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EFFECT OF MOISTURE CONTENT AND PARTICLE SIZE OF SOIL ON TUNNELING ACTIVITY OF SAND TERMITE *PSSAMOTERMES HYBOSTOMA* (DESNEUX) UNDER LABORATORY CONDITIONS

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ABSTRACT: *Experiments of the research were conducted at Youssef El-Sediek locality, Fayoum Governorate to study the effect of soil moisture and particle sizes on the tunneling activity of sand termite, Psammotermes hypostoma (Desn.). The Obtained results revealed that, the highest results of tunneling activity were recorded of the treatments of 10, 20 and 30 water per 100gm sand soil 850µ and 250µ as particle sizes, while the lost results of tunneling was recorded at the treatment of 40ml water per 100gm sand soil (850µ and 250µ). Tunneling activity was gradually increased at moisture level of 20 and 30ml per 100gm soil for the two tested soil particle size. Tunneling ability (Length and branches numbers) was higher in the tested of soil particle size 250µ, at all moisture levels than the tested particle size 850µ. Statistical analysis clarified that, the differences between tested factors, (moisture levels and soil particle size), were highly significant with variable factors, (Length and number of branches). The recommendation of the best period of control at increasing of surface activity (highly population density).*

Key words: *Tunneling, Branches, Moisture, Particle size, sand termite, P. hybostoma.*

INTRODUCTION

Subterranean termites are highly susceptible to soil factors, moisture, temperatures and chemicals. Subterranean termites live in tunnels covered inside by wax layer for maintenance of suitable factors. Many studies have examined the influence of moisture content on the tunneling and feeding behavior of subterranean termites, Evans (2003); Su and Puche (2003); Arab and Costa-Leonardo (2005); Green *et al,* (2005); Mc Manamy *et al,* (2008) and Gautam and Henderson (2011a, 2011b). In order to tunnel into dry soils, termites need to relocate water molecules from moist soil into the dry soil by using their salivary reservoirs as water sacs, Grube and Rudolph (1999a, 1999b); Gallagher and Jones (2010). In a study where the only available food source was located on dry soil, mortality of the subterranean termite *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae) was high, even though termites were able to travel freely between moist sand and dry soil. Clusters of desiccated termite bodies were observed on the surface of the dry soil in many of the replicates, possibly due to rapid desiccation caused by contact with dry soil, and there is an interaction between moisture availability and soil type. Both moisture retention and availability are affected by particle size. Water retention is higher in soils with smaller particles sizes, but moisture availability is greater in soils with larger particles sizes. Hence, termites are able to obtain of water from sandy soils with lower water content than clay soils, Lys and Leuthold (1994). Moisture availability affected *C. formosanus* preferences for different soil types. When soils were moist, termites were significantly more likely to aggregate in topsoil than in potting soil or peat moss. In moist soils, termites aggregated in the soil with the smallest particle size and the least organic matter. When soils were dry, termites were significantly more likely to move into the soils containing the largest amount of organic matter, peat moss and potting soil, than into the soils with the least amount of organic matter, sand and clay, Cornelius and Osbrink (2010). The present study was conducted to evaluate the tunneling activity of sand termite throughout two tested particle sizes and four moisture levels under laboratory conditions.

MATERIALS AND METHODS

Termite and soil collection:

In Kasr Al-Gebaly region, Youssef El-Sediek district, at Fayoum Governorate, an area of about (600m^2) highly infested by subterranean termite *Psammotermes hybostoma,* (Desneux) was selected to obtain a great numbers of subterranean termites *Psammotermes hybostoma,*. All superficial and partially buried of dead and debris were removed from this area to prevent any nutrient interferences with the applied traps. Traps were inspected and individuals were separated from the traps by using small brush, then the different casts were maintained in plastic boxes for using in test, and subterranean termite can be live for 2-4 months or more in moisten sand soil with source of cellulose.

Soil collection and screening:

Soil samples were taken at depths of 30, 60, 90cm from the different sites of infested area, where the termite activity was carried out and the samples were mixed for each depth. Samples were screening to obtain coarse particle size 850µ and fine particle size 250µ by using USA Standard Testing Sieve (ASTM. E11. Specification).

The field work:

Naturally infested area (600m^2) with sand termite *P. hybostoma*, was irrigated and left to full dry. 50 holes were arranged in 10 rows and 5 column, with 2m^2 intervals between this holes and the hole depth was 12cm. 50 traps (P.V.C. trap consists of cylindrical container from a thermo plastic polymer, (12cm length and 7cm in diameter), the cylindrical container was drilled 6-9 drills and corrugated card board roll 12cm length and 5-7cm diameter was putted inside it, Fig (1). Card board traps were prepared in the laboratory and distributed in the 50 holes which prepared previously after moistation with water for termite attraction and buried in the soil holes, El-Sebay modified trap (1991). The P.V.C traps were appear on the soil surface for simplify place it disseveration. Traps were collected every 15 days and replaced by new ones. Termite collections were kept in tightly closed plastic bags and transported at laboratory for examined and separation of healthy termite individuals. Healthy termites from all caste were used in the treatment.

The laboratory work:

An apparatus designed by N. Johnson, USAD, Forest Service, USA (Jones, 1988), was adopted for the termite make crossing to the soil. Design consists of double transparent plastic plates attached in between together with 2mm distance, except from above and fixed in a base on wooden carrier. A hole 1cm in diameter make on one side of plates and fixed with 30cm long of plastic tube attached with a plastic cup, Fig (2). 100gm of soil particle size were putted between double plates with a piece of corrugated cardboard 5 × 5cm, putted in the plastic cup, El-Sebay, Y. (1993) and El-Bassiouny (2007). Soil particle sizes were 850µ and lower, as well as, 10, 20, 30 and 40ml of water sizes were chosen as a moisture to study their effects on termite tunneling activity, and the water volume were added to tested soil by siring from above of double plates and then, plates were closed from above for maintenance of moisture. One hundred healthy termite workers were liberated in the plastic cup and covered with led. Control contained sand without moisture. Treatments and control were replicated five times, investigated daily. Length and number of tunnels branches) were taken after 1, 2, 3 and 4weeks, Jones (1988), Games *et al* (1990) and El-Sebay (1993).

Statistical analysis:

The obtained data were analyzed using Proc ANOVA in SAS (SAS Institute 1988).

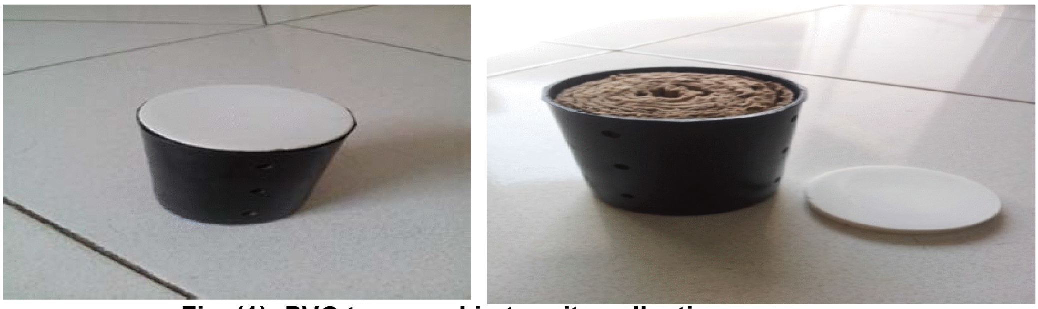

Fig. (1): PVC trap used in termite collection

Fig. (2): Illustration of design used in tunneling activity

RESULTS AND DISCUSSIONS

The soil moisture consider essential factors for all termite activity and the termite, when make new generation start firstly in nest construction (Tunneling activity), so, termite start to penetrate soil and go through to tunnels its pathways. Tunnels branching (number and length), just one to evaluate termite activity. The present work could be assist to knowledge the importance of moisture to determine the highly numbers of population (surface activity), it is suitable time for control.

Data illustrated in Table (1) and Figures (3&4), at soil treated with 10ml moisture and particle size 850µ, at 1^{st} week, the length and number of tunnel branches, calculated 29.8ml and 1.8 in average for each, respectively, while at 2^{nd}, 3^{rd} and 4^{th} week, data resulted (58.2ml & 3.6), (85.8ml & 5) and (110.4ml & 6.4), in average respectively. At soil treated with 20ml moisture, data resulted (40.8ml & 2.8), (81.0ml & 5.2), (129.8ml & 8.8), and (169.4ml & 11.4), for length and branches number at 1^{st}, 2^{nd}, 3^{rd} and 4^{th} week, respectively. Also at the trend the results were (74.6ml & 3.8), (108.8ml & 7.8), (144.4ml & 11), and (172.6ml & 14.2), at soil treated with 30ml moisture for all, respectively. But, when added highly amount of moisture 40ml, termites were unable to construct tunnels and counted lower values in the four weeks, (15.8ml & 1.2), (43.4ml & 1.8), (34.8ml & 2.4), and (35.8ml & 2.6) for length and branches number, respectively. Tunneling activity was not found in controlz

Scheffrahn *et al.,* (1988), in Florida, reported that in a laboratory study the barriers composed of mixed particle sizes (1.18-2.80mm) effectively prevented penetration by both *C. formosanus* and *R. flavipes.* When the laboratory prepared sized particle barriers were exposed to field populations of subterranean termites, effective ranges were smaller than those reported from the laboratory study. In areas where both C. *formosanus* and *Reticulitermes* spp. occur, the two single-size particle beamers (2.00-2.36mm and 2.36-2.80mm) appeared to be the most effective exclusion devices against field populations of these subterranean termites. Su *et al.* (1991), at a laboratory study, found that soil beamers composed of particles 1.7-2.4mm in diameter were not penetrated by C. *formosanus,* and that a wider size range

Table (1): Length and Number of tunnels of sand termite *P. hybostoma*, throughout 4 weeks as affected four in moisture degrees in coarse soil of (850µ) particle size.

Soil treated with 10ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	26	2	67	4	95	7	132	8
2	51	3	90	5	130	7	155	9
3	25	2	48	4	92	5	143	8
4	47	2	86	5	112	6	122	7
5	00	0	00	0	00	0	00	0
Mean	29.8	1.8	58.2	3.6	85.8	5	110.4	6.4
Soil treated with 20ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	36	3	81	5	131	9	164	11
2	55	4	90	5	120	8	185	12
3	34	2	92	6	142	9	191	13
4	34	2	66	5	134	10	144	11
5	45	3	76	5	122	8	163	10
Mean	40.8	2.8	81	5.2	129.8	8.8	169.4	11.4
Soil treated with 30ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	83	4	105	7	135	11	160	15
2	78	3	110	8	144	10	189	16
3	43	2	77	5	120	9	120	10
4	100	6	150	10	168	15	200	17
5	69	4	102	9	155	10	194	13
Mean	74.6	3.8	108.8	7.8	144.4	11	172.6	14.2
Soil treated with 40ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	23	2	23	2	23	2	23	2
2	12	1	44	2	57	5	62	6
3	24	1	33	2	33	2	33	2
4	20	2	50	3	61	3	61	3
5	00	0	00	0	00	0	00	0
Mean	15.8	1.2	43.4	1.8	34.8	2.4	35.8	2.6
Control soil only without water								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0

L.T. = Length of tunnel /mm
N.B. = Number of branches / tunnel

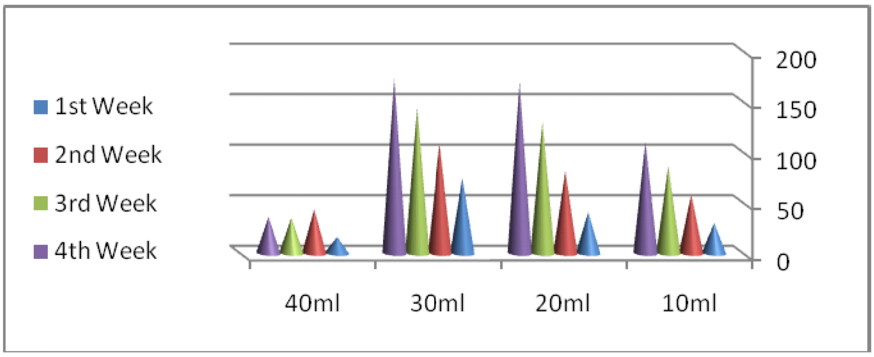

Fig. (3): Average numbers of tunnel lengths (cm)/week of *P. hybostoma* in 850µ soil particle size

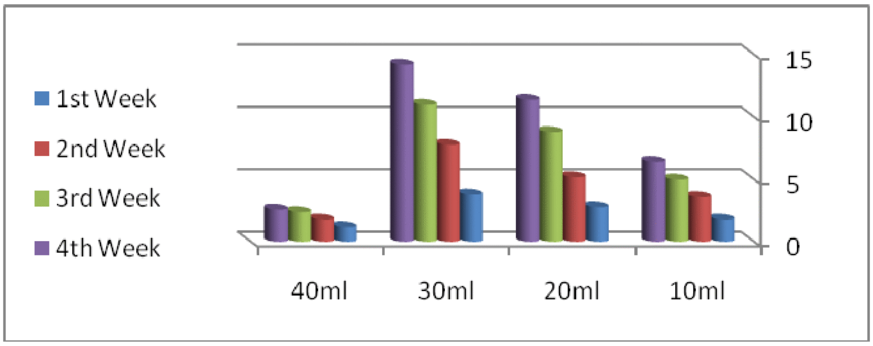

Fig. (4): Average numbers of tunnel branches (cm)/week of *P. hybostoma* in 850µ soil particle size

of particles (1.00-2.36mm) excluded penetration by the eastern subterranean termite, *Reticulitermes flavipes* (Kollar). SU and Scheffrahn (1992), mentioned that, barriers of seven single-sized and two mixed-sized particles were exposed to field populations of the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, and the eastern subterranean termite, *Reticulitermes flavipes* (Kollar) for 1-3mm compared with previous laboratory results, field populations of subterranean termites were generally more successful in penetration of sand barriers composed of sized particles. El-Bassiouny (2007), stated that, the tunneling distance and number of branching were the highest with the large soil particle size, while it was less at the small particle size treated with insecticides. The fine treated soil was more toxic and termites were died quickly in the tunnels than in the coarse soil.

Data in Table (2) and Figs. (5&6), clarified that, in the soil particle size 250µ, treated with 10ml moisture, the average length and number of tunnel branches were (39.4ml & 2.8), (72.4ml & 6.2), (105.2ml & 8.8) and (131.4ml & 10.6), branches throughout the 1st, 2nd, 3rd and 4th week respectively. At the same trend, data resulted (62.4ml & 4.2), (92.2ml & 7.4), (134.2ml & 11.4), and (168.2ml & 14.2), for all at 1st, 2nd, 3rd and 4th week, respectively, in tested soil treated with 20ml moisture. Also at soil treated with 30ml moisture, the results were (88.8ml & 5.6), (126ml & 9.2), (168.6ml & 13.2), and (185.8.6ml & 17.2), for length and branches number throughout the four weeks, respectively. At high volumes of water (40ml moisture), results were the lowest and counted in the four weeks, (20ml & 1.8), (32.4ml & 2.6), (38.6ml & 3.4), and (44.6ml & 4) for length and branches number, respectively.This means

Table (2): Length and number of tunnels subterraneantermite *P. hybostoma*, throughout four weeks affected by fourmoisture degrees to fine particle size 250µ.

Rep.	1st week		2nd week		3rd week		4th week	
Soil treated with 10ml water								
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	65	4	92	7	135	11	173	13
2	00	0	38	3	62	5	72	6
3	55	4	80	9	125	11	158	14
4	23	2	55	5	82	7	92	8
5	54	4	97	7	122	10	162	12
Mean	39.4	2.8	72.4	6.2	105.2	8.8	131.4	10.6
Soil treated with 20ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	84	5	109	8	142	13	179	16
2	76	5	96	7	149	11	183	15
3	60	4	101	8	130	10	171	13
4	34	3	74	6	107	10	117	11
5	58	4	81	8	143	13	191	16
Mean	62.4	4.2	92.2	7.4	134.2	11.4	168.2	14.2
Soil treated with 30ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	93	6	125	9	166	14	200	19
2	98	5	134	9	175	13	211	17
3	53	4	84	7	127	11	140	15
4	112	8	164	12	194	16	238	18
5	88	5	123	9	181	12	240	17
Mean	88.8	5.6	126	9.2	168.6	13.2	185.8	17.2
Soil treated with 40ml water								
Rep.	1st week		2nd week		3rd week		4th week	
	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.	L.T.	N.B.
1	31	3	53	4	63	6	73	7
2	00	0	00	0	00	0	00	0
3	47	4	64	5	74	6	84	7
4	22	2	45	4	56	5	66	6
5	00	0	00	0	00	0	00	0
Mean	20	1.8	32.4	2.6	38.6	3.4	44.6	4
Control soil only without water								
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
Mean	0	0	0	0	0	0	0	0

L.T. = Length of tunnel / mm
N.B. = Number of branches / tunnel

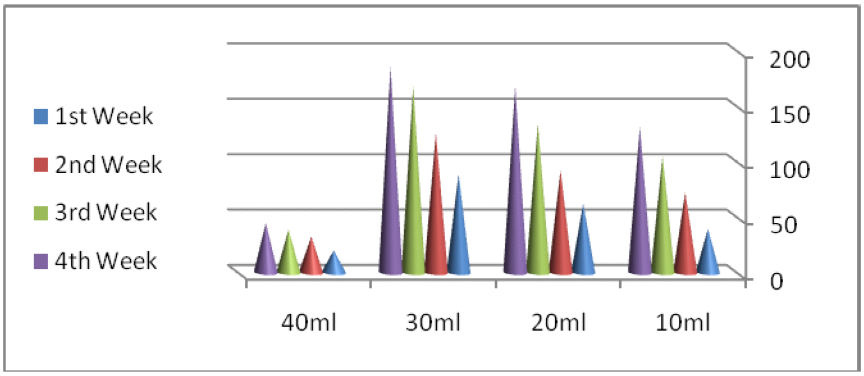

Fig. (5): Diagrammatic drawn clarified the effect average of different moisture degrees on tunnel lengths / Week of *P. hybostoma* in soil particle size 250µ.

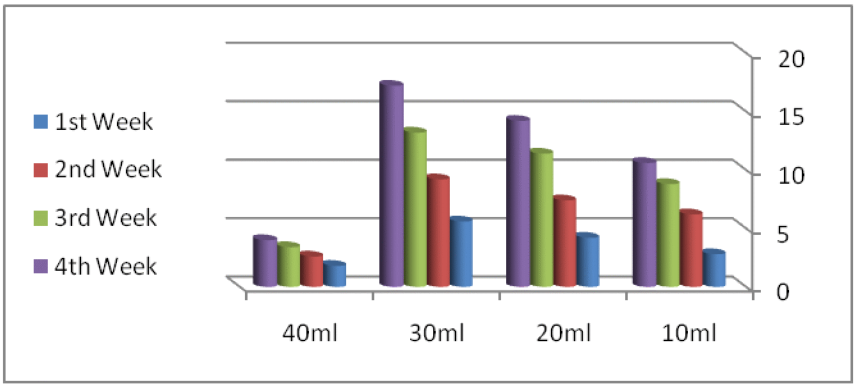

Fig. (6): Diagrammatic drawn clarified the effect average of different moisture degrees on tunnel numbers (Branches) / Week of *P. hybostoma* in soil particle size 250µ.

that, the increasing of moisture caused decreasing in termite activity and escape to subsurface activity. Data indicated that, the suitable moisture level caused highly termite activity, as well as tunneling activity, and vice versa in case of unsuitable moisture (increasing moisture), so, the recommendation of the best period of control must be at increasing of surface activity (highly population density).

El-Bassiouny (2001), mentioned that, surface activity (food consumption and soil translocation and population) was higher during autumn and winter, while was lower in summer. Smith and Rust (1990), found that *Reteculetermes hesperus* did not penetrate beamers consisting of particles of 8-20 mesh (0.85-2.36mm dim.). Tunneling activity was not found in control.

Finally, the tunneling activity and number of branching decreased by the increases of the soil moisture content. On the other hand the high density and suitable quantity of added water to soil were the principal factors in tunneling activity of termites *P. hybostoma* (Desn.), with treated particle sizes of soil.

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تأثير الرطوبة الأرضية وحجم حبيبات التربة على نشاط بناء الأنفاق لحشرات نمل الرمال " ساموترمس هيبوستوما " تحت الظروف المعملية

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الملخص العربى

تم إجراء هذا البحث معمليا وذالك لدراسة تأثير المحتوى الرطوبى على النشاط البنائى لنمل الرمال " ساموترمس هيبوستوما " وأثبتت النتائج أن النمل الأبيض المختبر خلال الأسابيع الأربعة كان قادرا على بناء الأنفاق خلال مستوى الرطوبة 10 ، 20 ، 30 مل/100 جرام تربة رملية و كان غير قادر على بناء الأنفاق عند مستوى رطوبى 40 مل/100 جرام تربة رملية لكل من أحجام التربة المختلفة 850 ، 250 ملليميكرون . أيضا كان معدل بناء الأنفاق أقل فى مستوى رطوبة 10 مل ثم إزداد تدريجيا فى كل من المستويين 20 ، 30 تدريجيا على التوالى لكل من الأحجام المختبرة للتربة . كما أثبتت النتائج أن معدل بناء الأنفاق (طول وعدد الأنفاق) كان مرتفعا فى حجم التربة 250 ملليميكرون عنه فى حالة حجم التربة 850 ملليميكرونفى كل مستويات الرطوبة المختبرة . وأثبتت نتائج التحليل الإحصائى أن هناك فروق معنوية عالية بين العوامل المختبرة . من خلال النتائج السابقة نوصى بإجراء مكافحة النمل الأبيض وقت إرتفاع النشاط السطحى فى فترات توافر مستوى رطوبى مناسب .