Indian Journal of Weed Science **47**(1): 66–70, 2015

Impact of invasive weeds on soil attributes at invaded sites

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Received: 2 December 2014; Revised: 11 February 2015

ABSTRACT

Impact on soil chemistry of *Calyptocarpus vialis* Less., (Straggler daisy), *Chromolaena odorata* (L.) King and Robinson (siam weed) and *Parthenium hysterophorus* L. (congress weed) invaded and uninvaded sites were studied during 2014-2015 in selected sites of GKVK, Bengaluru and Mysore district of Karnataka (India). Two soil cores (5 and 10 cm depth, litter discarded) were collected and subjected for analysis of pH, OC, available P K, Zn, Cu, Fe and Mn content. In *C. vialis*, siam weed and congress grass infested sites at surface soil (5 cm depth) and subsoil layer (10 cm depth) pH, C, P and K were less when compared to the uninvaded sites. Soil ions Zn, Cu, Fe and Mn in *C. vialis* and *C. odorata* invaded sites were more at 5 and 10 cm depth. Whereas in *P. hysterophorus* invaded soil, Cu, Fe ions were less at 5 and 10 cm depth and Zn was more at 5 cm and less at 10 cm depth. Mn ion was less at 5 and more at 10 cm depth. Phosphorus was less available at surface layer and more at subsoil layer in all the three weeds infested sites. Whereas, in the uninvaded sites, there was sufficient availability of P. The same is the case for K. Since the form and availability of P and K is highly pH dependant, the low pH had affected the solubility of P and K. A high variability in response to invasion was observed. Results reflected that soil chemistry was disturbed by the presence of *C. vialis, C. odorata* and *P. hysterophorus* to some extent with regard to soil pH, C, P and K contents at 5 and 10 cm depth and micronutrients Zn, Cu, Fe and Mn were increased only in the presence of *C. vialis* and *C. odorata.*

Key words: Invasive weeds, *Calyptocarpus vialis, Chromolaena odorata, Parthenium hysterophorus*

Alien plant invasions are a cause of intense and serious changes in ecosystems around the world (Vitousek 1990, Gusewell *et al.* 2006). But not all invading species are able to alter longer-scale processes. However, it is difficult to generalize about their effects on ecosystem properties, since these vary according to the traits of the invading species, and the properties of the invaded vegetation and habitat. Yet, knowing the inherent functional traits of an exotic invasive plant, could improve understanding of its invasion success and impact, since plant traits affect ecosystem properties such as through impact on indigenous species diversity, soil nutrient competition, loss of production of crops, altering forest fire cycles (Westoby and Wright 2006). The alien invasive species *Calyptocarpus vialis* (straggler daisy), *Chromolaena odorata* (siam weed) and *Parthenium hysterophorus* L. (congress grass) are capable of rapid colonization which are in general more likely to have negative impacts on biodiversity. Since these impacts result from differences in traits between the alien and native species, ultimately soil is the victim which undergoes changes in its constituents suffering severe loss of nutrients.

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C. vialis. has spread extensively in Bengaluru and Mysore districts within a short span of less than one decade. It can be rightly presumed that this invasive weed is going to replace the entire ground flora in a couple of years, unless curative steps are initiated (Rao and Sagar 2010). *C. odorata* and *P. hysterophorus* are the declared invasive alien weeds. Many reports from worldwide on impact of these two weeds on floristic changes, ecological integrity of native habitats, loss of crop yields, effect on forest fire cycles, effects on human and animals are available (Callaway and Ridenour 2004, Pimentel *et al.* 2005, Ortega and Pearson 2005, Rao and Sagar 2012, Kavitha *et al.* 2014,Sushilkumar 2014). Since the negative impact of weeds on soil constituents are seldom discussed, the present study was carried in the quest whether *C. vialis*, *C. odorata* and *P. hysterophorus* affect soil nutrients of the selected sites at different layers of soil?

MATERIALS AND METHODS

Survey of total 5 sites with semi-natural and homogenous vegetation were undertaken. Three sites were invaded by *C. vialis* selected from Botanical Garden, GKVK, Bengaluru and

Chromolaena odorata selected from 'Elachipalya grama' near 'Chennapatna' of Mysore district and *P. hysterophorus* was selected from 'Shambhu-devanapura' near 'Malavalli', Mysore District. Remaining two uninvaded sites were adjacent to the invaded sites although they contained native species. In invaded sites, vegetation structure is profoundly affected by invasion, *with C. vialis*, *C. odorata* and *P. hysterophorus* generally forming pure stands. The sites were having well-established and still expanding populations of test weeds surrounded by native uninvaded vegetation, they were having sufficiently homogeneous soil. The invasion of the weeds in all the sites dates back three decades.

At each site, three 1m^2 plots were marked in invaded patches and two 1m^2 plots were located in adjacent, uninvaded vegetation. The study was carried out from 2014 -2015. In each plot, two soil cores (5 and 10 cm depth, litter discarded) were collected with a soil borer (4 cm in diameter, one core at each corner of the square and one core at the centre of the square) in a zipper polythene bag.

Soil samples from different sites were collected in triplicates to assess the following parameters on each sample: soil pH, organic carbon (C), phosporous (P), potassium (K), magnesium (Mg), zinc (Zn), copper (Cu) and manganese (Mn). Soil analysis were done at the laboratory of Zuari Agro Chemicals Limited, Agricultural Development Laboratory, Puttenahalli, Yelahanka, Bengaluru.

Data collected were subjected to one way ANOVA using SPSS software. The treatment means were separated by using Duncan's multiple range test and least significant difference test (LSD) at P=0.005 probability level (Steel *et al*. 1996).

RESULTS AND DISCUSSION

Soil pH at 10 cm depth was less in *C. odrata* and *C. vialis* invaded sites compared to uninvaded site. Statistically soil pH of *C. vialis* and *C.odorata* invaded and uninvaded were significinantly different ($P<0.05$) unlike congress grass, where soil pH was almost same as uninvaded soil (Fig.1)

In the soil invaded by straggler daisy C percentage was less at 5 and 10 cm depth than uninvaded site. In *C. odorata* invaded soil, C percentage was more at 5 and equal at 10 cm depth, compared to uninvaded site, respectively. In *P. hysterophorus* invaded site, it was more at 5 cm depth and less at 10 cm depth compared to uninvaded soil. Soil C (%) under stands of *C. vialis*, *C. odorata* and *P. hysterophorus* were significantly different ($P<0.05$) when compared to uninvaded sites. (Fig. 2).

Phosphorous content in 5 cm depth soil was less and at 10 cm depth, it was almost equal and more in *C. vialis* and *C.odorata* invaded sites, respectively. In *P. hysterophorus* invaded site, P content was less at 5 cm and more at 10 cm depth. Values of P at subsoil layers in *C. odorata* and *P. hysterophorus* invaded sites were significantly different, whereas at surface layer, they formed group which implied that the P values were not significant at 5 cm depth ($P>0.05$) but *C. odorata* and *P. hysterophorus* were significantly different at 10 cm depth ($P<0.05$) (Fig. 3).

Potassium availability in 5 and 10 cm depth soil invaded by *C. vialis*, *C. odorata* and *P. hysterophorus* was less compared to uninvaded soils. (Fig.4).

Cu in *C. vialis* and *C. odorata* invaded sites was more at 5 and 10 cm depth and less in *P. hysterophorus* invaded site compared to uninvaded sites (Fig. 5). In *C. vialis* and *C. odorata* invaded sites available Zn was more at 5 and 10 cm depth compared to uninvaded soil. Whereas, in *P. hysterophorus* invaded soil, Zn was more at 5 cm and less at 10 cm depth soil compared to uninvaded soil (Fig. 6). Iron (Fe) in *C. vialis* and *C. odorata* invaded sites was more at 5 and 10 cm depth and less at 10 cm depth in *P. hysterophorus* invaded site. In uninvaded sites Fe was less (Fig.7). Mn in *C. vialis* and *C. odorata* invaded sites at 5 cm depth was more and at 10 cm depth was less. In uninvaded sites Mn content was less (Fig. 8). Impact of invasive plants depends on properties of invaded ecosystem, with site fertility being particularly important. Invasive plant species may increase or decrease nutrient composition in soil (Dassonville *et al*. 2008). At the same time nutrient enrichment has been found to promote plant invasions (Lake and Leishman 2004). In the present study, soil pH of *C. vialis*, siam weed and congress grass infested sites at surface layer (5 cm depth) and subsoil layer (10 cm depth) was less when compared to the uninvaded sites. This may be attributed to the acidic nature of the soil of invaded sites. Soil pH, C, P and K in *C. vialis* invaded site was less at 5 and 10 cm depth. *C. odorata* and *P. hysterophorus* invaded sites whereas in the availability of these nutrients was varying at 10 cm depth which could be attributed to higher concentration of organic matter in the upper layer than in the subsoil layer which in turn is the result of decomposition of more organic matter in the upper layer. The weeds had significant effect on soil nutrients ($P<0.05$). But, Zn, Cu, Fe and Mn were more in invaded sites by *C. vialis* and *C. odorata* at 5 and 10 cm depth. This indicates the presence of these two weeds have

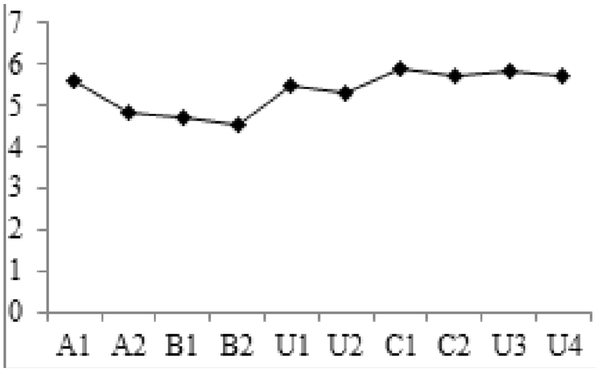

Fig. 1. pH

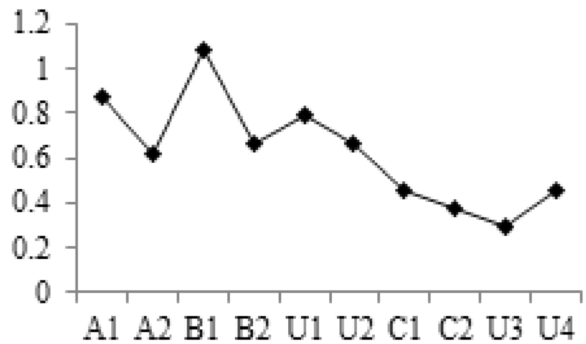

Fig. 2. Org.C %

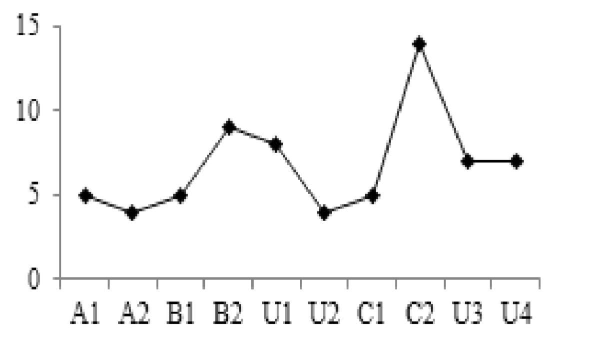

Fig. 3. Available P_2O_5 kg/acre

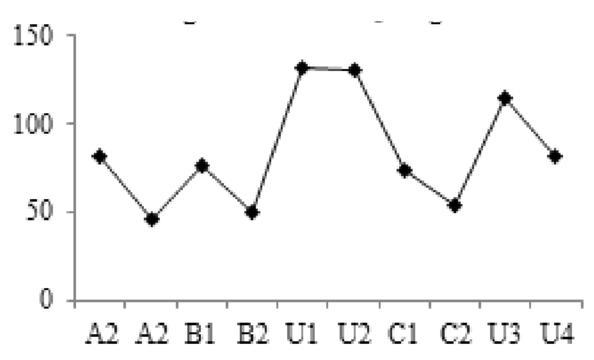

Fig. 4. Available K_2O kg/acre

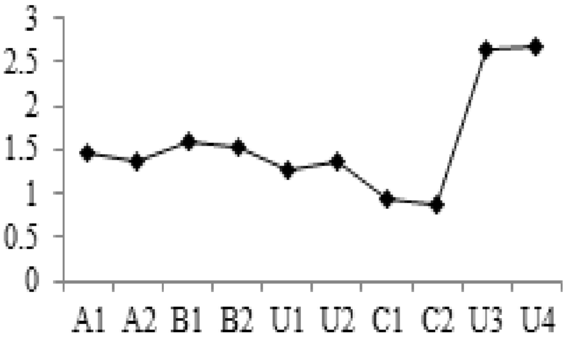

Fig. 5. Cu (ppm)

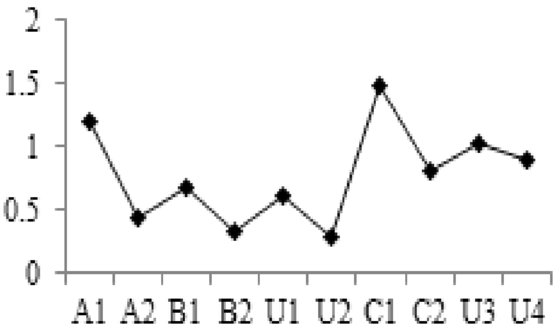

Fig. 6. Zn (ppm)

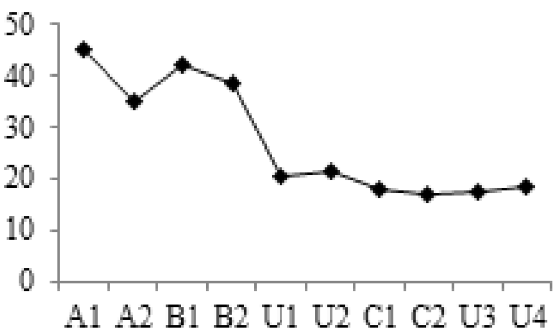

Fig. 7. Fe (ppm)

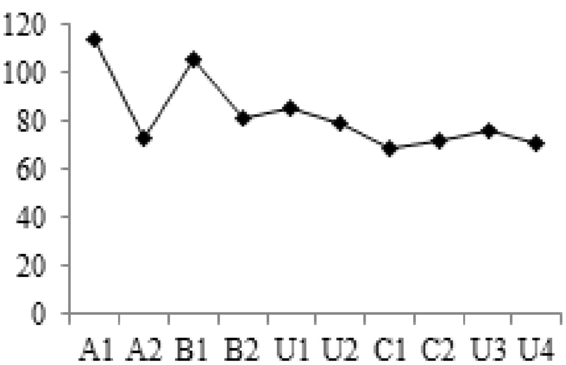

Fig. 8. Mn (ppm)

enriched the availability of ions. Whereas in *P. hysterophorus* invaded site, less availability of Cu, Fe and Mn at surface layer indicated the negative impact of the weed. Less availability of Zn, Cu and Mn at the sub soil (10 cm depth) may be due to soil compaction, reduced air and water circulation and reduced microbial activity. But, P ion was less at surface layer and more at subsoil layer in all the three weeds infested sites. Whereas, in the uninvaded sites available P was sufficient.

The present study revealed that surface layer lacks sufficient P, which supports only herbaceous plants for uptake of P but not shrubby plants. Since the soil is acidic, the cycling of organic matter is slower and ultimately has reduced its availability. Bhowmik *et al.* (2007) and Batish *et al.* (2002c) were of the opinion that in *Parthenium* invaded plots due to allelochemicals and residues from root exudates, the soil might become slightly acidic or neutral. Since the form and availability of P is highly pH dependant, the low pH has affected the solubility of P. The same was the case for K. Though the soil pH was slightly acidic in surface layer, yet all the three weeds have successfully thrived. It is known that acidic soil has less K, P and micronutrients, which are necessary for plant growth.

The test weeds survived and established by forming monocultures in such acidic soil. This implies that they can withstand decreased availability of organic contents and they have expressed high adaptability for acidic soil condition. Recent reviews have concluded that, on an average, alien invasive plants increase nutrient pools and luxes in invaded ecosystems. But, the relationship between soil nutrients and plant invasion is not found uniform. However, in the present study high variability in the response to invasion has been observed. Similar reports are available with (Ehrenfeld 2003, Liao *et al.* 2008). Batish *et al.* (2002c), Bhowmik *et al.* (2007), Manpreet Kaur *et al.* (2014) have found the changes in the above ground vegetation as well as in below ground soil nutrients in the invaded sites. The above interpretations reveal that *C. vialis*, *C. odorata* and *P. hysterophorous* have no difficulty for their establishment and colonizing in acidic soil. *C. vialis* being herbaceous weed, well utilized the available micronutrients in surface layer resulting in less availability of micronutrients. *C. odorata* and *P. hysterophorous* although being subshrubs, have acted equally in reducing the availability of micronutrients in both surface and sub soil layers of soils.

In recent report, *C. odorata* and *P. hysterophorous* have replaced many native flora and medicinally important plants in Mysore district (Kavitha *et al.* 2014). This effect may be due to synergistic adverse impact of allelochemicals on metabolic, biochemical and enzymological processes of the associated native flora. Furthermore, the changes in vegetation and soil nutrients could lead to ultimate changes in other trophic levels and alter the function of the ecosystem. Over all, it can be said that soil chemistry was disturbed by the presence of *C. vialis*, *C. odorata* and *P. hysterophorus* to some extent with regard to soil pH, C, P and K contents at 5 and 10 cm depth and micronutrients Zn, Cu, Fe and Mn were increased only in the presence of *C. vialis* and *C. odorata*. Whereas, in the presence of *P. hysterophorus*, these micronutrients were reduced. Varying effects were exhibited by all the three weeds in increasing/decreasing the soil attributes at both the soil layers. However, this conclusion should be tested in edaphic contexts, using much older invading sites. This was beyond the scope of this paper. However, this report provides some clues to mechanisms of the reduction of soil nutrient at surface and subsoil layers by these alien weeds. Therefore, a better understanding of the mechanisms occurring between weeds and soil communities is needed, through which strategies can be developed for reducing direct and indirect negative impacts on soil quality. Simultaneously, research on understanding potential benefits that these invasive alien weeds may provide to either cropping systems or native flora, if carried out, in a way that are beneficial to soil quality and enhanced crop yields.

ACKNOWLEDGEMENT

The first author sincerely thanks University Grants Commission, New Delhi for the award of Post Doctoral Fellow and for financial support. We would also thank Dr. Usha MS, Jain University, Bengaluru for logistic assistance.

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