ASSOCIATION INDEXATION OF VARIOUS PLANT SPECIES WITH EARTHWORM *PHERETIMA POSTHUMA*

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Received: November 22, 2025; Accepted: January 28, 2026

ABSTRACT

To feed a growing global population while minimizing environmental damage, we require comprehensive and quantitative knowledge of ecological factors influencing crop production. Through their burrowing and casting activities, subterranean detritivores like earthworms can boost the availability of nutrients in the soil. Many recent researches have investigated whether plant performance may be impacted by earthworm-caused alterations. In view of importance of plant association with various organisms in an ecosystem, The index of association was found to be 100 for *Cynodon dactylon*, 91.6 for *Digitaria* sp., 86.6 for *Oryza sativa*, 83.3 for *Triticum indicum*, 37.3 for *Pennisetum typhoideum*, 58.3 for *Arachis hypogea*, 46.6 for *Avena sativa*, 41.6 for *Zea mays*, 30 for *Solanum tuberosum* and 20 for *Hordeum vulgare*, respectively. The present study shows that owing to high temperature the quantity of earthworm found less in number resulting in less growth of plants. On the other hand, moisture effects demonstrated totally opposite consequences as compare to high temperature. The above findings suggest that suitability of temperature and moisture are vital factors for the growth of earthworm as well as plants.

Key words: *Pheretima posthuma*, *Cynodon dactylon*, index of association.

INTRODUCTION

Generally earthworm is considered as ecosystem engineers because it is among the significant detritivores (soil eater) within food webs of soil (Blouin *et al.*, 2013; Cunha *et al.*, 2016). During their casting and burrowing behavior, they enhance the organic matter in soil. They also stimulate the microflora of soil and alterations of soil porosity and aggregation (Bertrand *et al.*, 2015; Cunha *et al.*, 2016; Van Groenigen *et al.*, 2014). Earthworms have been reported to put an explicit effect on the fertility and permeability of soil (Wang *et al.*, 2004). Earthworms also act as soil aerators, penetrating the soil while burrowing; this movement within the soil allows for plant roots to grow more compared to an environment with no worm activity (Bertrand *et al.*, 2015). Earthworms increase physical properties of soil for example aggregate constancy, porosity, infiltrability, hydraulic conductivity and bulk density (Devkota *et al.*, 2014). The relationship between plants and earthworms is an example of these types of interactions. Plants require nutrients such as nitrogen, phosphorus, and potassium for proper growth and development; for instance, enzyme activity, photosynthetic processes, and maintenance of homeostasis are all impacted by levels of these macronutrients. Nitrogen, phosphorus, and potassium, obtained through root systems embedded in the soil, are more accessible with the presence of earthworms (Yoshitake *et al.*, 2014).

Bustos-Oberg-n and Goicochea, (2002) have pointed out that owing to extensive use of agro pesticides, the danger of soil contamination has provoked a growing concern the world over. Along the important soil factors such as pH, C/N ratio and total content of these elements such as Al, Ca, Mg, organic material, coarse sand and silt etc that affect the different plant species and as well as the earthworm. As this threat lead to effects on plant species as a result of effects on earthworm species, therefore, the biodiversity study of earthworms has been recognized as an important area of research interest for a large number of biologists in the world wide (Tsai *et al*., 2000; Blakemore, 2000; 2002 and 2003; Chang and Chen 2004, 2005a and 2005b; Blakemore *et al*., 2006). Never the less, the earthworms have been found indispensable for the ecosystem, in soil they constitute a very large part of in terms of weight to other animals found there, thus, played a role in the profiic properties of soil fertility and the organic matter decomposed (Zang *et al*., 2000).

Unfortunately, a few scientists have worked for a better understanding of earthworm's effects on modifications in plant growth as mediator in respect of surface communities in natural habitats. Hence, interest in to integrate

below and above the soil surface communities in a more holistic view of respective ecosystems become of prime importance (Van der Putten *et al*., 2001; Scheu and Setala, 2002 and Wardle, 2002). Additionally, earthworms can alter the physiological and ecological status of plant (Puga-Freitas *et al.,* 2012; Puga-Freitas *et al.,* 2016). At last, agreed that earthworms enhanced yield in domestic crops often decreased levels of wild associations (Turcotte and Poveda, 2017). Therefore, the present study was conducted to understand the extent of plant species association with earthworm in soil ecosystem as an indexation pattern.

MATERIALS AND METHODS

Samples of plant species collected and brought to the Department of Botany University of Karachi and identification was made by the courtesy of plant taxonomist at the department. Earthworm (*Pheretima posthuma*) used in the current work in association with common lawn grass (*Cynodon dactylon*), crabgrass (*Digitaria sp.*), rice (*Oryza sativa*), wheat (*Triticum indicum*), millet (*Pennisetum typhoideum*), groundnut (*Arachis hypogea*), oats (*Avena sativa*), maize (*Zea mays*), potato (*Solanum tuberosum*) and barley (*Hardeum vulgare*) plant species.

Collection areas

Nurseries, gardens and various fields located in the areas of Korangi, Malir, Quaidabad, Gharo, Gujjo, Thatta and different other areas of Sindh were visited to collect earthworm *Pheretima posthuma*. During the study number of earthworm collected from 1-meter radius of a plant was noted along with the name and place of the plant species.

Identification

During the process of earthworm collection, other identical animals could also be gathered. Thus the collected samples were identified by the field key firstly, at the spot then, through a detailed key study, their confirmation was made in the laboratory after (Stephenson, 1923). *Pheretima posthuma* has elongated and cylindrical body. It is about 15-20 cms long, having a dark brown glistening color. The anterior end is pointed while the posterior end is rounded. The body is divided into 100-120 segments. The anterior end has a prostomium, which is not a segment; beneath the prostomium a crescentic opening mouth is present. Segments are encircled by a thick spherical band like gland clitellum. The female genital pore, on the 4^{th} segment, lies on the ventral surface of clitellum and two male genital pores lie on the ventral surface of the 18th segment behind the clitellum. On the ventral surface of the 17 and 19th segments, two pairs of copulatory papillae are found. In the inter-segmental grooves of 5th 6th 7th and 9th segments four pairs or spermathica are present (Kotpal *et al.,* 1987).

Index of association:

Index of association was calculated with minor amendment after (Zaidi and Khan, 1994), as $Ia = Nx. Nm^{-1}. 100$

Where:

Ia = Index of association, Nx = No. of organism of x status recorded

Nm^{-1}= No. of organism among x status having maximum in numbers recorded. (Table-1)

Statistical Analysis

Data were statistically analyzed by one-way ANOVA and means were compared by Tukey Test using IBM SPSS® Version 19.

RESULT

Earthworm is a soil-engulfing animal. It dwells in the muddy, wet and moisture soil (Figure 1), under the trees, in the nurseries, garden and riverbanks. It was usually present in the upper layer of the soil down to 10-12 inches in depth. The earthworm uses as food the dead organic matter and small animals, present in the soil. The earthworm digests food in the soil, while the undigested food and soil is ejected in the shape of worm casting. They were generally found in the morning. However, during the high temperature, they were found burry deeply into the soil, and were not easily available (Figure 2). The same happened during the cold weather as well. Therefore, the suitable time for its collection was early in the morning during summer and noontime during the winter. It was observed that during the rainy period, they appeared on the surface. They also grew in size during this period. In order to search them in the dark, a field light was required. They were stored in the plastic bags, filled with suitable quantity of wet and compost soil.

Table 1. Index of association of plant species with earthworm (in descending order).

Plant species associated with earthworm	**Common name**	**Average number of earthworm collected**	**Index of Association** $Ia = Nx . Nm^{-1}. 100$
Cynodon dactylon	Common Grasses	60	100 %
Digitaria sp.	Crabgrass	55	91.6 %
Oryza sativa	Rice	52	86.6 %
Triticum indicum	Wheat	50	83.3 %
Pennisetum typhoideum	Millet	44	73.3 %
Arachis hypogeal	Ground nut	35	58.3 %
Avena sativa	Oats	28	46.6 %
Zea mays	Maize	25	41.6 %
Solanum tuberosum	Potato	18	30 %
Hordeum vulgare	Barley	12	20 %

$Ia = Nx . Nm^{-1}. 100$

Where: Ia = Index of association; Nx = No. of organism of x status recorded

Nm^{-1} = No. of organism among x status having maximum numbers in record.

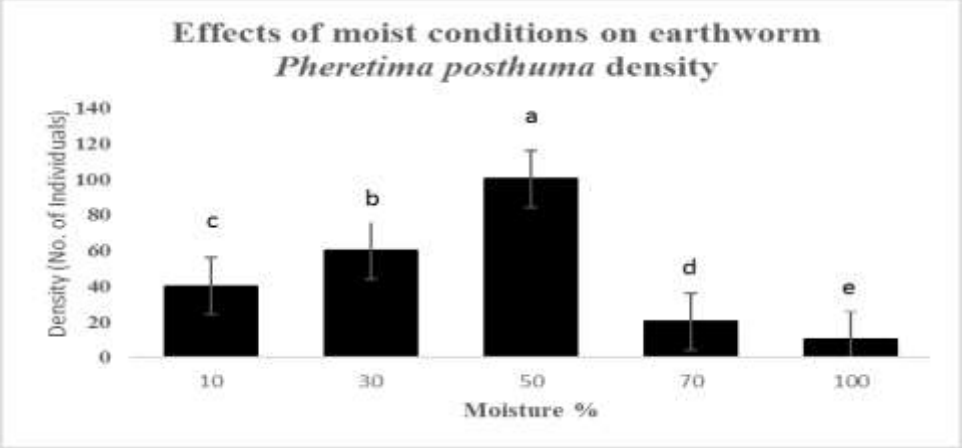

Fig. 1. Effects of moisture on earthworm *Pheretima posthuma* density.
Similar letter are not significant at p<0.05 by DMRT.

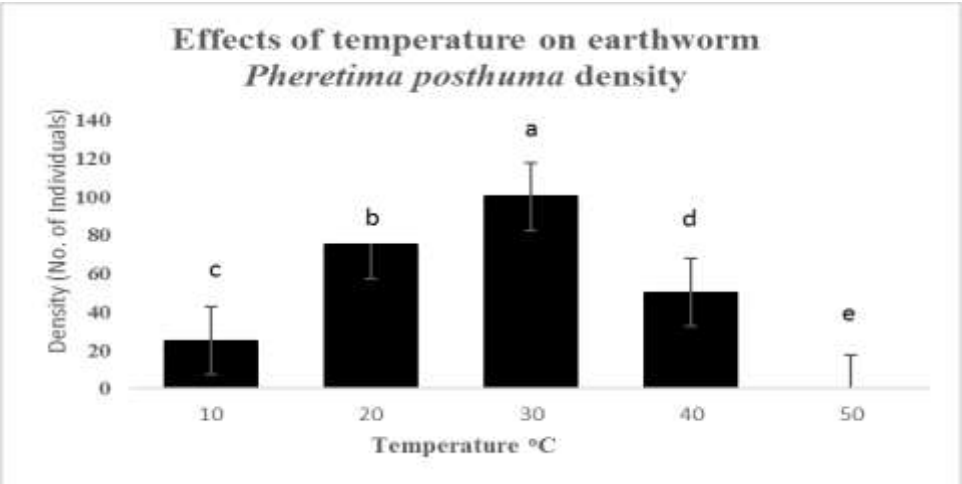

Fig. 2. Effects of temperature on earthworm *Pheretima posthuma* density.
Similar letter are not significant at p<0.05 by DMRT.

As regards present study earthworm collected from the different areas pertaining to Karachi and Thatta. The order of association was found as common lawn grass (*Cynodon dactylon*), >crabgrass (*Digitaria sp.*) >rice (*Oryza sativa*) >wheat (*Triticum indicum*) >millet (*Pennisetum typhoideum*) >groundnut (*Arachis hypogea*) >oats (*Avena sativa*) >maize (*Zea mays*) >potato (*Solanum tuberosum*) and barley (*Hardeum vulgare*). The index of association was found to be 100 for *Cynodon dactylon*, 91.6 for *Digitaria sp.*, 86.6 for *Oryza sativa*, 83.3 for *Triticum indicum*, 37.3 for *Pennisetum typhoideum*, 58.3 for *Arachis hypogea*, 46.6 for *Avena sativa*, 41.6 for *Zea mays*, 30 for *Solanum tuberosum* and 20 for *Hordeum vulgare*, respectively. (Table 1 and Fig. 3). During present studies, units were used for determination of moisture as one unit: ═ 20 in Figure 1 and temperature as one unit: ═ 25 in Fig. 2.

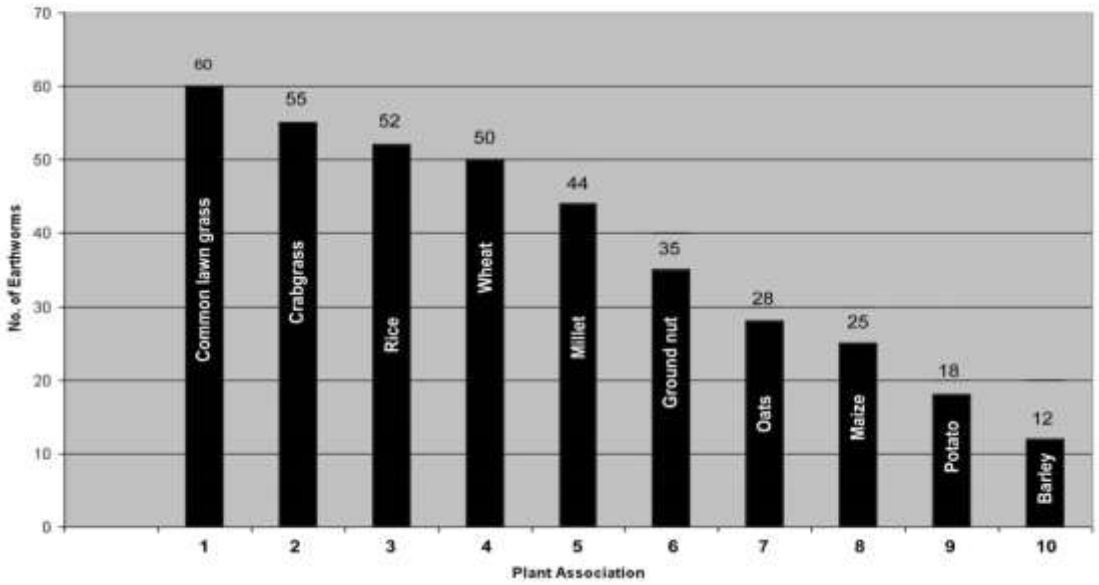

Fig. 3. Earthworms found/sq meter around one plant up to 8" depth.

DISCUSSION

The present findings support the hypothesis, which calibrated the association of different plant species with earthworm. The order of association was found as common lawn grass (*Cynodon dactylon*), > crabgrass (*Digitaria sp.*) > rice (*Oryza sativa*) > wheat (*Triticum indicum*) > millet (*Pennisetum typhoideum*) > groundnut (*Arachis hypogea*) > oats (*Avena sativa*) > maize (*Zea mays*) > potato (*Solanum tuberosum*) > and barley (*Hardeum vulgare*). Nonetheless, workers have shown association of earthworm with environmental conditions including plant species, however, presently; the associations of earthworm with plant species have been shown in more legitimate way of indexation.

Ghafoor, *et al.* (2008) reported that earthworm's collection was made from croplands, gardens, green lawns, flower, banks of canal and cultivated areas. The sites of collection were Jinnah garden, Govt. College, Gutwala forest and PARS institution, at Jhang road Faisalabad. In the present work earthworm were collected from the gardens, banks of canal, croplands and cultivated areas as well. Mackay and Kladivko (1985) reported links between various species of earthworms with respect to the environment in Europe. In the present work, the link of various plant species with earthworm *Pheretima posthuma* was observed. The some areas of earthworm's fauna in Pakistan reported (Khatoon, 1996 and Noreen, 1997). Rana *et al*. (2002) studied with a view to have a comprehensive list of earthworm population in Pakistan; they surveyed crop fields of Gujranwala. In respect of earthworm *Pheretima posthuma* they reported that 228 specimen were collected from eight plant and order of *Pheretima posthuma* in various habitats was *Capsicum frutiscens* (Green Chili), 60 > *Cucurbita pepo* (Pumpkin), 45 > *Sasbania sasban* (Jantar),28> *amodica charantia* (Bitter gourd), 25>*Triticum aestivum* (Wheat), 24>*Sorghum bicolor* (Sorghum), 23>*Pennisetum american* (Millet), 22>*Oryza sativa* (Rice), 1. They reported the presence of *Pheretima posthuma* in these areas as well as other species. In the present study earthworm collected from the different areas of Karachi and Thatta. Likewise (Gafoor, *et al.*, 2008) earthworms were collected from the different areas of Karachi and Thatta. The order of association was found as common lawn grass (*Cynodon dactylon*),>crabgrass (*Digitaria* sp.) > rice (*Oryza sativa*) > wheat (*Triticum indicum*) > millet (*Pennisetum typhoideum*) > groundnut (*Arachis hypogea*) > oats

(*Avena sativa*) > maize (*Zea mays*) > potato (*Solanum tuberosum*) and barley (*Hardeum vulgare*). The index of association was found to be 100 for *Cynodon dactylon*, 91.6 for *Digitaria sp.*, 86.6 for *Oryza sativa*, 83.3 for *Triticum indicum*, 37.3 for *Pennisetum typhoideum*, 58.3 for *Arachis hypogea*, 46.6 for *Avena sativa*, 41.6 for *Zea mays*, 30 for *Solanum tuberosum* and 20 for *Hordeum vulgare*, respectively.

Jalal (1998) and Khanum (1999) reported that *P. morrisi* outnumbered water channels and water ditches of some localities but lacked in specific habitats. Rafique and Rana, (2001) have demonstrated a relationship between the three species of genus *Pheretima* in different types of habitats located in Faisalabad and Sargodha regions. In the present work the relationship between the earthworm *Pheretima posthuma* and plant species in different areas of Sindh was observed. Manyuchi, *et al.* (2012) reported that the earthworms can be used for bio-conversion process such as novel composting techniques. Bauchhenss (1991) has indicated association of various agro environments e.g. Irrigated water and soil fertility etc. with the earthworm populations, obviously, plants are also associate with certain environment conditions therefore, it was established that because of specific requirements plants were grown in a certain area and the presence of earthworm over there in various level was because of such reason and a common interest between the earthworm and the plant species. Hence, the present study shows that owing to high temperature the quantity of earthworm found less in number resulting in less growth of plants. On the other hand, moisture effects demonstrated totally opposite consequences as compare to high temperature. Blouin *et al.* (2006) studied that the earthworms stimulate growth of plants by feeding and movement activity. Ghafoor, *et al*. (2008) and Rana, *et al*. (2002) have advocated that different soil conditions favour different plant species thus favour soil fauna as well, since the earthworms have some mutualism with plants, therefore, they have shown association that was observed in the present study and calibrated as index of association.

The current study suggests that suitability of temperature and moisture are vital factors for the growth of earthworm as well as plants.

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