International Journal of Ecology and Environmental Sciences 49: 569-577, 2023
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2023.2863

Influence of Chemoedaphic Factors on Soil Microarthropods in Forest Ecosystem of South Assam

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ABSTRACT
Soil is the uppermost weathered layer of the earth supporting diverse group of soil fauna. Soil inhabiting microarthropods play a vital role in sustaining the food web of the soil ecosystem through their association in the process of nutrient mineralization, litter decomposition and microbial activity. The present study elucidates the influence of edaphic factors on soil inhabiting microarthropods in a forest ecosystem. Soil samples were randomly collected at a monthly interval with a stainless steel soil corer at depths of 0-10 cm, 10-20 cm and 20-30 cm. From the collected soil samples, microarthropods population was extracted using Modified Tullgren funnel apparatus and standard protocol was followed for the assessment of various edaphic factors. Oribatid and Collembola were reported as the most dominant microarthropods group across all soil depths. The soil dwelling microarthropods population densities peaked during monsoon season while the least was observed during post-monsoon season. Among the various physico-chemical parameters, soil temperature and soil available potassium depicted statistically significant positive correlation with soil microarthropods population. The present study provides evidence of the close interaction of the soil inhabiting microarthropods population with edaphic factors.

Key words: Microarthropods, Chemoedaphic parameters, Oribatid, Collembola, Regression

INTRODUCTION

Soil, the most complex habitat on the earth (Voroney and Heck 2007), is an imperative habitat supporting various faunal groups (Manu et al. 2016). It contributed about 23% of the total diversity of living organisms (Decaëns et al. 2006). The soil inhabiting microarthropods are responsible for modulating the structure and function of soil and their persisting ecosystems (Jeffery et al. 2010, Menta 2012, Wardle et al. 2004). Soil microarthropods are an abundant group of soil fauna which play an important role in soil ecosystem functioning through their involvements as a decomposer, detritivores, predator, soil structure engineers and biological population regulator (Bernard et al. 2012, Neher et al. 2012, Bedano et al. 2016, Roy et al. 2020) which in turn contributes to nutrient retention and nutrient cycling (Moore et al. 1988, Rumble and Gange 2013, Wagg et al. 2014) and thereby enhancing soil structure and texture. Moreover, microarthropods are capable of maintaining the productivity of soil in every ecosystem be it natural such as forest, grassland or man-made like agro-ecosystems (Roy et al. 2017). Acari, Collembola, Spiders, Pseudoscorpion, Diplopods, Chilopods, etc. are the major groups of soil inhabiting microarthropods (Menta 2012, Manu et al. 2016). With a collective contribution of around 90% (Wallwork 1976, Seastedt 1984, Norton 1990, van Straalen 1998) among the total microarthropods, Acari and Collembola (*i.e.,* mites and springtails) are the two most abundant (Brussaard et al. 2010, Zhu et al. 2010, Santos-Roch et al. 2011, Abbas 2012) and widespread (Nielsen et al. 2015) groups of soil dwelling microarthropods. Different factors greatly influenced the abundance and functioning of these soil microarthropods. The variations of these factors would in the long run aggravate the population structure and density that in turn degrade the soil texture and quality of an ecosystem. The soil parameters such as soil temperature, pH, moisture content, and organic carbon content are also imperative factors that greatly influenced the microarthropods diversity (Curry 1994, van Gestel and van Diepen 1997, Cassagne et al. 2003).

The present study was conducted with aims to elucidate the faunal diversity of soil microarthropods and to specifically explore soil physico-chemical properties that influenced soil microarthropods communities in a forest ecosystem in South Assam. The study provides the quintessential insight to the effect of soil parameters on the community structure of soil-dwelling microarthropods.

MATERIALS AND METHODS

Study area

The present study was carried in a tropical forest ecosystem in Cachar district, South Assam, Northeast India, a global biodiversity hotspot (Myers et al. 2000). The study area lies at (24°42'22.31" N latitude and 92°42'6.29" E longitude with an altitude of 39 metres above mean sea level. The characteristic climate of the study area is subtropical warm and humid with an average rainfall of 3874.5 mm, most of which is received during the southwest monsoon season (May-September). Some of the dominant plant species in the study site include *Albizia lebbeck, A. odoratissima, Bombax ceiba, Dysoxylum* sp., *Ficus* sp., *Litsea* sp*., Macaranga* sp*., Mangifera indica.*

Sampling and estimation of microarthropos

The sampling was conducted for a period of 12 months from October 2019 to September 2020. Soil samples were collected between 08.00 to 9.00 hrs regularly at a monthly interval from the study site. Five sample units were collected at random with stainless steel soil corer (5 cm diameter) at depths of 0-10 cm, 10-20 cm and 20-30 cm. Modified Tullgren funnel apparatus with 25W electric bulb was used for the extraction of soil microarthropods. Soil samples after transferring to the laboratory was carefully placed on the mesh above the funnel before inserting the collecting vial containing preservative liquid (2 parts 75% ethanol and 1 part glycerol) beneath the funnel. The whole extraction system was kept free from vibration and external disturbances. The duration of extraction of soil microarthropods was 72 hours or as proportionate to moisture content of the soil sample. All collected microarthropods were preserved in vials containing preservative liquid and identified up to order level following the taxonomic keys of Julka (2016) using a stereoscopic binocular microscope (10X x 40X).

The density of soil microarthropods was estimated using the formula given by Singh et al. (1978).

$$P = 10000X/0.785d^2$$

Where, P= (population density)^2, X= population/sample, d= diameter of the soil corer

Soil analyses

Five replicates of the soil samples were collected using soil corer (5 cm dia) so as to get soil samples of desired depths i.e., 0-10, 10-20 and 20-30 cm, respectively. The collected soil samples were mixed to prepare depth-wise composite soil mixture to assure accurate assessment of the soil physico-chemical properties. For the analyses except for soil temperature and moisture content, the soil samples were air dried under room temperature for few days until it is relatively dry. The air dried samples were then grinded and sieved through a 2 mm sieve size and stored in polythene bag.

Physico-chemical factors like soil temperature, moisture content, pH, organic carbon, available nitrogen, available phosphorous and available potassium were analysed using standard protocols (Allen et al. 1974, Subbaih and Asija, 1956, Jackson 1958). SPSS® 18.0 (ver) software was used for analysis of variance and regression and at 95% confidence level, significance was defined as $p < 0.05$.

RESULTS AND DISCUSSION

Microarthropod groups extracted and their contribution

During the investigation period, a total of 498 soil inhabiting microarthropods belonging to 15 orders were extracted. The soil layer 0-10 cm contained 318 microarthropods representing 63.86% of the total individuals, while 128 (25.7%) and 52 (10.44%) were observed in the soil depths 10-20 and 20-30 cm, respectively. Hymenoptera was the most dominant group in 0-10 cm soil layer with a contribution of 20.44% followed by Oribatid (18.87%) and Collembola (16.04%) (Fig.1a). On the other hand, Collembola (25.78%) was the most abundant order in the soil layer 10-20 cm closely followed by Oribatid (22.66%) (Fig. 1b). Oribatid and Collembola with 25% contribution each were the predominant group in the soil depth 20-30 cm (Fig. 1c). Dominance of oribatid and collembola groups in soils was reported by many scientists working in different ecosystems (Banerjee et al. 2009, Abbas and Parwez 2012, Ray et al. 2012, Parwez and Sharma 2014, Borah and Kakati 2014, Ray and Pator 2016, Pator and Ray 2020). The possible reason for the

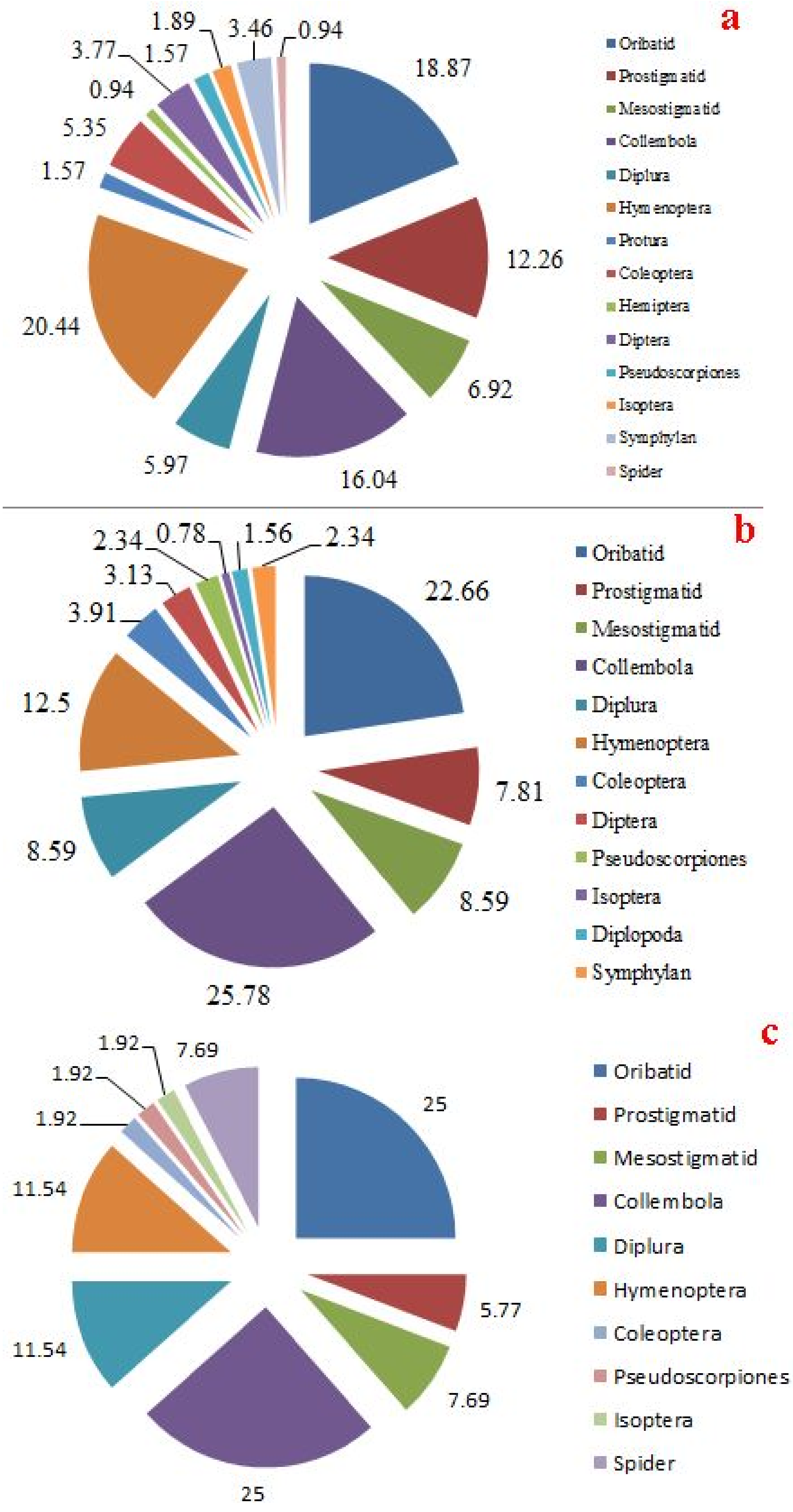

Figure 1. Contribution (%) of different soil microarthropod groups in 0-10 cm (a), 10-20 cm (b) and 20-30 cm (c) soil depths

dominance of these two groups might be their high resistance to water and temperature stress (Lavelle and Spain 2001) and the flexibility in their feeding habits which range from living to dead organic matter (Badejo and Akinwole 2006).

Temporal variation in population density

The maximum population of soil inhabiting microarthropods for the soil depths 0-10, 10-20 and 20-30 cm were observed in the month of May, 2020 (46.88±3.74 x100 No./m^2); September, 2020 (19.36±5.2x100 No./m^2) and July, 2020 (9.17±1.91 x100 No./m^2), respectively (Table 1). On the other hand, the minimum population of microarthropods of 11.21±2.97 x100 No./m^2 and 4.08±2.97 x100 No./m^2 were reported in the month of December, 2019 for both the soil depth 0-10 cm and 10-20 cm, while they were completely absent in the soil samples collected from depth 20-30 cm during November, 2019 (Table 1). The seasonal fluctuations in the abundance and density of the soil inhabiting microarthropods in several ecosystems was studied globally by many pedologists (Banerjee et al. 2009, Ray et al. 2012, Parwez and Sharma 2014, Borah and Kakati 2014) indicating seasonal fluctuations with maximum and minimum densities recorded during the monsoon and post-monsoon seasons, respectively. This might be resulted from the availability of suitable soil physico-chemical factors during the monsoon season (Narula et al. 1998). Additionally, the least microarthropod population during post-monsoon was justified by the findings of Yadava and Singh (1988).

Edaphic factors and their

Table 1. Temporal variation in population density (No./m^{2}x100) of soil microarthropods across the soil profile

Month	0-10 cm	10-20 cm	20-30 cm
October, 2019	27.52±4.73	5.1±2.79	4.08±2.5
November, 2019	22.42±11.8	5.1±2.79	0±0
December, 2019	11.21±2.97	4.08±2.97	2.04±2.04
January, 2020	15.29±5.34	9.17±3.38	3.06±2.04
February, 2020	29.55±8.12	14.27±2.97	2.04±1.25
March, 2020	34.65±3.74	13.25±2.6	3.06±1.25
April, 2020	29.55±4.67	11.21±2.97	4.08±1.91
May, 2020	46.88±3.74	10.19±1.61	6.11±2.97
June, 2020	21.4±4.38	9.17±2.97	4.08±1.02
July, 2020	30.57±4.26	13.25±2.6	9.17±1.91
August, 2020	23.44±6.16	16.31±4.38	8.15±2.6
September, 2020	31.59±11.21	19.36±5.2	7.13±1.25

correlation with microarthropod popultion

During the study period, monthly variation of the soil temperature (°C) was observed in all the soil depths. The maximum soil temperature 28.2±0.1, 28.1±0.1 and 28±0.1°C were observed in the month of July, 2020 for the soil depths 0-10, 10-20 and 20-30 cm, respectively. However, the minimum temperature was observed in December, 2019 (17.5±0.1, 17.5±0.1 and 17.4±0.1°C for 0-10, 10-20 and 20-30 cm, respectively) (Fig. 2a). The regression analysis of soil temperature and total number of microarthropods revealed a positive correlation but was significant ($r = .69$, $p < 0.05$) only in the soil depth 20-30 cm (Fig. 3a). These findings were similar to those observed by Islam et al. (2015) and Shakir and Ahmed (2015). Favourable soil temperature range facilitates the growth and survival of soil microarthropods by enhancing their metabolisms (Islam et al. 2018).

The variation of the soil moisture content (%) for all the three soil depths was depicted in Figure 2b. Soil moisture content was maximum in depths 0-10, 10-20 and 20-30 cm in November, 2019 (25.64±0.38), October, 2019 (24.99±0.44) and August, 2020 (26.31±0.38), respectively. On the other hand, minimum soil moisture content was reported in the month of January, 2020 (9.44±0.36, 9.62±0.38 and 9.97±0.42 for 0-10, 10-20 and 20-30 cm, respectively). The linear regression analysis between soil moisture content with total number of microarthropods revealed no significant correlation (Fig. 3b). Similar findings were reported by Reddy (1984), Gope and Ray (2006), Moitra (2017) and Sharma and Parwez (2018). According to Sharma and Parwez (2018) increased growth of fungi was facilitated by higher moisture content, which serves as a good source of food for soil microarthropods.

Throughout the investigated period, soil pH showed variation across all soil depths. The highest value of soil pH was observed in the month of February, 2020 (4.79±0.04, 4.74±0.06 and 4.71±0.04 in the depths 0-10, 10-20 and 20-30 cm, respectively). However, the least soil pH for the depths 0-10 and 10-20 cm was in November, 2019 (3.47±0.04 and 3.69±0.02, respectively) while it was in the month of May, 2020 (3.85±0.02) for the depth 20-30 cm (Fig. 2c). A weak but non-significant correlation was seen between the soil pH and total number of microarthropods in all soil depths (Fig. 3c). Similar finding were reported by earlier works also (Banerjee 1988, Wiwatwitaya and Takeda 2005, Gope and Ray 2006, 2012). According to Lavelle et al. (1995), acidic soil limits the survivability of soil inhabiting fauna while more or less neutral soil favours the growth of soil microarthropods (Hazra and Choudhuri 1983).

Similar to that of soil moisture content and soil temperature, soil organic carbon (%) depicted a monthly variation during the study period. The highest soil organic carbon was observed in the month of April, 2020 (1.65±0.02 and 1.32±0.03) for soil depths 0-10, 10-20 cm, respectively) and January, 2020 (1.26±0.02) for 20-30 cm. However, soil organic carbon was least for the soil depths 0-10, 10-20 and 20-30 cm in September, 2020 (1.08±0.04), July, 2020 (0.98±0.02) and November, 2020 (0.87±0.02), respectively (Fig. 2d). The regression analysis between soil organic carbon and total number of microarthropods showed negative correlation in 0-10 cm soil depth but showed positive correlation in both 10-20 and 20-30 cm soil depths, albeit without showing any statistical significance (Fig. 3d) across all soil depths. Ray and Pator (2016), Pator and Ray (2020) reported similar insignificant positive correlation between soil organic carbon and microarthropods. The availability of soil organic carbon directly affects the density and diversity of soil inhabiting microarthropods (Körschens et al. 1997).

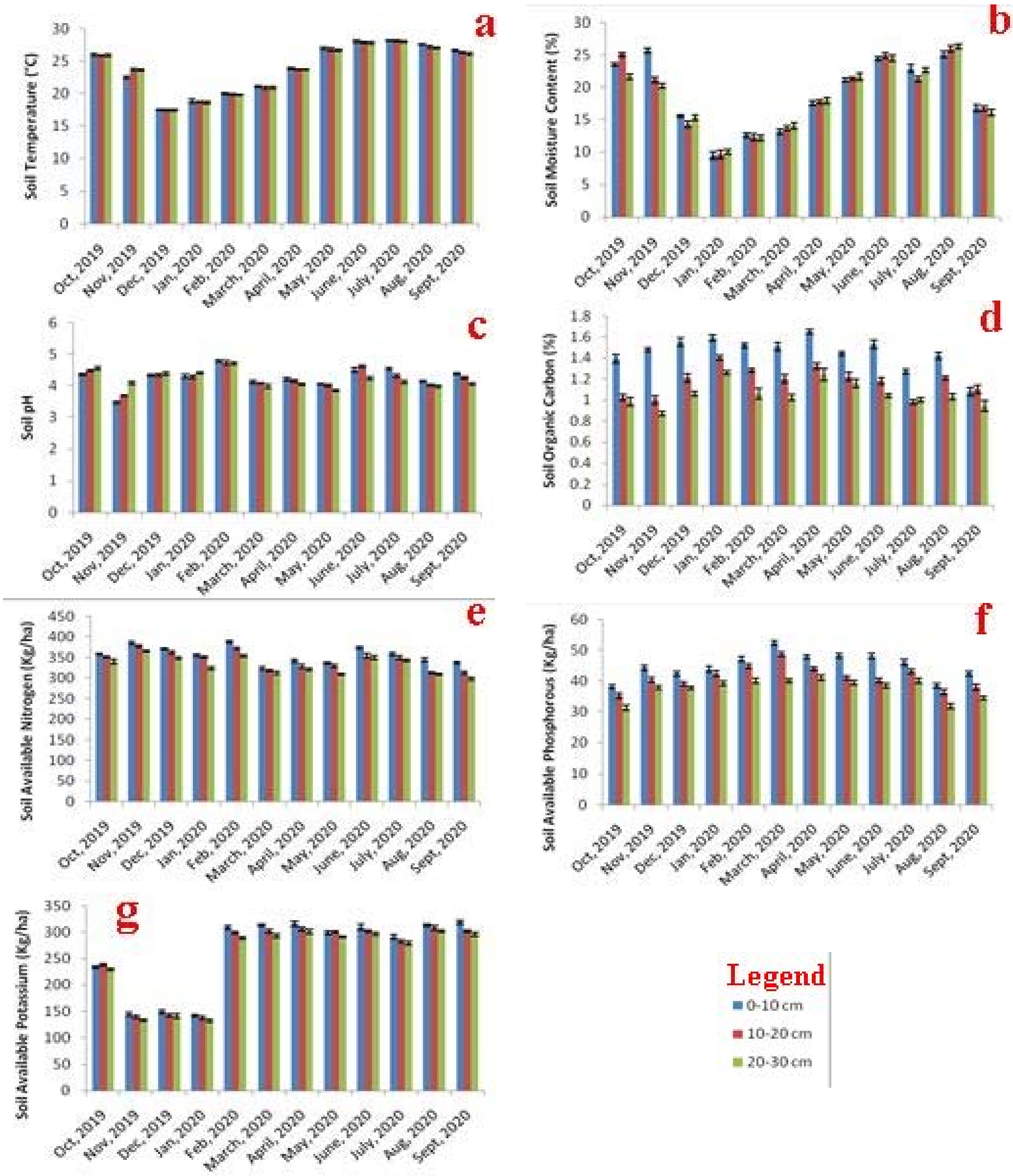

Figure 2. Monthly variation (October, 2019 to September, 2020) in edaphic factors. (a) Soil temperature (°C), (b) Soil moisture content (%), (c) Soil pH, (d) Soil organic carbon (%), (e) Soil available nitrogen (Kg/ha), (f) Soil available phosphorous (Kg/ha), and (g) Soil available potassium (Kg/ha)

Soil available nitrogen (Kg/ha) was maximum in the month of February, 2020 (389.06±2.18), November, 2019 (378.08±2.42) and November, 2019 (365.12±1.86) for soil depths 0-10, 10-20 and 20-30 cm, respectively. On the other hand, it was minimum in the month of March, 2020 (323.12±3.62) for soil depth 0-10 cm and September, 2020 (312.86±3.82, 298.14±3.62) for soil depths 10-20 and 20-30 cm, respectively (Fig. 2e). The linear regression analysis between soil available nitrogen with total number of microarthropods revealed negative correlation in all soil depths but significant ($r = -.66$, $p < 0.05$) only in the soil depth 10-20 cm (Fig. 3e). Parwez and Abbas (2012) and Verma et al. (2014) also reported non-significant correlation of microarthropods with soil nitrogen content.

Soil available phosphorous (Kg/ha) was maximum in the month of March, 2020 (52.36±0.74, 48.81±0.76) for soil depths 0-10 and 10-20 cm, respectively, and April, 2020 (41.14±0.82) for 20-30 cm. It was minimum (38.08±0.62, 35.32±0.86 and 31.26±0.86 for soil depths 0-10, and 10-20 and 20-30 cm, respectively) in the month of October, 2019 (Fig 2f). The linear regression analysis between soil available phosphorous and total number of microarthropods showed no significant correlation

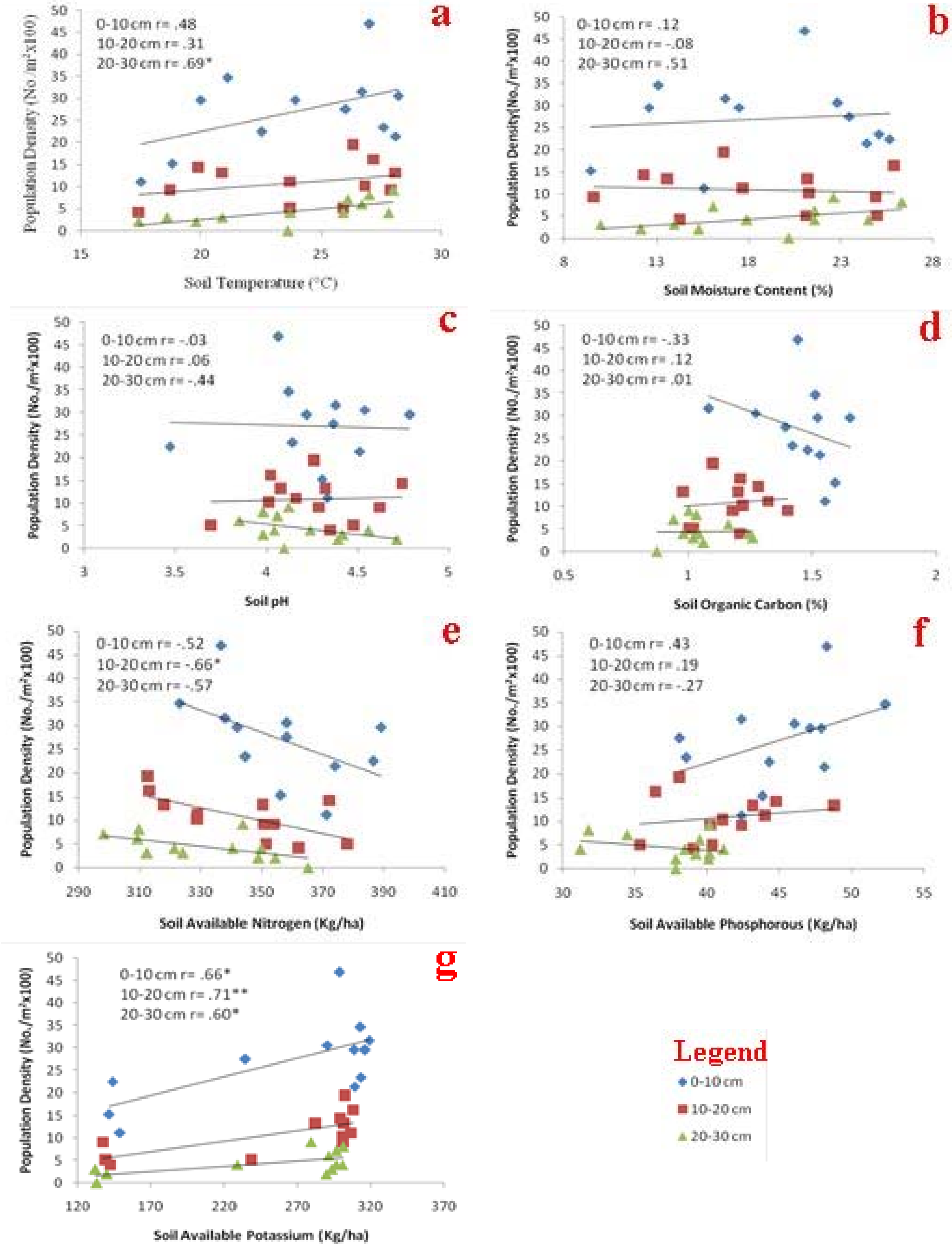

Figure 3. Linear regression between the population density of total microarthropods and the soil parameters. (a) Soil temperature (°C), (b) Soil moisture content (%), (c) Soil pH, (d) Soil organic carbon (%), (e) Soil available nitrogen (Kg/ha), (f) Soil available phosphorous (Kg/ha), and (g) Soil available potassium (Kg/ha)

(Fig. 3f). Gope and Ray (2012), Ray et al. (2012) and Islam et al. (2018) analyzed the effect of phosphorous on soil microarthropods and reported no significant relation between them and thus, clearly supporting the finding of the present study.

Soil available potassium (kg/ha) was maximum in the month of September, 2020 (318.82±3.82) for soil depth 0-10 cm and August, 2020 and 307.86±4.42 and 301.43±2.12 for soil depths 10-20 and 20-30 cm, respectively. However, it was minimum (141.46±2.12, 137.08±3.24 and 132.02±2.44 for soil depths 0-10, 10-20 and 20-30 cm, respectively) in the month of January, 2020 (Fig. 2g). The regression analysis of soil available potassium and total number of microarthropods revealed statistically significant positive correlation in all soil depths (Fig. 3g). Similar findings were also reported by Gope and Ray (2012). However, Ray et al. (2012) and Islam et al. (2018) found no such correlation.

CONCLUSIONS

The present study revealed that various physico-chemicals parameters of the soil have fluctuating effect on soil dwelling microarthropods and their influence varied. Soil temperature and soil potassium directly influenced the diversity and density of soil microarthropods and revealed statistically significant effects. Moreover, other parameters of the soil also affected the population of soil inhabiting microarthropods but did not show any statistical significance. It can be concluded that chemoedaphic factors played a vital role in manipulating the microarthropods population either as individual parameter or in combination.

ACKNOWLEDGEMENTS

The research work was supported with Senior Research Fellowship to the first author from Maulana Azad National Fellowship for Minorities Students, University Grant Commission, Ministry of Minority Affairs, Government of India, New Delhi.

Authors' contributions: All authors contributed equally.

Conflict of interest: Authors declare no conflict of interest.

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Received:24th February 2023
Accepted:15th April 2023