academicJournals

Vol. 6(5), pp. 116-124, May, 2015
DOI 10.5897/JSSEM12.015
Articles Number: FC2A08952496
ISSN 1996-0816

http://www.academicjournals.org/JSSEM

Journal of Soil Science and Environmental Management

Full Length Research Paper

Impact of *Parthenium hysterophorus* L. (Asteraceae) on soil chemical properties and its distribution in a reserve area: A case study in Awash National Park (ANP), Ethiopia

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Received 23 February, 2012; Accepted 19 February, 2015

The study was conducted in Awash National Park (ANP), East Shewa Zone of Oromia National Regional Sate, Ethiopia, and aimed at determining the impact of parthenium weed (*Parthenium hysterophorus* L.) on soil chemical properties and assessing the current distribution of the weed in the Park. A transect belt of 13.5×0.10 km of parthenium weed infested land was identified. Four quadrats were purposively laid every 250 m interval two for infested and two for non-infested each from both sides of the road where the weed highly and uniformly distributed. A total of 216 soil samples were collected from the top 10 cm. Most of the soil parameters considered in this study were found to be better for the infested quadrats than non-infested quadrats, suggesting that parthenium weed does not impose adverse impact on soil nutrients. The distribution of the weed following the highway indicated that vehicular transportation could be the major way of dispersal in ANP. The control strategy should, thus, focus mainly on these factors without undermining the contribution of livestock and overgrazing.

Key words: Fentale Mountain, invasive alien species, sugar cane plantation.

INTRODUCTION

Parthenium weed (*Parthenium hysterophorus* L.) is an exotic species native to tropical America, but by now it is found highly spread in several African countries (Kenya, Ethiopia, Somalia, Mozambique, South Africa, Swaziland and Zimbabwe) (McFadyen and Cruttwell, 1992; Adkins et al., 1996; Towers et al., 1977; Rezene, 2005). The species was introduced to Ethiopia through an unclear rout; however, there exist different speculations, of which most weight was given an introduction through the Djibouti-Dire Dawa railway line, the Dire Dawa airport, and army vehicles from Somalia during the Somalian-Ethiopian war of 1976-1977 (Tadele, 2002).

Parthenium weed puts reserve areas like the Awash National Park and Yangudi Rasa National Park under risk due to the aggressive spread of the weed in the parks (EARO, 2002). Although the weed has reached almost

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every spot of the Ethiopia by this time, still some people have the tendency to say parthenium weed is a typical weed of road sides and degraded areas only basing the frequent appearance of the weed following highways and disturbed lands.

There are various hypothesis regarding the most suitable soil type for the growth of parthenium weed. Mahadevappa et al. (2001) stated that it grows on almost all soils and the growth is luxuriant on black soils compared to laterite soils. Others state that alkaline to neutral clay soils (Dale, 1981) or sandy to heavy clay (ARMCA, 2000) are preferred by parthenium. Lakshmi and Srinivas (2007) stated that it can grow on all soil types except near the seashore as the saline soil is not conducive to parthenium weed flowering. ARMCA (2000) reported that the growth of the plant was reduced on acidic soils. In summary, parthenium may grow on every soil category with a slight variation in its growth on those soils that are considered harsh for other vegetation types.

Awash National Park is one of the most prominent national parks in Ethiopia. A number of wild animals inhabit the park. It is already under risk of parthenium because of the aggressive expansion of the invasive alien species in the park. To prevent adverse effects of invasive alien species, identification of their distribution strategy is mandatory. The specific mechanisms of distribution of parthenium weed in the Awash National Park are not yet identified. However, assessing the distribution strategy of the weed and deducing an appropriate control strategy is an issue that needs attention to tackle the problem. Therefore, this study investigated the current status of invasion of parthenium in the ANP and identified possible major mechanisms of distribution within the park.

Although several researchers have expressed their worry about the adverse effects of parthenium weed on soil nutrients (Kanchan and Jayachandra, 1981; Bhowmik and Doll, 1984; Alam et al., 2001), yet there is little effort made to quantify the impact of parthenium weed on soil physico-chemical properties. Therefore, this study investigated the impact of parthenium weed on soil fertility indicators.

MATERIALS AND METHODS

Study area description

The study was carried out at Awash National Park, 225 km south-east of Addis Ababa at 39° 48' - 40° 10' E and 8° 50' - 9° 10' N (Figure 2). ANP lies to the either side of the main Addis Ababa-Asab/Dire Dawa highway between the towns of Metehara and Awash Station. Fentalle Mountain, a semi-dormant volcano rising to 2,007 m a.s.l., dominates the northern half of the Park. Its altitude ranges from 705 to 2007 m a. s .l. Awash National Park is one of the most geologically active regions of the world (Birdlife International, 2008). Grassland, savana and shrub land dominate the park. Grasslands are found within the crater and on the slopes of Fantalle Mountain as well as on the surrounding plains. Much of the grassland in the northern and western part of the park is overgrazed, resulting in up to 50% bare soil and rock and the domination of invasive, unpalatable plant species (Birdlife International, 2008). Awash National Park is located in semi-arid mid rift valley of Ethopia. The rainfall of the area is unpredictable. The remarkable amount of average monthly rain obtained in March puts the area in the area experiencing bimodal rainfall (Figure 1). The area receives a mean maximum monthly rainfall of less than 130 mm, and a mean annual rainfall of 482 mm. When the rainfall trend has been analyzed from the data obtained from Ethiopia Metreology Agency (EMA) and data used by Abule Ebro (2003) on the same area showed that the area faces 1-2 times critical drought in a decade. Ten year temperature data (1997-2006) collected from EMA has shown that the area experiences a mean maximum temperature of 33.8°C and a mean minimum temperature of 18.1°C. The mean minimum temperature goes in line with the maximum temperature throughout the year.

Assessment of parthenium weeds distribution in ANP

Distribution of the weed in the park area was assessed with the help of the park scouts and experts. Known and suspected areas for the availability of parthenium weed were visited together with the Park's expert. Whenever parthenium weed was observed (either in patches or individually), a location reading (longitude and latitude) of the points was recorded using GPS. The points were over laid on the map using GIS tools.

Soil sampling method

A reconnaissance survey was carried out in September 13, 2008 to see the pattern of parthenium weed distribution and to design an appropriate sampling method. Based on the uniform distribution of the weed along the highway run East-west a total length of 100 × 13.5 km was considered on both sides of the road. A systematic sampling was used. The sampling plots were arranged on the transect line on both sides of the road. A sampling point was laid in an interval of 250 m. At each point two samples were taken; one from infested (IN) and one from non-infested (NI) areas and, thus, a total of 216 samples were considered. Soil samples were collected from the top 10 cm by using augur. Considering the chemical analysis, cost composite of soil sample was prepared by classifying the quadrats in to four altitudinal ranges (973 - 992, 993 - 1014, 1015 - 1034 and 1035 - 1048 m asl.).

Abundance (U) and dominance (D) of each category (infested and non-infested) was determined as of MacIntosh (1967) diversity indexs:

$$U = \sqrt{\sum_{i=1}^{s} ni^2}$$

and

$$D = \frac{N - U}{N - \sqrt{N}}$$

Where: U = MacIntosh diversity index; S = the number of species; n = number of the individuals or abundance of the i^{th} species in the quadrat, and N = ∑ni

Soil chemical analysis

Sixteen composite soil samples were taken to Ziway Soil Testing

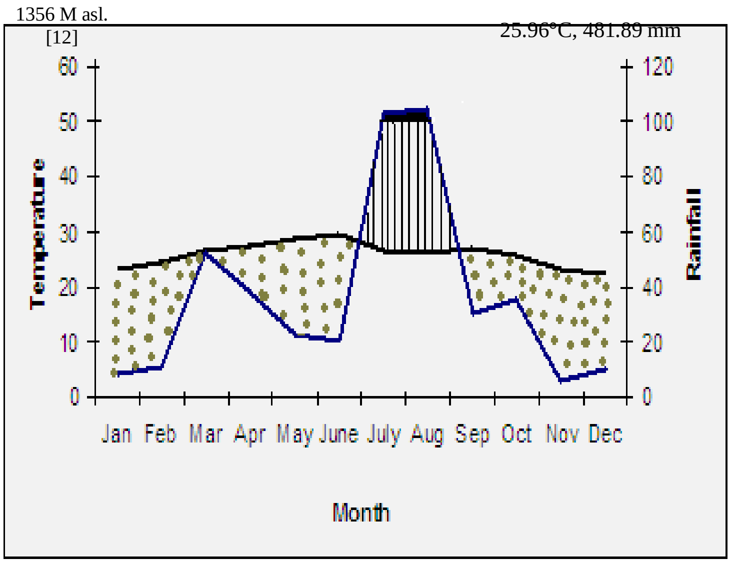

Figure 1. Climate diagram of the study area ANP (1997-2008).

Laboratory Center. The samples were dried, sieved and made to pass a 2 mm sieve following FAO guidelines (FAO, 1990). Soil moisture content was determined by oven drying. The pH of the soil was determined in water suspension with a soil to water ratio of 1:2.5 and the same procedure was used for electrical conductivity (EC) of the soil samples (van Reeuwijk, 1992). Percent organic carbon (%OC) was determined by Walkley-Black Method (Olsen et al., 1954). Percent of total nitrogen (%tN) was determined by Kjeldhal Method (van Reeuwijk, 1992). Available phosphorus (Av. P) was determined by extraction with sodium bicarbonate (Olsen et al., 1954). Exchangeable bases (Na, K, Mg, and Ca) were determined by ammonium acetate sand percolation method and cation exchange capacity (CEC) was tested by ammonium distillation method (van Reeuwijk, 1992). Data of each category was compared by a t-test for every parameter.

RESULTS

Parthenium weed distribution in ANP

A wider distribution of parthenium weed was observed in the southern side of the park following the highway, internal vehicle roads, footpaths, livestock/wildlife passages, drainage canals, and flood plains. High populations of the weed were observed along the highway from Addis Ababa to Djibouti. This may be due to vehicles and other related have probably enhanced dispersal of the weed. Densely populated parthenium weed areas were also observed along the vehicle road disjunction from the main road to the museum, on the sediments of Awash River bank, and along the livestock paths from the center of the park to the direction of Metahara Irrigated Sugar Cane Plantation. A spot of parthenium was also observed on the vehicle roads from the main office to the Ras Hotel and from the Hotel to the main road and to the northern side to around Filuwuha (Hot spring) (Figure 2).

Pastoralized grazing lands and cultivated lands around the park have been highly infested (Plate 1D). Disturbed roadsides, flood plains (Plate 1F), termite mounds (Plate 1B), water logged sites (Plate 1E), drainage canals (Plate 1C and 1G) and tree shades (Plate 1A) were found to be the main sites of parthenium weed infestation that could serve as seed bank for further distribution of the weed. Furthermore, it was observed that parthenium weed has gone deep into the grazing lands following the foot print of livestock (Plate 1H) providing clear evidence for the severity of the weeds further expansion.

Impact of parthenium weed on soil chemical properties

Species abundance was decreases with increasing parthenium density in the quadrat in opposite to species dominance (Table 2; Appendix 2). The species abundance of the infested and non-infested quadrats was increasing with altitude, while the parthenium weed component of the infested quadrats slightly declined with altitude. As the altitude increases the ground cover of infested quadrats started to decline below the non-infested quadrats (Figure 3). This could be due to the decline in parthenium weed component of the infested quadrats as the competitive potential of the other species increases. The t-test mean comparison result showed no significant differences ($P > 0.05$) between the means of the parameter of infested and non-infested sites (Table 1; Appendix 1).

Although the differences were not statisticaly significant the mean values of soil chemical analysis results were higher for the infested samples for most of the soil fertility parameters considered in this study. The influence of the

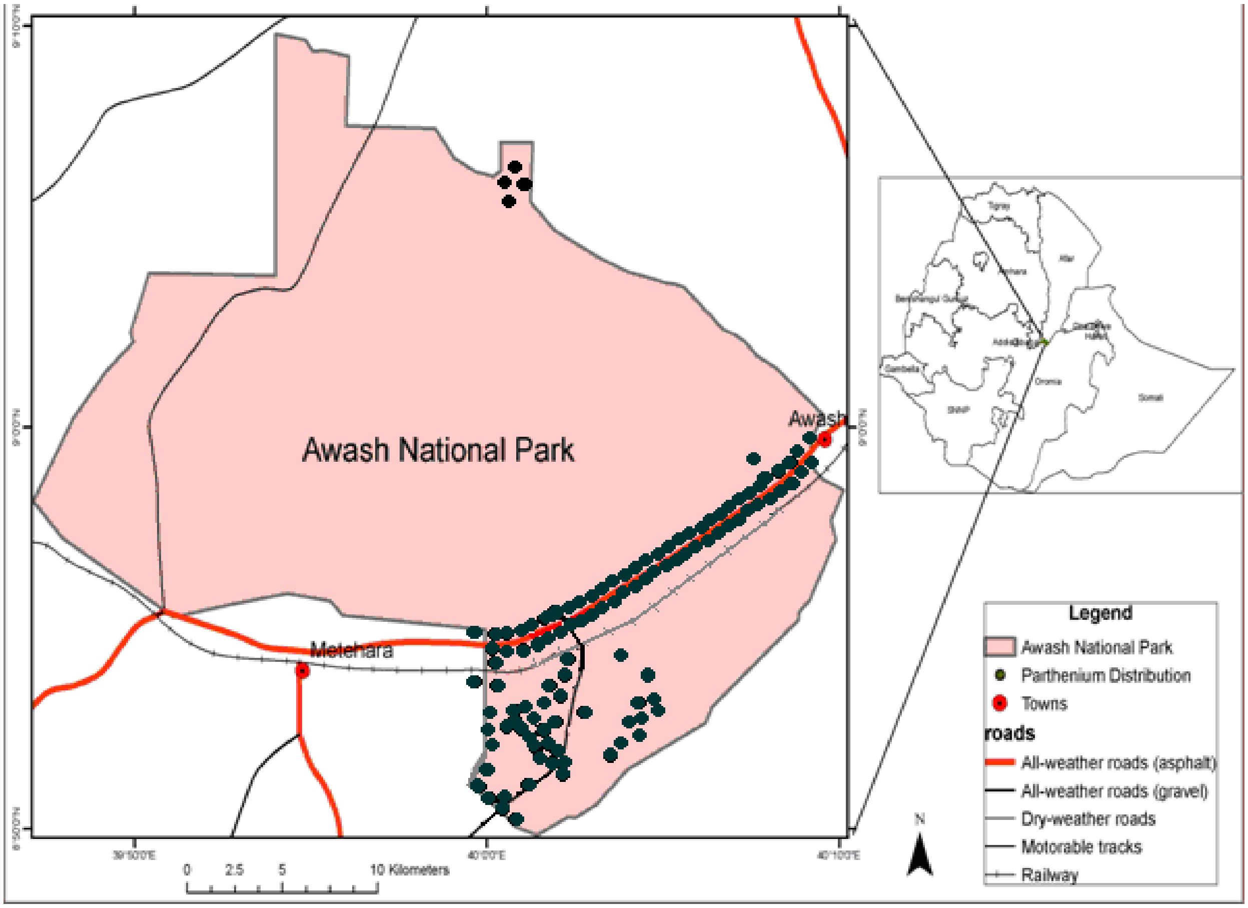

Figure 2. Current distribution statuses of parthenium weed in ANP.

weed is primarily seen in exchangeable calcium, soil moisture content, exchangeable potassium, exchangeable sodium and percent organic carbon (Figure 4).

DISCUSSION

Parthenium weed introduction and distribution in ANP

Parthenium weed has been distributed and become a prominent weed around and in ANP within a short period of time. Abule (2003), made intensive investigations in middle Awash range lands including ANP and discussed a lot about the threats of range land herbaceous and woody vegetation but did not mention parthenium weed. This indicates that parthenium weed was not present and/or was not of concern before 2003 around ANP. The current invasion situation is in line with what was predicted by Wittenberg and Cock (2001), that the Awash National Park and the Yangudi Rasa National Park are at high risk, as the weed spreads in a series of small to large jumps with the accidental assistance of human activity. At the moment, the parthenium weed is found distributed in some parts of the Awash National Park (Figure 2). The existence of parthenium weed following the main road (highway) and roads connecting the parks structures supports what was suggested by Wittenberg and Cock (2001). In the same manner the regular disturbance of the area around the highway and other roads for the purpose of road construction and the transportation of soil and other construction materials from other infested areas attributed for the large population of the weed following the roads.

Bryson (2000) stated that, Parthenium weed is a rather weak competitor compared to other native and non-native plant species. Raghubanshi et al. (2005) also stressed that parthenium weed is an invasive species that aggressively colonizes degraded areas with poor ground cover and exposed soil such as fallow wastelands, roadsides and overgrazed pastures. In support of this, parthenium weed infestation was not a problem in ANP where there was no and/or limited disturbances and dense pastures. Very sparsely distributed parthenium weed was found following the railway. This shows that

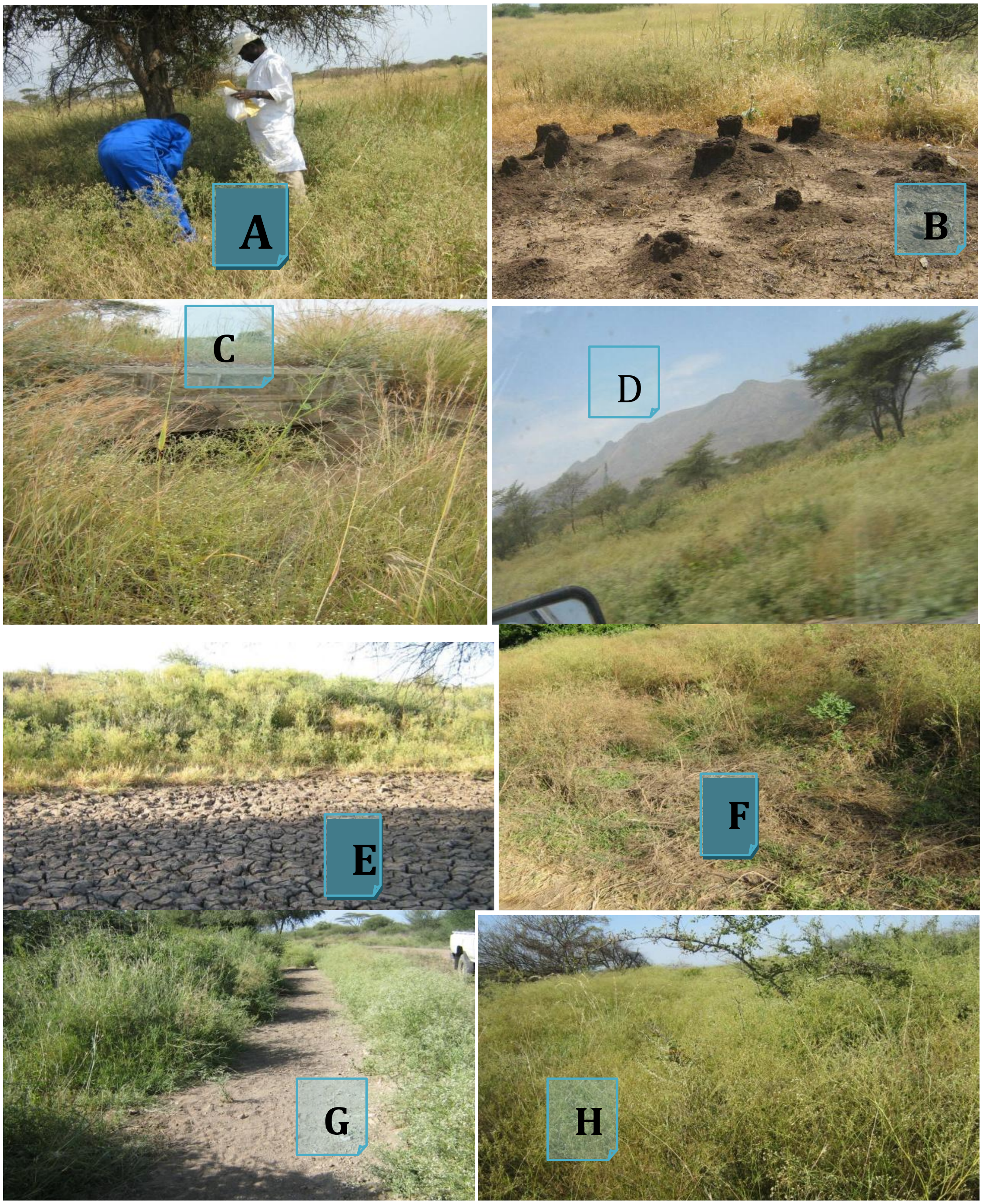

Plate 1. Representative sites identified as source for parthenium weed distribution serving as primary seed source for further invasion in ANP. A=tree shade, B=termite mound, C&G=drainage canals, D=poorly managed arable lands, E=edges of water logged area, F=accumulated sediment area (edge of Awash River), H=Livestock passages.

railway transportation plays an insignificant role in parthenium weed seed dispersal when compared to vehicular transportation. This could be due to a limited contact of railways with parthenium plants, soil and the soil seed bank.

Similar to ARMCA (2000) we observed the weed to intensly inhabitate the edge of Awash River indicating that the invasion rate in the park is influenced by the upstream existing weed status. The Awash River passes through irrigated sugar cane plantations and other

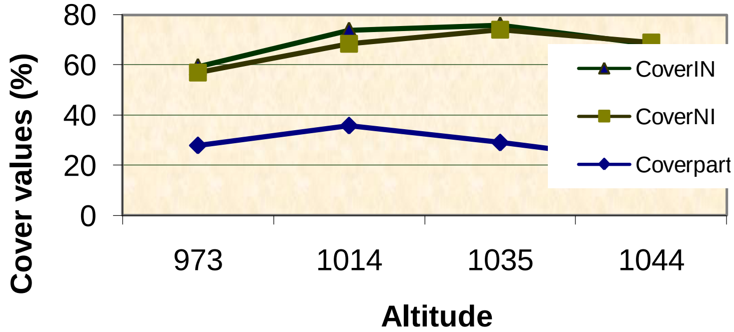

Figure 3. Average plant stand cover (percent) of infested (IN) and non-infested (NI) sample sites and contribution of Parthenium weed to ground cover (coverpart) in relation to altitude.

Table 1. T-test values for comparison of the infested (IN) and non-infested (NI) soil fertility parameters.

	pH H_2O (1:2.5)	EC (mmhos/cm)	%OM	%tN	Av.P (ppm)	Exchangeable Base (meq/100 g soil)				CEC (meq/100 g soil)	%Moisture
						Na	K	Mg	Ca		
d (IN-NI)	-1.63	0.27	2.28	0.05	5.89	4.97	3.69	9.09	11.05	-6.37	2.85
d^2	3.75	0.04	3.13	0.04	15.46	10.26	4.4	161.9	51.19	323.9	10.77
t calculated	0.825	1.862	1.365	0.232	1.652	1.736	2.1	0.691	1.724	0.334	0.854
t at df=7 and α = 0.05						2.365					
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*d = difference; d^2 = difference square; IN = infested; NI = non-infested; NS = statistically not significant.

Table 2. Abundance and Dominance of infested (IN), non-infested (NI) and infested non-parthenium components (INNP) quadrats.

S/No.	Categories	Abundance value	Dominance (D)
1	IN	59369	0.4984
2	NI	53665	0.5533
3	INNP	36877	0.6709
4	Parthenium weed	22492	
5	Lesser scores	31569	

upstream irrigated crop farms. Yirefu and Tamado (2006) confirmed that the Metahara Irrigated Sugar Cane Plantation has been highly infested with parthenium weed by the weed survey made in 2004. Because of that, any physical agent including flooding, which links the farm with the park contributes to the spread of the weed into the park. This is why parthenium weed was found highly populated in the parts of the park bordered with the farms.

Parthenium weed was found to be vigour in the arable and pastoral grazing lands, as a result of that the competition of other herbaceous vegetation lessens because of cultivation and grazing. Valuable species in the infested area which were essential for grazing animals have already disappeared due to the continued increase of parthenium weed and livestock selection pressure. Some preferred grass species have shown signs of serious decline in terms of biomass production and area coverage (Appendix 2).

The frequent grazing of those non-parthenium weed herbaceous plants by livestock should limits their capacity to compete with parthenium weed for below and above ground resources. In addition, the trampling of land during overgrazing facilitates favorable conditions for parthenium weed invasion. High grazing pressure caused by high stock number or the prevailing drought may lead to a decrease in vigor and competitiveness of the pasture thereby allowing the entry and spread of parthenium weed (Mountmorgan, 2006 cited by Sheshie , 2007). This helps parthenium weed to successfully dominate the area within a short period of time. Movement of cattle during rainy season will aid in spreading the seeds in muddy soils (AFPISN, 2007).

Kanchan (1978) noted that parthenium weed is shade sensitive and rarely grows under shade. In this study, however, densely populated parthenium weed was observed frequently under the shade of *Acacia tortilis* and *A. albida* around the highway and under the shade of big river bank *Ficus* species. The present observation is in agreement with what was reported by Shabbir and Bajwa (2006).

The availability of parthenium weed following livestock passages indicated that the distribution of parthenium weed from the primary source (road sides and drainage canals) to the main grazing field has been facilitated by the livestock. The interference of livestock from the surrounding infested pastoral areas into the park aggravates the infestation rate and makes the control measures difficult. Livestock facilitate the spread of parthenium weed by moving seeds through their hoof and dropping in the grazing land while trampling and disturbing the land surface and by suppressing the competent grasses through grazing. In particular, flooding after drought is advantageous for the weed, as flood is one of the main agents of parthenium weed seed dispersal (ARMCA, 2000).

Impact of parthenium weed on soil chemical properties

The intention of this study was not to evaluate the chemical property of the soil but the variability that takes place due to the invasion of parthenium weed for the prevailing soil properties. Almost all the parameters considered in this study (except Mg^{2+}) were found to be better for the infested quadrats than the non-infested quadrats. This could be due to the fact that parthenium weed has no natural enemies in newly invaded countries and even cattle do not feed on it (Mahadevappa et al., 2001). All of its biomass can, thus, returned to the soil and decompose. This should result in an increae of soil organic matter (OM) under infested quadrats compared to non-infested quadrats. Furthermore, this should increase other soil nutrients influenced by the soil OM level. The release/retention of organic phosphorus is somewhat controlled by the quantity and variety of microorganisms present and the type of OM which is added (Winegardner, 1996). Parthenium weed can extract nutrients even from nutrient deficient soils resulting in high tissue levels of nitrogen (3%), phosphorus (2%), potassium (4.3) and other macro and micro-nutrients and recommending it as green manure for field crops (Javaid et al., 2007). Efficient extraction of nutrients from deficient soils in addition to its allelopathic effect could be two of the potentials of parthenium weed to combat other species in its vicinity. Through its effect on the physical condition of soils, OM also increases the amount of water available for plant growth (Brady, 1984). Electrical conductivity (EC) of soil is directly affected by the soils water contents, texture and proportion of soluble salts. When the texture and soluble salt contents are constant, then the moisture content can be determined by changes in EC (Winegardner, 1996). Similarly, in this study the variation in percent moisture content of the soil and the EC showed an increase with infestation.

The relation of cation exchange capacity (CEC), pH and OM in this study was as already discussed by a number of researchers. CEC is affected quite dramatically by pH changes. It is clear that soils rich in OM have a high CEC. Fine textured soils are usually rich in OM and hence their CEC values are often high (Olaitan and Lombin, 1984).

Some farmers in the study area boldly noted that parthenium weed helped to improve the fertility of their field (personal communication). Javaid et al. (2007) reported that 4% parthenium treatment gave maize biomass production equivalent to that of recommended NPK fertilizers, however, the effect of parthenium weed green manure on growth, nodulation and yield of a leguminous crop *Vigna radiata* (L.) Wilczek did not prove beneficial. That could be the reason why the percent total nitrogen (%tN) of the infested quadrats failed to show a clear difference from that of non-infested quadrats (Figure 4).

CONCLUSIONS AND RECOMMENDATION

The existence of parthenium weed strongly and uniformly following the highway shows that the introduction of the weed to ANP and its distribution within is predominantly through vehicular transportation. The existence of weed monocultures on land disturbed during road construction leads to the conclusion that land disturbance aggravates the invasion of the weed. Parthenium weed was observed very sparsely on well drained and sloppy areas, while water logged and sediment areas were highly infested. This indicates that parthenium weed seeds are easily transported by water showing that water is one of the major local and regional dispersal agents for the weed. The appearance of patches of the weed along livestock pathways indicates that livestock also contributed to the dispersal of parthenium weed in ANP.

The soil fertility parameters considered showed a tendency of improvement because of parthenium weed infestation. This shows that the adverse impact of parthenium weed on plants in its vicinity through competition of soil nutrients is not a predominant problem. This leads to the conclusion that parthenium weed suppresses the growth of plants in vicinity either through allelochemicals released or by making the soil

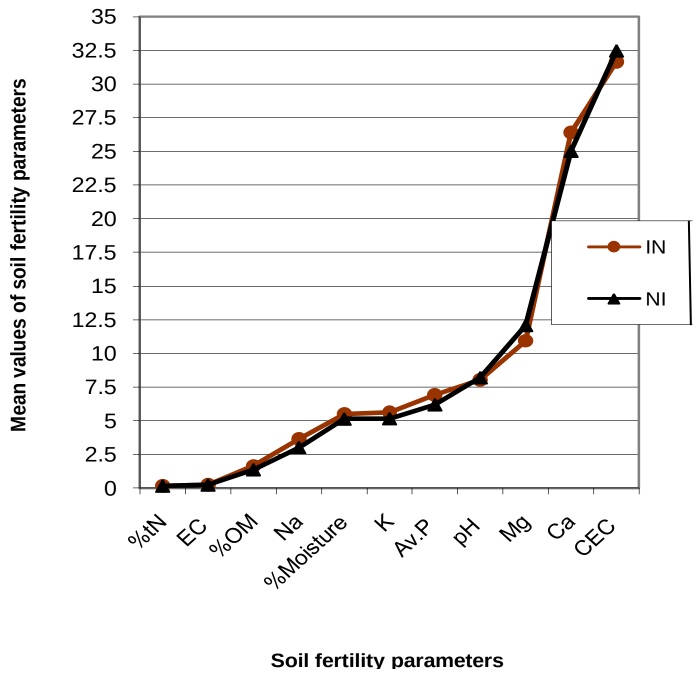

Figure 4. Comparison of mean soil fertility parameter values for infested (IN) and non-infested (NI) soil samples.

out of the suitable range for the growth of the other plant species.

Parthenium weed establishes monocultures on bare grounds and gradually weakens even the survival of drought tolerant herbaceous plants in the vicinity. Based on these strategic ways of its expansion, parthenium weed can create a great challenge for ANP ecosystems.

Most literature sources noted parthenium weed as “weed of road side and degraded land”. Based on this, people tend to underestimate the impact of parthenium weed. But what was observed in Awash National Park (ANP) was very special. The weed was found spreading aggressively to the potential grazing lands. So, weed management is an essential and integral part of the sustainable management of natural resources and requires an integrated multidisciplinary approach. Minimizing disturbance of the land surface, construction of appropriate drainage canals, controlled movement of livestock optimizing the stand density of range lands through appropriate management techniques and minimized overgrazing are areas of attention to overcome the adverse impact of parthenium weed in protected areas.

ACKNOWLEDGEMENTS

The financial assistance of the GoE UNEP/GEF “Removing Barriers to Invasive Plant Management in Africa (RBIPMA) project through the Ethiopian Institute of Agricultural Research (National Executive Agency of the project in Ethiopia) is gratefully acknowledged.

Conflict of Interest

The authors have not declared any conflict of interest.

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APPENDICES

Appendix 1. Data sheet of soil chemical parameters analysis.

Sample No.	Category	pH_{H2o}(1:2.5)	EC (mmhos/cm)	%OM	%TN	Av. P (ppm)	Na	K	Mg	Ca	CEC (meq/100g soil)	%Moisture
T1	INN	6.72	0.220	2.46	0.19	6.78	2.23	6.73	3.68	30.12	33.56	5.22
T2	NIN	8.17	0.250	2.10	0.32	6.07	2.24	5.15	15.33	29.99	31.10	7.60
T3	INS	8.17	0.263	1.44	0.15	6.28	1.58	4.41	5.14	31.54	30.00	8.30
T4	NIS	8.15	0.236	2.35	0.16	6.41	1.12	4.69	5.65	27.98	27.22	7.60
T5	INN	8.14	0.301	2.15	0.19	12.13	3.30	6.85	11.53	30.36	37.43	6.04
T6	NIN	8.12	0.246	1.79	0.16	6.16	2.01	6.07	9.54	27.17	30.20	4.52
T7	INS	8.36	0.209	1.40	0.27	5.95	3.84	5.28	13.98	24.01	31.55	5.53
T8	NIS	8.21	0.236	1.39	0.14	5.14	3.25	5.69	10.72	24.30	35.44	4.54
T9	INN	8.20	0.233	1.48	0.14	5.58	3.44	5.41	16.48	22.80	31.19	5.44
T10	NIN	8.21	0.209	1.06	0.17	6.79	2.39	4.90	18.20	21.21	34.88	4.76
T11	INS	8.33	0.250	1.56	0.11	5.88	4.42	5.79	13.64	23.61	30.33	4.95
T12	NIS	8.14	0.230	0.98	0.13	5.73	2.15	5.17	13.07	24.18	34.83	4.58
T13	INN	8.14	0.360	1.86	0.17	7.52	3.19	5.53	7.40	28.43	32.29	3.84
T14	NIN	8.18	0.236	0.65	0.10	5.93	4.41	5.16	9.85	23.59	34.53	3.69
T15	INS	8.38	0.339	0.90	0.11	5.40	7.10	5.00	15.69	20.26	36.92	4.58
T16	NIS	8.42	0.259	0.65	0.10	4.28	6.56	4.48	14.27	21.66	31.44	3.78

[a] INN = Infested quadrats to the north of the highway; [b] INS = Infested quadrats to the south of the highway; [c] NIN = Non-infested quadrats to the north of the highway; [d] NIS =Non-infested quadrats to the south of the highway.

Appendix 2. Comparison in species absolute frequency (AF) and absolute stand density (AD) between non-infested (NI) and infested (IN) quadrats of common species.

No.	Botanical name	Non-infested(NI)		Infested (IN)		Difference (%)	
		AF	AD	AF	AD	AF	AD
1	*Becium filamentosum*	8	1525	5	83	37.5	94.6
2	*Chloris virgata*	16	3384	10	423	37.5	87.5
3	*Panicum coloratum*	21	2205	11	309	47.6	86.0
4	*Leucas martinicensis*	9	95	3	11	66.8	88.4
5	*Heteropogon contortus*	22	2353	26	1246	(-)15.4	47.1
6	*Melinis repens*	31	4562	32	2256	(-)3.1	50.6
7	*Ischaemum afrum*	19	3084	12	992	36.8	67.8
8	*Cencherus ciliaris*	21	967	15	354	28.6	63.4
9	*Rullia patula*	9	74	7	30	22.2	59.5
10	*Peristrophe paniculata*	18	320	16	158	11.1	50.6
11	*Blepharis moderaspatensis*	9	652	6	260	33.3	60.1
12	*Tephrosia pumila*	18	353	9	110	50.0	68.8
13	*Blepharis edulis*	34	1188	19	466	44.1	60.8
14	*Urochloa panicoides*	17	2955	21	2867	(-)19.1	3.0
15	*Indigofera schimperi*	31	443	22	257	29.0	42.0
16	*Launa intybacea*	11	105	14	114	(-)21.4	(-)7.9
17	*Phyllanthus maderaspatensis*	10	55	8	38	20.0	30.9
18	*Bidens pilosa*	15	603	15	523	0	13.3
19	*Sorghum arundinaceum*	23	228	26	235	(-)11.5	(-)3.0

Appendix 2. Contd.

20	*Tetrapogon tenellus*	63	22578	58	19045	7.9	**15.7**
21	*Boerhavia erecta*	11	234	13	289	(-)15.4	(-)19.0
22	*Indigofera articulata*	17	138	13	113	23.5	18.1
23	*Solanum coagulans*	26	181	20	156	23.1	13.8
24	*Abutilon fruticosum*	8	54	7	54	12.5	0
25	*Rhynchosia minima*	25	152	23	166	8.0	(-)8.4
26	*Sida ovata*	13	33	10	31	23.1	6.1
27	*Abutilon bidentatum*	18	48	15	59	16.7	(-)18.6
28	*Eragrostis papposa*	17	736	12	814	29.4	(-)9.6
29	*Cymbopogon commutatus*	24	1635	19	2568	20.8	(-)36.3
30	*Enneapogon cenchroides*	8	127	6	245	25.0	(-)48.2
31	*Ocimum forskolei*	8	68	5	124	37.5	(-)45.2
32	*Dactyloctenium scindicum*	6	172	5	532	16.7	(-)67.7