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Short Communication

Correlation of soil temperature and moisture with burrow dimensions of Indian gerbil (*Tatera indica)*in loamy-sand soil of Punjab

ABHA SHARMA and RAJWINDER SINGH*

Department of Zoology, Punjab Agricultural University, Ludhiana-141004
**E-mail : rajwinder-singh@pau.edu*

Rodents are vertebrate pests of agricultural crops which start causing damage from sowing till consumption of food grains (Goyal and Ghosh, 1993). Rodents constitute the largest and most ancient group of mammalsof which 40% belong to order rodentia (Kaur and Singh, 2019) due to their small size, short breeding cycle and ability to gnaw, eat a wide variety of foods, cosmopolitan in distribution and have the ability to adapt to a wide variety of habitats (Jacob and Cox, 1977). Taxonomically T. indica belong to order "Rodentia" and family "Muridae', which constitutes 41.6% of rodents found in the sandy biome. Burrows are used for different activities like nesting, food storage, hibernating and shelter (Butler, 1995). Indian gerbil is nocturnal in nature and inhabits burrows having shapes of "Y" or "V" shape, complex network of tunnels and lives as single individual in burrows (Kocher and Parsad, 2003). The length and depth of burrows varies with change in seasons, topography (Porter *et al.,* 2002), soil quality and colony size (Begall and Gallardo, 2000). The annual and seasonal climatic variability at Punjab (Hundal and Kaur, 2005), may influence the burrow formation bahaviour by rodents. Therefore, knowledge of burrowing habit of rodents is required to study their social organization, behaviour of dominance (Prakash and Mathur, 1987), population estimation and placing poison baits in burrows to control them.

The study was carried out during 2015-16 in the fields of village Ladhowaal, having loamy-sand soil, District Ludhiana (Punjab) (30.599^{0}N latitude and 75.499^{0}E longitude) and laboratory experiments were carried out in the Departments of Zoology and Soil Science, Punjab Agricultural University, Ludhiana. The farmers prefer to grow crops like maize, paddy, wheat, vegetables like radish, cabbage, spinach, carrot, lady finger, cucurbits and fodder crops. During study about 20 to 25 burrows were excavated per month and each burrow was 1-2 day old.Since the study was done on monthly basis so, the months were grouped into different seasons like winter (December to February), spring (March to April), post-monsoon (September to November), monsoon (July and August) and summer (May and June) depending upon weather conditions. During summer season, the site selected was harvested fields of wheat crop, similarly paddy crops in monsoon season, around paddy and maize crops in post-monsoon and around wheat fields during winter and spring seasons.

Excavation was done with the help of spade and khurpa. Burrow parameters recorded during excavation were length/breadth of open ends (cm), count of open/blind ends, branches, number of nest chambers, length/breadth of nest chambers, weight of hoarded food, number of rats captured. Collection of soil samples from excavated burrows were collected at different depths from zero, one and two feet. Soil was examined by recording soil temperature, soil moisture, electrical conductivity (EC), soil texture, soil pH, bulk density (D_b), particle density (D_p) and organic carbon (OC). Before taking soil sample surface litter was removed thoroughly. Soil samples were taken out separately with spade and packed in cloth bags. Soil texture was determined by method as suggested by Mehra (2014). Soil moisture content was determined by using Gravimetric method (Prihar and Sandhu, 1968). Soil temperature at varied depths (5, 10 and 30cm) was recorded by using digital soil thermometer (R-Tek^{TM} Shenzhen Tonglixing Technology Co., Ltd. China, Mainland).

Soil parameters

No ball was formed in loamy-sand soil and it was observed as gritty with length of ribbon as 0.72±0.05cm. Earlier in a study Mehra (2014) also recorded length of ribbon formed in the range from 0.50 to 1.0 cm in loamy-sand soil. With increase in depth of soil the pH value of soil also increased. Mean soil pH values recorded in loamy-sand soil, were 7.90±0.13, 7.94±0.15, 8.02±0.12 at varying soil depths 0, 1 and 2 feet, respectively. Electrical conductivity of soil decreased with increase in depth. EC value of loamy-sand soil at different depths of 0, 1 and 2 feet recorded ranged

Table 1: Moisture content (%) and soil temperature (^{0}C) of excavated *Tatera indica* burrows in loamy-sand soil during different seasons at varied depths

S. no.	Seasons	Depth(feet)	Moisture content (%)	Soil temperature(^{0}C) at different soil depths		
				5cm	10cm	30cm
1	Summer	0	8.56±0.54	36.05±0.60	34.9±0.49	33.5±0.53
		1	9.82±11.84			
		2	11.98±0.57			
		Average	10.12±0.81			
2	Monsoon	0	21.16±0.47	33.45±0.03	32.5±0.24	31.9±0.35
		1	22.0±0.35			
		2	22.66±0.11			
		Average	21.94±0.35			
3	Post-monsoon	0	17.05±0.45	27.15±4.20	26.25±4.20	26.3±3.88
		1	17.61±0.39			
		2	18.88±0.31			
		Average	17.84±0.44			
4	Winter	0	19.97±0.84	16.03±1.09	17.25±0.94	17.86±0.77
		1	20.55±0.76			
		2	21.79±0.64			
		Average	20.77±0.43			
5	Spring	0	9.92±0.92	26.25±1.44	25.1±1.62	23.25±1.23
		1	14.45±0.67			
		2	16.4±0.49			
		Average	13.59±1.05			

from 0.140±0.09 to 0.146±0.08. Bulk density of soil increased with increase in depth. The mean bulk density of loamy-sand soil at depths 0, 1 and 2 feet ranged from 1.52±0.07 to 1.57±0.01.

Particle density of loamy-sand soil at varying depths ranged from 2.63±0.05 to 2.68±0.03 and as the depth of soil increased its particle density also increased. Organic carbon of loamy-sand soil at varying depths ranged from 0.380±0.06 to 0.416±0.07. It decreased with increase in soil depth. Bulk density and particle density of loamy-sand soil increased with depth due to low organic carbon and more sand content which lead to decrease in water holding capacity that provide suitable condition for burrowing activity of rodents. Per cent moisture content of loamy-sand soil, ranged from 10.12±0.81 to 21.94±0.35 during different seasons. Per cent moisture content of soil increased with increase in soil depth. Soil temperature (^{0}C) decreased with increase in depth of soil. It ranged from 17.04±0.43 to 34.81±0.61 in loamy-sand soil (Table 3).

Burrow parameters

While excavating burrows at different times, the burrow parameters recorded are as under; Burrows of *T. indica* has single or multiple openings and it follow Y or V shaped pattern. The main entrance of burrow run deep like slanting tunnel. In loamy-sand soil, lower length (199.67±4.12cm) of burrow was recorded in summer whereas higher (255.00±6.48cm) in winter season (Table 4). The increase in burrow length was higher during winter, which declined in spring season. Similar variation was observed in recording depth during different seasons. Maximum depth (84.50±1.41cm) was observed in summer, whereas minimum (52.25±1.32cm) during winter. From our results, we have come to the conclusion that in winter season, formation of length is maximum and depth is minimum, whereas maximum depth and minimum length was observed during summer season, because of high temperature during summer season, whereas low in winter. In a study by Kaur and Singh (2019) higher mean value of length (189.34cm) and lower of depth

Table 2: Various parameters of excavated *Tateraindica* burrows in loamy-sand soil during different seasons

Parameter of burrow	Seasons				
	Summer	Monsoon	Post-monsoon	Winter	Spring
Burrow length (cm)	199.67±4.1	216.18±2.2	3.43±16.2	255.0±6.4	228.68±1.1
Burrow depth (cm)	84.50±1.4	68.87±1.3	57.43±2.8	52.25±1.3	65.18±5.8
Length of open ends (cm)	7.54±0.78	7.42±0.32	7.82±0.10	7.74±0.41	7.93±0.15
Breadth of open ends (cm)	8.96±1.15	8.09±0.16	8.58±0.82	7.76±0.25	7.08±1.41
Number of branches	3.01±0.03	5.29±0.03	4.28±0.19	2.49±0.19	3.52±0.02
Number of open ends	1.48±0.25	3.17±0.21	2.46±0.25	1.39±0.19	1.89±0.13
Number of blind ends	1.46±0.63	2.88±0.55	1.81±0.36	1.10±0.13	1.57±0.30
No. of nest chambers	1.50±0.10	1.75±0.17	1.95±0.17	1.78±0.44	0.75±0.31
Length of nest chambers (cm)	37.40±0.90	40.30±15.2	31.51±1.94	32.25±7.95	28.95±8.70
Breadth of nest chambers (cm)	33.20±1.76	35.60±6.48	31.80±1.20	27.50±10.25	24.16±9.88
Area of nest chambers (cm)	1339.05±87.29	1628.50±82.08	1125.80±53.5	968.60±54.50	718.20±42.90
Number of rats recovered	0	0	pups=5male=1 female=4	Adult=1	0
Hoarding material in food chamber	26 gm wheat straw and bushes	nest 1 = 405 gm wheat straw, nest 2 = 902 gm wheat straw,moong bean = 57 gm and wheat ears=193 gm	0	0	155gm paddy straw

(53.53cm) was recorded when mean soil temperature (^{0}C) and soil moisture (%) observed were 15.00 and 23.01, whereas lower length (163.60cm) and higher depth (76.84cm) was recorded when mean soil temperature and soil moisture (%) were 30.65 and 17.08, respectively. Mean burrow length of 159.0cm in sandy soil and 129.30cm in loamy soil was recorded in B. bengalensis burrow (Kocher and Parsad, 2003).

Relationship of soil moisture and temperature burrow dimensions

The maximum mean soil temperature was recorded during summer season (34.81±0.61^{o}C) due to high atmospheric temperature while minimum during winter (17.04±0.43^{o}C) due to low atmospheric temperature in loamy-sand. Maximum soil moisture (21.94±0.31%) was recorded in monsoon, while minimum (10.12±0.77%) was recorded during summer. There was a high atmospheric and soil temperature which tends to increase evaporation rate during summer.

In loamy-sand soil, length of burrow is positively correlated with soil moisture content (+0.573) and negatively correlated with soil temperature (-0.976). Depth of burrow is negatively correlated with soil moisture content (-0.691) and positively correlated with soil temperature (+0.875).

Linear regression equations for calculating the relationship between length, depth, soil temperature and soil moisture were developed for loamy-sand.

In loamy-sand soil, the equation derived is:

Length= 279.920-2.569×soil temperature+0.860×soil moisture (R^2 = 0.98)

Depth= 48.428+1.256×soil temperature-1.004×soil moisture (R^2 = 0.95)

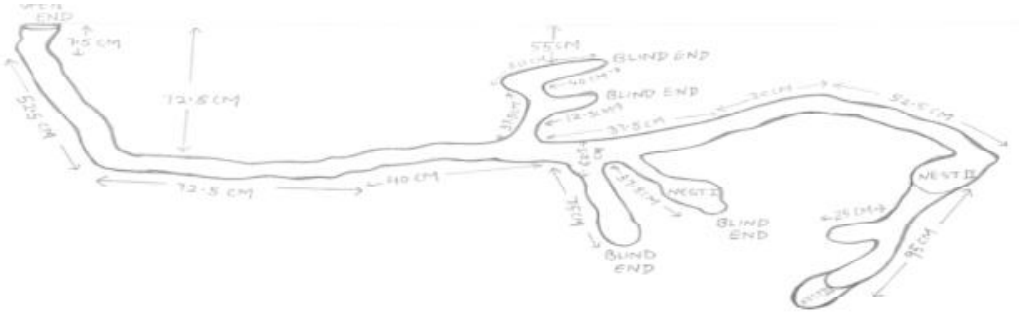

Fig 1: *Tatera indica* burrows during winter season

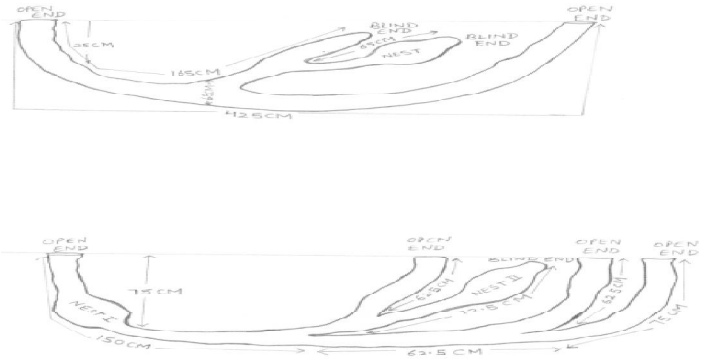

Fig. 2: *Tatera indica* burrows during summer (a) and spring season (b)

This model was statistically significant with R^2 value of 0.98 and 0.95 for length and depth, respectively. By this model, if we know the values of soil temperature and soil moisture, we can calculate the values of length and depth of burrows dig by Indian gerbil rat, (Tatera indicia), respectively if the soil is of loamy-sand in texture.

Thus it can be concluded that Indian gerbil rat dig burrows deep (84.50cm) during summer when mean soil temperature and moisture are 34.81^{0}C and 10.1%, respectively and more in length (255.0cm) in winter season, when mean soil temperature and soil moisture are 17.04^{0}C and 20.8%, respectively. Burrow length in loamy sand soil is positively correlated with soil moisture content and negatively correlated with soil temperature. Depth of burrow is negatively correlated with soil moisture content and positively correlated with soil temperature. Present study is useful for the management of rodents in crop fields i.e., for placing poison baits in burrows, to reduce rodent damage.

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