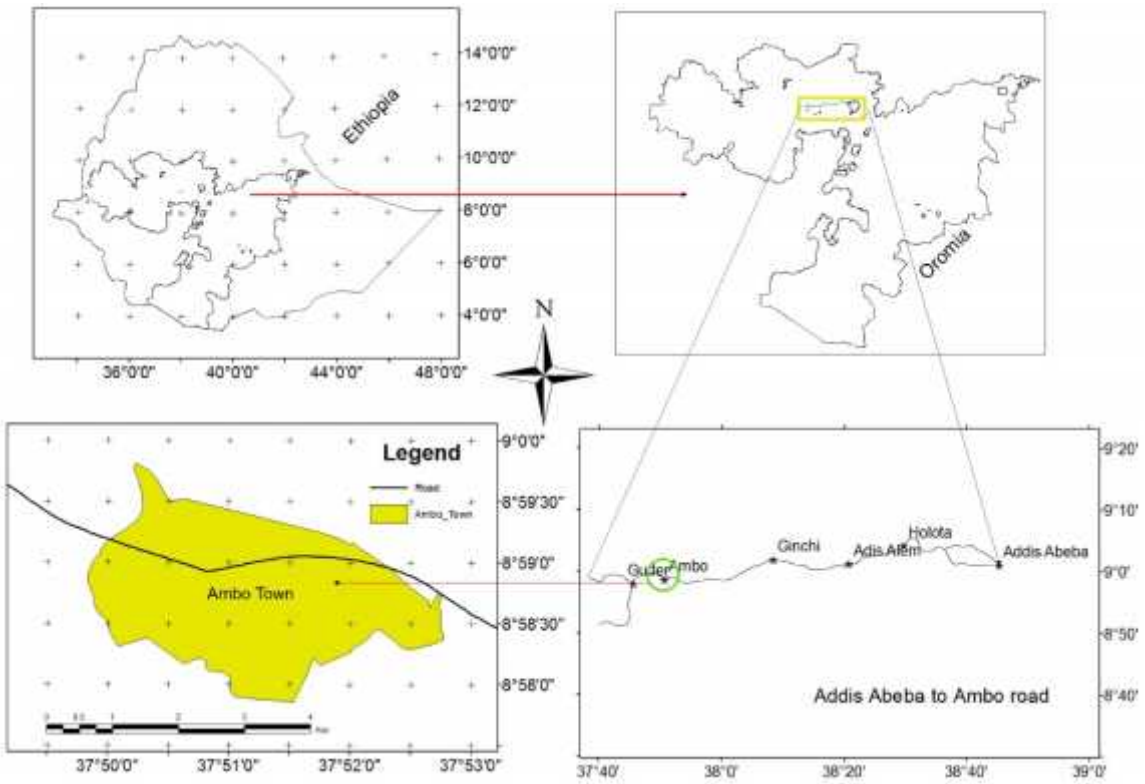

Fig. 1. Map showing Location of the study area for the presence of *Parthenium hysterophorus*

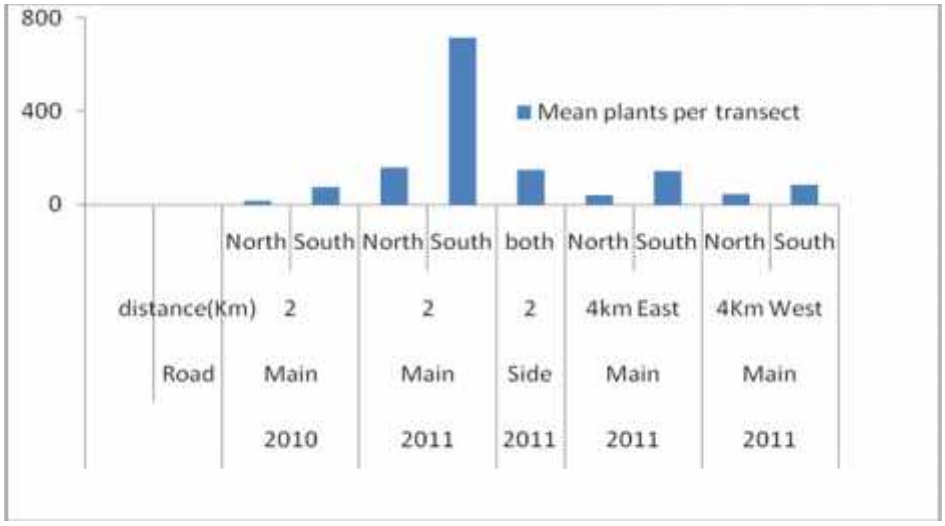

Fig. 2. Presence of plants (*Parthenium hysterophorus*) along the North and South sides of the Highway

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