EXCELLENT PUBLISHERS

International Journal of Current Research and Academic Review

ISSN: 2347-3215 Volume 3 Number 5 (May-2015) pp. 341-345

www.ijcrar.com

Analysis of Physico-chemical characteristics of ant hill soil and impact of plant growth in the green gram *Vigna radiate*

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KEYWORDS

Ant mound soil, physico-chemical parameter, elemental composition

A B S T R A C T

Ant mound soil samples (black and red) are collected from Nagapalayam, Virudhunagar District (Tami Nadu) were analysed for their physico-chemical parameters and growth characteristics of green gran. The results revealed that the pH and EC ant mound soils were found to vary between the months. In both cases, pH of the soils (ant mound black and red soils) were found to be decreased, It is clearly indicated that ant colonisation in the soils could have influenced the physico-chemical parameters of the soil by creating an acidic environment. It is observed that the range of fluctuation in the soils parameter might also due to the climatic condition, soil types, types of soil and different species of ant. The characterization of the ant mound soil (red and black) clearly shows that ants are responsible for changes in soil, nitrogen, phosphorus, potassium and along with micro elemental concentration. Our experiment confirms that ants are able to modify soil chemical properties. Present study indicates a significant contribution of ant mound soil in enhancing soil nutrients in ecosystem. There was a substantial quantity of elemental nutrients increase in ant colonized soils, such as N, P, K and micro elemental content with respect to the monthly samples.

Introduction

Ants are known to be ecologically significant invertebrates in many ecosystems. The positively affect physical and chemical soil properties, plant and distribution and forest health (Holldobler and Wilson 1990). The old-word ant Genus *Polyrhachis* Fr. Smith includes approximately 500 described species organized into 12 subgenera and is the subject of extensive and ongoing taxonomic revisions. The taxonomic diversity of the genus is matched with an equal diverse socio-ecology (Kohout 2006). Ants are important components of ecosystems not only because they constitute a great part of the animal biomass and they act as ecosystem engineers. Ant biodiversity is incredibly high and these organisms are highly responsive to human impact, which obviously reduces its richness. However, it

is not clear how such disturbance damages the maintenance of ant services to the ecosystem. Ants are important in below ground processes through the alteration of the physical and chemical environment and through their effects on plants, microorganisms, and other soil organisms (Folgarait, 1998). The construction of ant nests changes the physical and chemical properties of the soil increasing its drainage and aeration through the formation of underground galleries, and transforming organic matter and incorporating nutrients by food storage, aphid (Homoptera) cultivation, and the accumulation of faeces and corpses (Brain, 1978). These bioturbation effects occur in the topsoil as well as in the subsoil whether the ant nest is subterranean or forms a mound. In the case of non-mound nests, the amound of soil translocated within the subsoil and packed into pre-existing chambers could be very high **(**Humphreys, 1994). Lafleur *et al*. (2005) studied that the effect of the invasive red imported fire ant, *Solenopsis invicta* Buren, on soil properties and plant growth. Ant activity decreased soil pH and increased phosphorus (P+) and potassium (K+) in the soil. We collected soil from within and adjacent to randomly selected nests in two common habitats of Louisiana – longleaf-pine (*Pinus palustris*) forests and longleaf-pine plantations.

After physical and chemical properties were measured, *Gardenia japonicus* seedlings were planted in the soil to determine growth rate. In comparison to adjacent soil, ant nest soils from both habitats were lower in moisture content and bulk density and higher in NH_4^+ . Ant nest soils were also higher in $Ca^{2+,}$ Mg^{2+}, K^+ and Na^+ than in adjacent soils in longleaf-pine forests. *G. japonicus* seedlings grown in nest soil from pine forests were an average of three times taller than those grown in adjacent soil, and those from pine plantations were twice as tall as those grown in adjacent soils. These results suggest that invasive fire ants alter the physical and chemical properties of the soil. These soil modifications enhance plant growth since NH^{4+}, a nutrient that limits growth, has been increased. Hence, the present has been carried out physico-chemical characteristics, and plant growth analysis of ant mound soil.

Materials and Methods

In the present study, ant mound soils (Black soil and red soil) were collected from agricultural fields of Nagapalayam village in Virudhunagar district in the month of October, 2013 to February 2014. The various physic-chemical characteristic of ant mound soil were analyzed by Soil Testing Laboratory, Virudhunagar. The healthy seeds of host plant, green gram where chosen and their surface was sterilized in 0.01% (w/v) Mercuric Chloride solution for few minutes. They were rapidly washed well with distilled water and then soaked in distilled water for 2 hours. After treatment the seeds were sown in plastic pots containing ant mound soil. After 45 days, the plants were removed with tap water and washed carefully with distilled water without causing any damage to the root system, and then the following growth characters such as Shoot and root length, Fresh and dry weight of shoot and root, Water content of shoot and root and Leaf area were analyzed.

Results and Discussion

The physico -chemical parameters along with elemental contents in ant mound black and red soil are presented in Table 1 and 2. The ant mound soils (black and red soils) and soils without ant mound collected for the month of October 2013 - February 2014

were studied for their physico-chemical parameters and elemental composition. As the elemental composition of the ant mound black soil is concerned, the N (106), K (500) and Mn (4) content found to be increased than control, whereas in the ant mound red soil showed a maximum amound in the element were of 98, 173 and 398 for N, K and Mn respectively in month of October 2013. Major important elemental concentration such as N, P, K Fe, and Mn were found to be increased with both black and red soils colonized by ant than the controls. However, black soil with ant showed a drastic increase in potassium content (229) than control (125). There was a slender amound increase in Phosphorous content (22) and Nitrogen (99) in the month of November- 2013 when compared other months. These values are found to be fluctuated in the Month of February, 2014. However, some of the micro nutrients such as Mn content (14.2), Zn content (1.1) along with macro elements N content (84) were observed a higher amound with black soil with ant, whereas similar fashion of N content (103.6) and along with micro nutrients such as Fe (11.1), Mn (12.1) and Zn content (0.8) were found to be increased with red soil with ant mound than the control. Our experiment confirms that ants are able to modify soil chemical properties. Present study indicates a significant contribution of ant mound soil in enhancing soil nutrients in ecosystem. There was a substantial quantity of elemental nutrients increase in ant colonized soils, such as N, P, K and micro elemental content with respect to the monthly samples.

The impact of ant mound on abiotic factors generally fit our predictions with analyzed nutrients being more concentrated in ant-mound soils than in non-ant soils. However, the soil moisture, texture of the soil, type of soils, seasonality and climatic condition could be related to our hypothesis. We predicted that ants would increase soil moisture inside nests presumably via respiration and excretion. Shukla *et al*. (2013) stated that the nest debris soil of *Pheidole* sp. had significantly higher nutrient content: with concentration of total C, N (each about 2–3 times higher), P (2–5 times higher) and NO_3-N (4–6 times) being higher in the debris soil in comparison to the concentrations of the respective chemicals in the control soil, at all the three sites. In addition, *Pheidole* sp. colonies translocate underground soil to the surface along with the discarded organic matter and contribute to reduction in bulk density, soil loosening, mixing and texture changes.

The growth characteristic of green gram in ant mound soils (black and red) treated plants. After 45 days, the plants grown on red and black ant mound soils were studied for their growth characteristics in terms of shoot length , root length (cm), root weight, shoot weight (fresh & dry), leaf area and percentage of water content in shoot and root . The results revealed that ant mound soil (black and red) soils showed comparatively higher growth parameters than the control (Table 3). Our experiments results revealed that ant mound soils are enhanced with nutrients especially soil nitrogen , which helped the plant (green gram) for their growth and development in terms of shoot and root length and leaf area etc. Mineral forms of soil nitrogen are often said to be the most limiting nutrients to plant growth. Ant mound soils were, therefore, of higher N fertility and, by implication, more favorable to plant growth than adjacent soils. Lafleur *et al.* (2002) showed that organic matter in nest soils mineralized proportionately more N and are thus richer in $NH4^+$ available for plant growth than adjacent soils.

Table 1. Physico- chemical characteristics of ant mound in black soil during October 2013 to February 2014

	October		**November**		**December**		**January**		**February**	
	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil
Physical parameter										
pH	8.46	7.4	8.1	8.2	7.7	7.5	7.98	7.88	8.1	7.4
EC	0.3	2.4	0.2	0.5	0.5	0.6	1.00	0.60	1.7	0.4
Chemical Parameter										
N	91	106	91	99	60.2	88.2	62	70	67.2	84
P	6.3	5.0	8.3	22	6.0	8.5	4.5	4.1	3.8	2.3
K	156	500	125	229	125	178.8	158	133	136.3	78.8
Fe	1.8	1.6	1.6	1.2	1.2	1.8	8.2	11.3	11.0	9.0
Mn	4.0	4.23	3.8	3.0	3.2	4.0	9.5	9.2	9.5	14.2
Zn	0.8	0.69	1.2	0.8	1.0	1.2	0.8	0.6	0.9	1.1
Cu	1.0	0.21	1.0	0.8	1.2	0.8	2.1	2.8	3.0	1.8

Table 2. Physico- chemical characteristics of ant mound in red soil during Oct. 2013 to Feb. 2014.

	October		**November**		**December**		**January**		**February**	
	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil	Control soil	Ant Mound Soil
Physical parameter										
pH	7.70	8,.19	8.2	8.2	7.6	7.5	7.2	7.4	7.25	7.12
EC	0.43	1.1	0.5	0.5	1.2	1.0	0.30	0.4	1.0	1.5
Chemical Parameter										
N	90	98	87	90	65.8	92.4	90	84	93.8	103.6
P	6.3	6.3	22	22	2.3	11.5	5.0	2.3	15.5	2.0
K	16	173	309	474	196	373.8	250	78.8	236.3	73.8
Fe	2.04	1.60	1.0	1.4	1.0	1.0	9.6	9.0	8.5	11.1
Mn	3,7	3.98	4.2	4.6	3.8	4.8	11.5	14.2	9.0	12.1
Zn	0.61	0.7	0.8	0.6	0.8	1.2	0.9	1.1	0.6	0.8
Cu	0.19	0.12	1.2	1.2	1.0	0.8	2.6	1.8	2.8	1.2

Table 3. Growth characteristics of green gram in ant mount soil treated plants

S.No	**Parameters**	**Control soil**	**Red soil**	**Black soil**
1	Shoot length (cm)	22.6 ± 0.30	32.2 ± 0.55	27.3 ± 0.30
2	Root length (cm)	8.5 ± 0.35	16.4 ± 0.40	10.5 ± 0.40
3	Fresh shoot weight (g)	1.33 ± 0.03	1.96 ± 0.03	1.42 ± 0.03
4	Fresh root weight (g)	0.71 ± 0.51	1.18 ± 0.04	0.62 ± 0.03
5	Dry shoot weight (g)	0.29 ± 0.04	0.44 ± 0.05	0.39 ± 0.02
6	Dry root weight (g)	0.32 ± 0.02	0.39 ± 0.05	0.27 ± 0.55
7	Leaf area (cm^2)	18.2 ± 0.35	18.91 ± 0.04	31.7 ± 0. 25
8	Water content (%) shoot	22.01 ± 0.04	20.48 ± 0.63	26.04 ± 0.63
9	Water content(%) root	41.02 ± 0.03	31.87 ± 0.35	42.92 ± 0.03

The plant (green gram) growth in terms of shoot lengths using ant mound soils (present study) were of 32 ± 0.55 cm and 27 ± 0.30cm for red soil and black soil respectively. However, the shoot of ant mound red soil showed a significance difference than the control. The root length of plants ant amound red soils and black soils were comparatively higher than the control. Our growth experiment clearly showed that plant seedlings grown in ant mound soil grew faster than those planted in control soil. Knowing that plant nutrition is related to concentrations of nutrients in the soil, we can combine the results from the growth experiment with those obtained from the soil fertility experiment and conclude that higher growth rate in nest soil is a result of higher fertility. In natural ecosystems, the distribution of nutrients in soils is spatially heterogeneous (Hodge *et al*., 1998). The black ant mound soils also comparatively higher shoot length was observed than the control. In overall, shoot length, root length, shoot weight, root weight, leaf area and water content in the shoot and root were maximum in the ant mound soils (black and red) than the control. Herewith it is suggested that ant mounds soils could be used for growth of commercially important plants. These soils might also serve as alternate to commercial fertilizer.

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