Effect of Soil Mixing with Organic Residues on Some Physical Properties of Soil and Plant Growth

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ABSTRACT

The effect of soil mixing with various organic materials on the physical properties of soil and plant growth was studied in the nursery of the Experimental Station of Al-Fateh University in Tripoli, Libya in 1978–1979.

Water holding capacity (WHC), and aeration porosity (AP) are the two main physical properties in consideration, both were effectively altered by soil mixing. The best results were obtained by adding 50% peat moss to 50% sand (M_3). WHC has increased from approximately 10% by volume in M_1 to approximately 35% in M_3. AP was reduced by mixing from approximately 17% on volume basis for M_1 to approximately 9% in M_3. As for the best plant growth M_3 is selected for growing *Eucalyptus camalgulensis* Dehn. For stronger and better stands; however, M_9 (50% sand + 50% peat moss + compound fertilizer + fish meal) is preferred. If sawdust is used as a substitute for the imported peat moss, it should be treated with urea before being incorporated into the mixture.

INTRODUCTION

The sandy soils used as a growing media in most of the nurseries in Libya, is not satisfactory for the production of high quality plant (10). Sand cultures are expensive media because of its low retension of moisture and nutrients. Hartmann and Kester (6) stated that sand contains virtually no mineral nutrients and has no buffering capacity. It is therefore used mostly in combination with organic materials. Mahdi and Sallam (9) reported that the incorporation of peat moss with sandy soils provides media with better physical conditions, yet because of their low level of nutrients, these mixtures are not the ideal media for the propagation of ornamental plants. Therefore, macro and micro nutrients should be added. Water holding capacity and aeration porosity are the most important physical properties to be altered by soil mixing. The mixtures of loamy soil, sand and peat are used to provide well aerated media for germination (6). Cowan (3) reported that when sawdust was mixed with peat and sand they form a successful rooting media for the nursery. The distribution and rate of

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growth of forest stands are influenced by soil physical, chemical and biological properties (5). The addition of NPK fertilizers assures a successful stand and better growth. Cromer (4) found that the application of N and P fertilizers to various Eucalyptus species had increased the growth.

Many attempts were made to improve both the physical and chemical properties of sandy soils. Soil mixing by adding organic residues is one of those attempts. The objectives of this study were:

1. To compare the effectiveness of the different materials used for mixing.
2. To find the best mixing ratio for best plant growth.
3. To test the nutritional status of these mixtures by comparing the growth in the non fertilized mixtures with the fertilized one.

MATERIALS AND METHODS

This experiment was carried out in the nursery of the Experimental Station of the Faculty of Agriculture, Al-Fateh University in Tripoli, Libya (S.P.L.A.J.). The characteristics of soil used for the study are shown in Table 1. The 12-24-12 compound fertilizer, peat moss, fish meal and sawdust were used in different combinations to grow transplants of *Eucalyptus camaldulensis* Dehn.

Table 1. Characteristics of soil used in the study.

Texture Name	Particle Density g/cm^3	Bulk Density g/cm^3	Sand %	Silt %	Clay %	OM %	$CaCO_3$ %	WHC %	AP %
Sandy	2.63	1.52	95.94	2.44	1.62	0.16	7.2	10	17

Eucalyptus camaldulensis Dehn. (River red gum) Fam. Myrtaceae is one of the Australia's commonest, and best evergreen gum trees. It is found in the dry and temperate main land of Australia (8). It was introduced to the Mediterranean countries in the nineteenth century (1).

The seeds were sown on February 15, 1978, in the green house in trays filled with a mixture of equal parts of sand and peat moss. In June 5, 1978 (110 days after sowing) one seedling was transplanted in a black polyethelene bag 16 cm high and 9 cm in diameter), containing the following soil mixtures:

1. 100% sand — M_1
2. 75% sand + 25% peat moss — M_2
3. 50% sand + 50% peat moss — M_3
4. 75% sand + 25% sawdust — M_4
5. 50% sand + 50% sawdust — M_5
6. 50% sand + 25% peat moss + 25% sawdust — M_6
7. 100% sand + compound fertilizer + fish meal — M_7
8. 75% sand + 25%peat moss + compound fertilizer + fish meal — M_8
9. 50% sand + 50% peat moss + compound fertilizer + fish meal — M_9
10. 75% sand + 25% sawdust + compound fertilizer + fish meal — M_{10}
11. 50% sand + 50% sawdust + compound fertilizer + fish meal — M_{11}

12. 50% sand + 25% peat moss + 25% sawdust + compound fertilizer + fish meal M_{12}

The chemical fertilizer and fish meal were added to the last six mixtures (7 to 12) at a rate of 1.5 kg/m^3 and 1 kg/m^3, respectively. Each of the twelve mixtures was mixed thoroughly before putting in the bag.

The lay out of the experiment was split plot design with three replicates and twelve treatments, with 15 transplants being used per treatment. The data recorded included:

1. Plant height which was recorded every other month from July 8, 1978 to May 8, 1979.
2. Stem diameter which was recorded every other month by a caliber, one cm above soil surface during the period from November 6, 1978 to May 9, 1979.
3. Number of leaves which was recorded every other month from August 4, 1978 to April 11, 1979.
4. Fresh and dry weight of plant tops was recorded 486 days after sowing.
5. The aeration porosity of soil for the first six mixtures (M_1 to M_6) was determined using the pressure plate apparatus (2).
6. The water holding capacity of soil for the six mixtures (M_1 to M_6) was determined using the pressure plate apparatus (7).

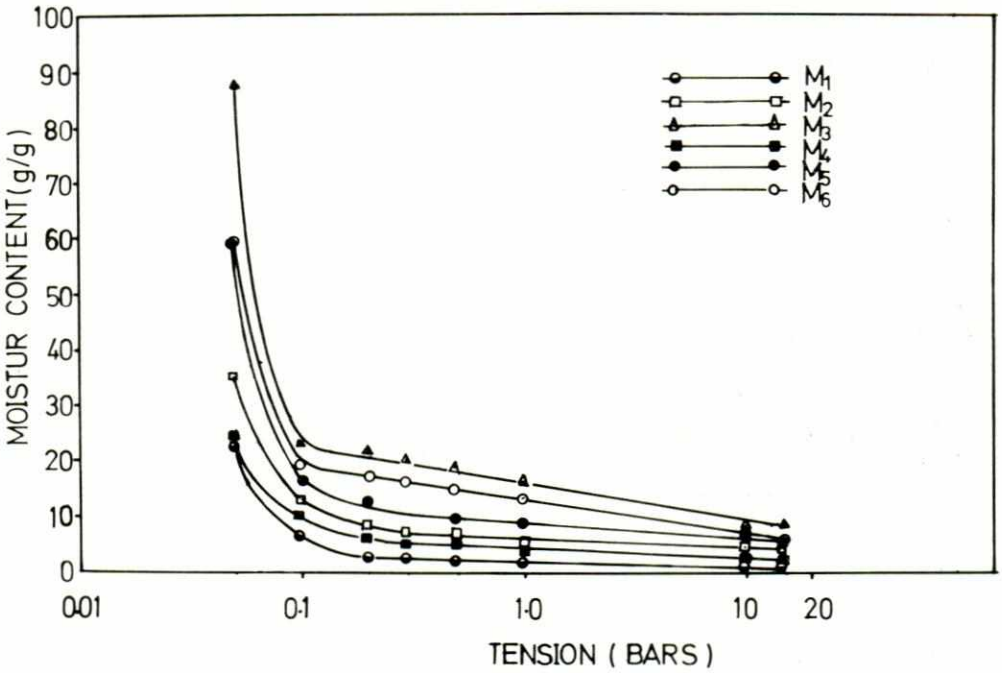

Fig. 1. Moisture tension curves for different soil mixtures.

RESULTS AND DISCUSSION

Data presented in Figure 1 shows the values of moisture content held by the different soil mixtures at various tensions, these values are on weight basis. The data indicated that addition of peat moss and or sawdust increased the moisture holding capacity of

the sandy soils (M_1). The available water was also varied due to soil mixing from 5.20% in M_1 to 8.65, 14.11, 7.60, 9.72 and 10.78% in M_2, M_3, M_4, M_5 and M_6 respectively. The highest value however reached in mixture M_3, the best mixture to be considered from the point of view of water holding capacity and the best condition as far as providing enough moisture for the plant growth. On the other hand the values of the aeration porosity shown on the same Figure (under tension value of 0.05 bar) supports this conclusion. The data indicated that M_3 provides the best conditions for plant growth from the stand point of both moisture as well as aeration. The conclusion that can be drawn from that is the effectiveness of peat moss in improving the soil structure, it is more effective than sawdust.

The data recorded on plant height and presented in Table (2), (3), and Fig. 2 indicated that the plant height within the non fertilized mixtures was significantly higher in M_3 than that recorded for M_1 mixture while there was no significant difference in height between M_1 and M_2. Due to the inhibiting effect of sawdust, the mixtures M_4, M_5, and M_6 showed a lower plant height than the other three mixtures (M_1, M_2 and M_3).

The same trend was recorded for the fertilized mixtures (M_7 to M_{12}), the tallest height was reached for M_9, the shortest was recorded for plants grown in mixtures including sawdust M_{11}.

There was a significant difference in plant height between the fertilized and non fertilized mixtures, the average was 28.50 cm for the former and 15.99 cm for the latter.

The data presented in Tables (4, 5), and Fig. 3 showed that within the non fertilized mixtures, plants grown in M_3 had developed the largest stem diameter. In the second order came M_2 and M_1 respectively, with no significant difference between the two averages.

The data showed a highly significant difference in the average stem diameter between the fertilized and non fertilized soil mixtures. The average stem diameter was 3.17 mm for the fertilized soil mixtures, and 2.17 mm for the non fertilized.

The results showed no significant difference in stem diameter within plants grown in the fertilized mixtures, however, the addition of sawdust to the mixtures had caused a significant decrease in stem diameter compared with other mixtures.

Data presented in Tables (6, 7) and Fig. 4 showed no significant difference between the average number of leaves of the first three mixtures (M_1, M_2 and M_3). The incorporation of sawdust in mixtures M_4 (13.50) and M_5 (12.81) had caused a significant decrease in the number of leaves compared with the first three mixtures. The difference was not significant however, between M_1 and M_6. No significant difference was recorded for the number of leaves in the first 3 mixtures of fertilized group; however, the incorporation of sawdust had caused a significant decrease in the number of leaves.

The data indicated a highly significant difference between the average number of leaves of the fertilized mixtures (19.55), and the non fertilized mixtures (16.17).

Data presented in Tables (8, 9, 10) and Fig. 5 & 6 indicated no significant difference in average weight of tops between the fertilized and non fertilized mixtures.

A heavier fresh and dry weight of tops was obtained from plants in M_3 mixtures than those obtained from the other 5 mixtures. This trend was a little different for the fertilized mixtures, where M_7 gave the highest value for both fresh and dry weight compared with the other 5 mixtures (M_8 to M_{12}), the difference however, was not

Table 2. Mean Height of *Eucalyptus camaldulensis* as Affected by Different Soil Mixtures and Plant Age, in cm.

Soil mixtures	Plant age										
	Jul.	Aug.	Sept.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Mean
Sand 100%	4.47	7.35	10.98	21.54	22.89	24.46	25.78	28.97	30.89	33.34	21.07
Sand 75% + Peat 25%	4.87	9.10	13.68	22.94	24.54	25.60	27.87	30.28	34.22	38.90	23.20
Sand 50% + Peat 50%	5.84	11.31	18.36	27.09	27.77	28.89	30.47	32.71	34.68	38.34	25.55
Sand 75% + Sawdust 25%	2.95	4.46	4.76	7.14	7.30	8.48	8.67	9.32	11.08	13.21	7.74
Sand 50% + Sawdust 50%	4.83	6.65	6.66	8.42	8.78	9.76	9.78	10.57	11.94	14.25	9.17
Sand 50% + Peat 25% + Sawdust 25%	3.55	4.77	5.67	8.67	9.13	10.06	10.35	11.11	13.08	15.92	9.23
											15.99
Sand 100% + F	8.40	17.12	26.50	39.74	41.89	42.87	45.07	46.94	52.39	59.95	38.09
Sand 75% + Peat 25% + F	11.41	18.53	28.92	37.17	38.12	40.26	41.92	43.95	48.06	51.65	36.00
Sand 50% + Peat 50% + F	17.22	22.60	35.41	46.72	49.04	49.12	51.21	53.09	56.39	60.43	44.12
Sand 75% + Sawdust 25% + F	4.60	7.37	8.66	12.68	13.84	15.70	15.94	17.03	19.73	23.67	13.92
Sand 50% + Sawdust 50% + F	4.41	6.39	7.98	11.76	12.55	13.45	13.65	14.69	17.82	23.64	12.63
Sand 50% + Peat 25% + Sawdust 25% + F	10.20	16.03	21.28	26.50	27.33	28.91	29.59	30.97	33.90	37.75	26.25
											28.50
Mean	6.90	10.97	15.74	22.53	23.60	24.80	25.86	27.47	30.35	34.26	22.25

L.S.D. (0.05) for plant age = 3.72 cm
L.S.D. (0.05) for soil mixtures = 4.08 cm
L.S.D. (0.05) for plant age X soil mixtures = 12.90 cm
F = NPK fertilizer + Fish meal

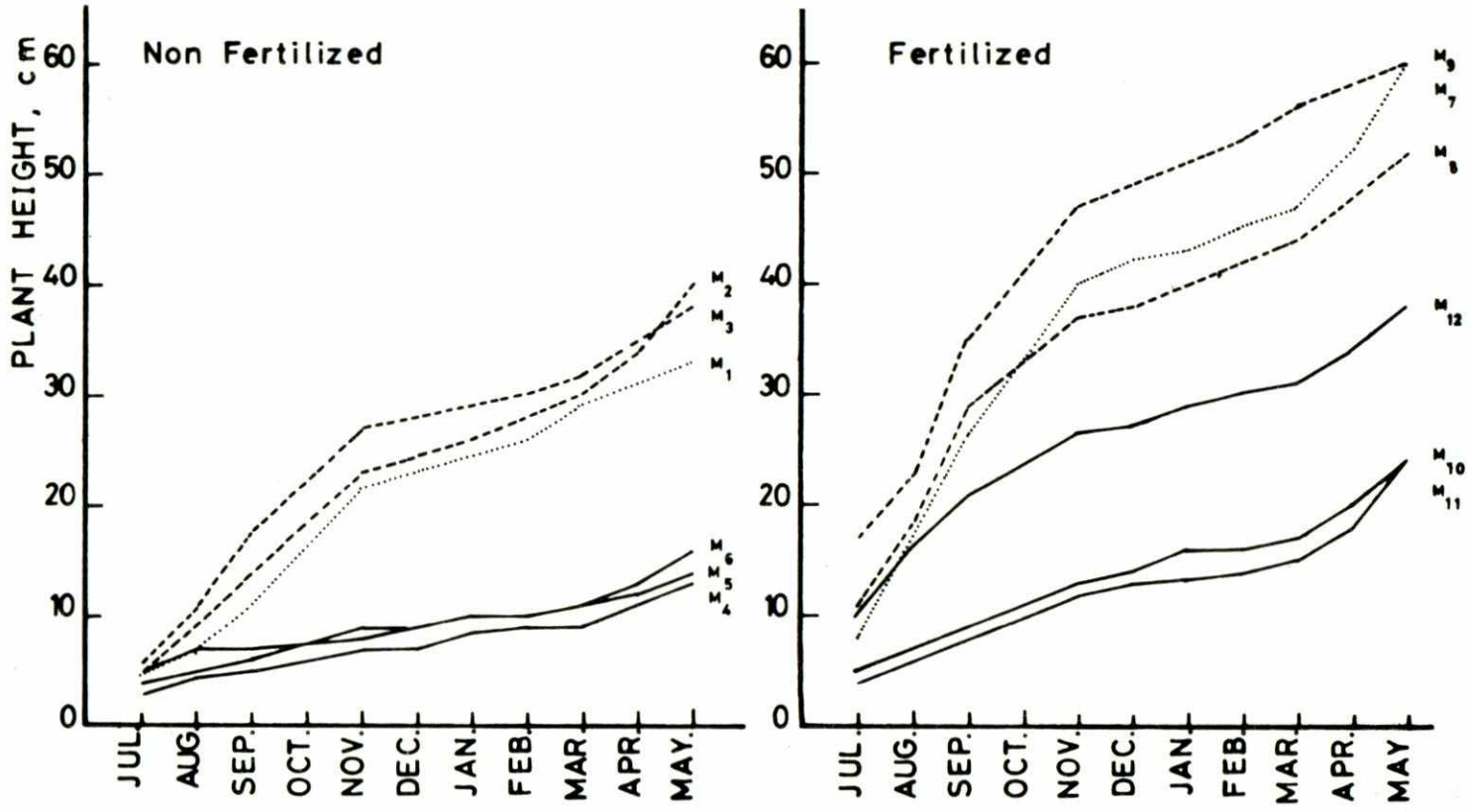

Fig. 2. Effects of soil mixtures on the height of *E. Camaldulensis* plants.

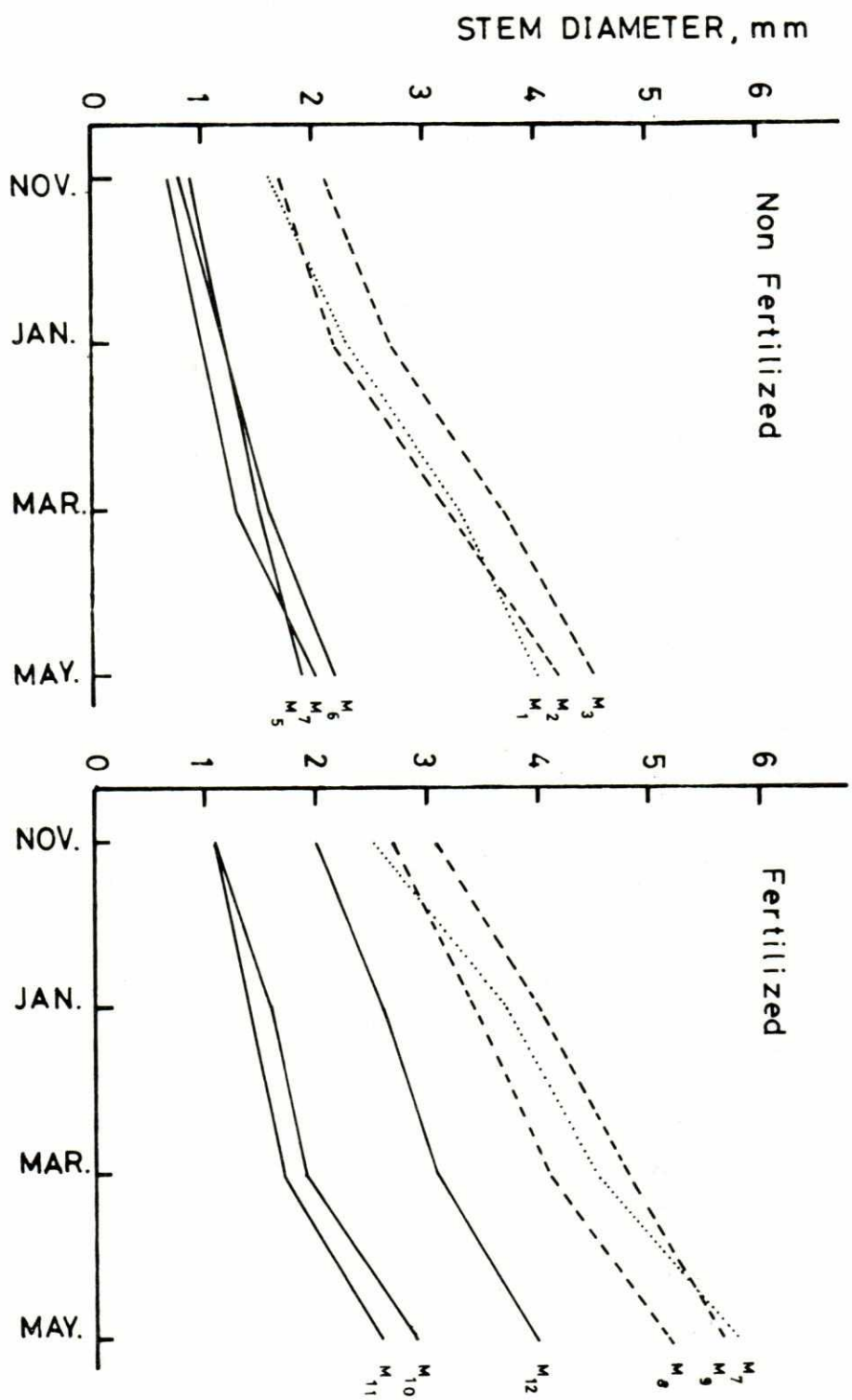

Fig. 3. Effect of different soil mixtures on the stem diameter of *E. Camaldulensis* plants.

Table 3. Analysis of Variance of Plant Height of Eucalyptus camaldulensis, as Affected by Different Soil Mixtures and Plant Age.

S.O.V.	d.f.	S.S.	M.S.	F
Replicates	2	226.3024	113.1512	1.74$^{n.s.}$
Plant age	9	23,891.8237	2,654.6471	40.89**
Soil mixture	11	49,812.8968	4,528.4452	69.75**
Fert. vs non fert.	1	14,084.6337	14,084.6337	216.95**
Within non fert.	5	9,883.2716	1,976.6543	80.45**
Within fert.	5	25,844.9915	5,168.9983	79.62**
Plant age x soil mixture	99	6,427.1919	64.9211	3.49**
Residual	238	4,424.7915	18.5916	
Total	359	84,783.0063		

n.s. Non significant at the 5% level.
* Significant at the 5% level.
** Highly significant at the 5% level.

Table 4. Mean Stem Diameter of *Eucalyptus camaldulensis* as Affected by Different Soil Mixtures mm.

Soil mixture	Nov./78	Jan./79	March./79	May/79	Mean
Sand 100%	1.62	2.29	3.31	4.04	2.28
Sand 75% + Peat 25%	1.66	2.19	3.21	4.19	2.81
Sand 50% + Peat 50%	2.06	2.70	3.69	4.52	3.24
Sand 75% + Sawdust 25%	0.73	0.95	1.32	1.96	1.24
Sand 50% + Sawdust 50%	0.86	1.16	1.48	1.87	1.34
Sand 450% + peat 25% Sawdust 25%	0.82	1.22	1.55	2.18	1.44
					2.17
Sand 100% + F	2.54	3.67	4.50	5.77	4.13
Sand 75% + Peat 25% + F	2.72	3.35	4.10	5.19	3.88
Sand 50% + Peat 50% + F	3.13	3.96	4.84	5.68	4.40
Sand 50% + Sawdust 25% + F	1.09	1.61	1.94	2.92	1.89
Sand 50% + Sawdust 50% + F	1.07	1.42	1.74	2.61	1.71
Sand 50% + Peat 25% + Sawdust 25% + F	1.99	2.60	3.05	3.95	2.90
					3.17
Mean	1.70	2.26	2.89	3.74	2.65

L.S.D. (0.05) for plant age = 0.21 mm
L.S.D. (0.05) for soil mixtures = 0.37 mm
F = NPK fertilizer + Fish meal

significant between the first three mixtures (M_7, M_8 and M_9) and significant with the last mixtures (M_{10}, M_{11}, and M_{12}).

The incorporation of NPK fertilizers (12:24:12) and fish meal into the soil mixtures has found to increase significantly the fresh weight of plant tops. The average was 18.75 g for the plants grown in the fertilized mixtures and 5.63 g for those grown in the non fertilized mixtures.

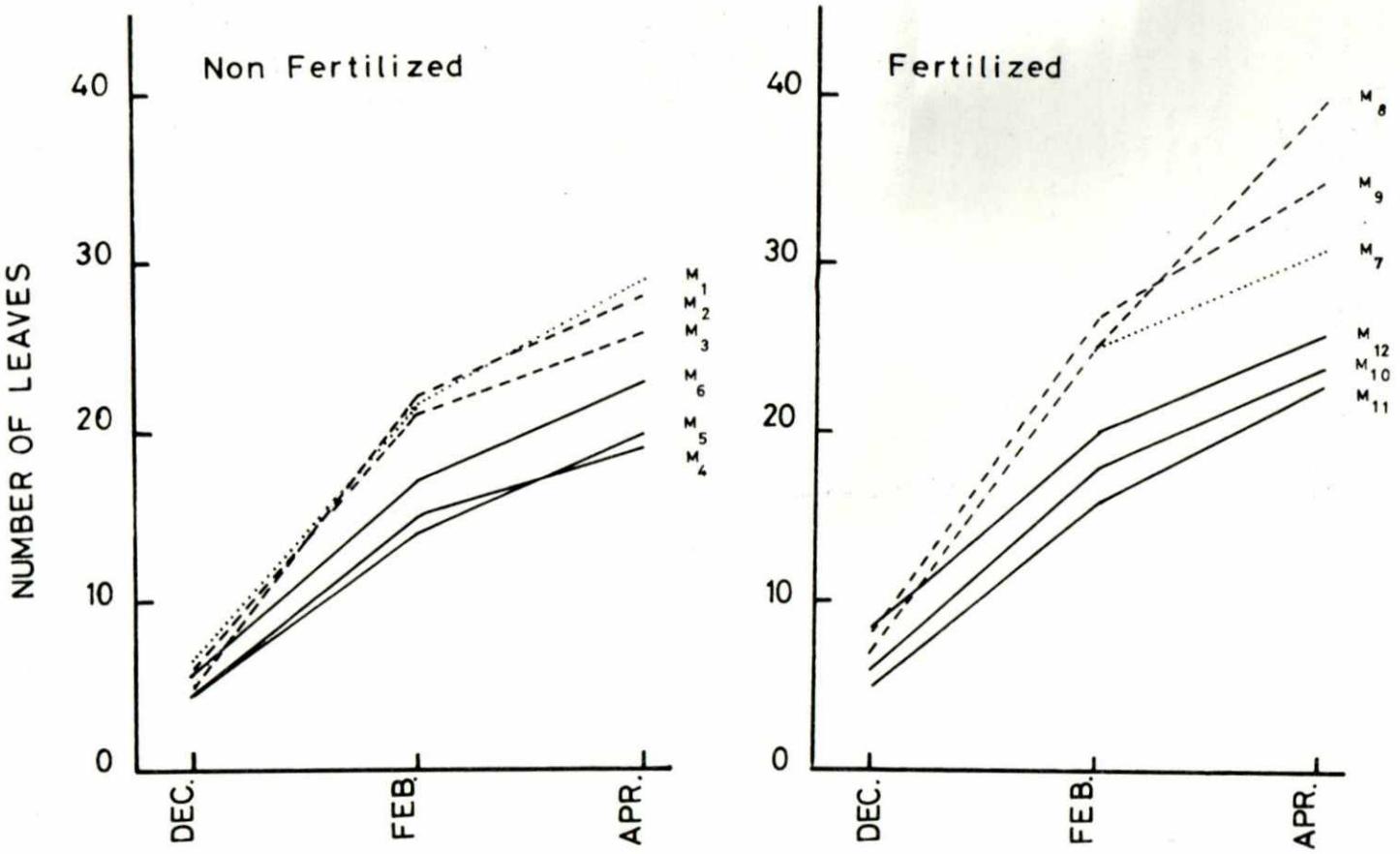

Fig. 4. Effect of soil mixtures on the number of leaves of *E. Camaldulensis* plants.

Table 5. Analysis of variance of stem diameter of *Eucalyptus camaldulensis*, as affected by different soil mixtures and plant age.

S.O.V.	d.f.	S.S.	M.S.	F	
Replicates	2	2.6038	1.3019	6.35**	
Plant age	3	83.3544	27.7848	135.47**	
Soil mixture	11	165.3037	15.0276	73.27**	
Fert. vs. non fert.	1	35.7803	35.7803	174.45**	
Within non fert.	5	48.6562	9.7312	47.45**	fert.
Within fert.	5	80.8671	16.1734	78.86**	
Plant age X soil mixture	33	9.0023	0.2728	1.33$^{n.s.}$	
Residual	94	19.2827	0.2051		
Total	143	279.5469			

** Highly significant at the 5% level.
n.s. Non significant at the 5% level.

Table 6. Mean number of leaves of *Eucalyptus camaldulensis*, as affected by different soil mixtures and plant age.

	Dec./78	Feb./79	Apr./79	Mean
Sand 100%	6.47	21.47	28.83	18.92
Sand 75% + Peat 25%	5.27	22.30	28.27	18.61
Sand 50% + Peat 50%	6.27	21.33	26.17	17.92
Sand 75% + Sawdust 25%	4.53	15.10	20.87	13.50
Sand 50% + Sawdust 50%	4.00	14.43	20.00	12.81
Sand 50% + Peat 25% + Sawdust 25%	5.20	17.40	23.17	15.26
				16.17
Sand 100% + F	7.40	24.60	30.93	20.98
Sand 75% + Peat 25% + F	7.07	25.07	40.30	24.14
Sand 50% + Peat 50% + F	7.93	26.90	35.40	23.41
Sand 75% + Sawdust 25% + F	5.87	18.30	24.07	16.08
Sand 50% + Sawdust 50% + F	4.67	15.67	22.57	18.39
Sand 50% + Peat 25% + Sawdust 25% + F	8.47	20.27	26.43	18.39
				19.55
Mean	6.09	20.24	27.25	17.86

L.S.D. (0.05) for plant age = 2.20
L.S.D. (0.05) for soil mixtures = 4.39
L.S.D. (0.05) for plant age X soil mixtures = 7.60
F = NPK fertilizer + Fish meal

The dry weight of plant tops had also significantly increased with NPK fertilizer and fish meal application. The average dry weight of plant tops was 7.96 g for the fertilized mixtures and 2.63 g for the non fertilized.

The incorporation of sawdust had caused a significant decrease in the dry weight of tops.

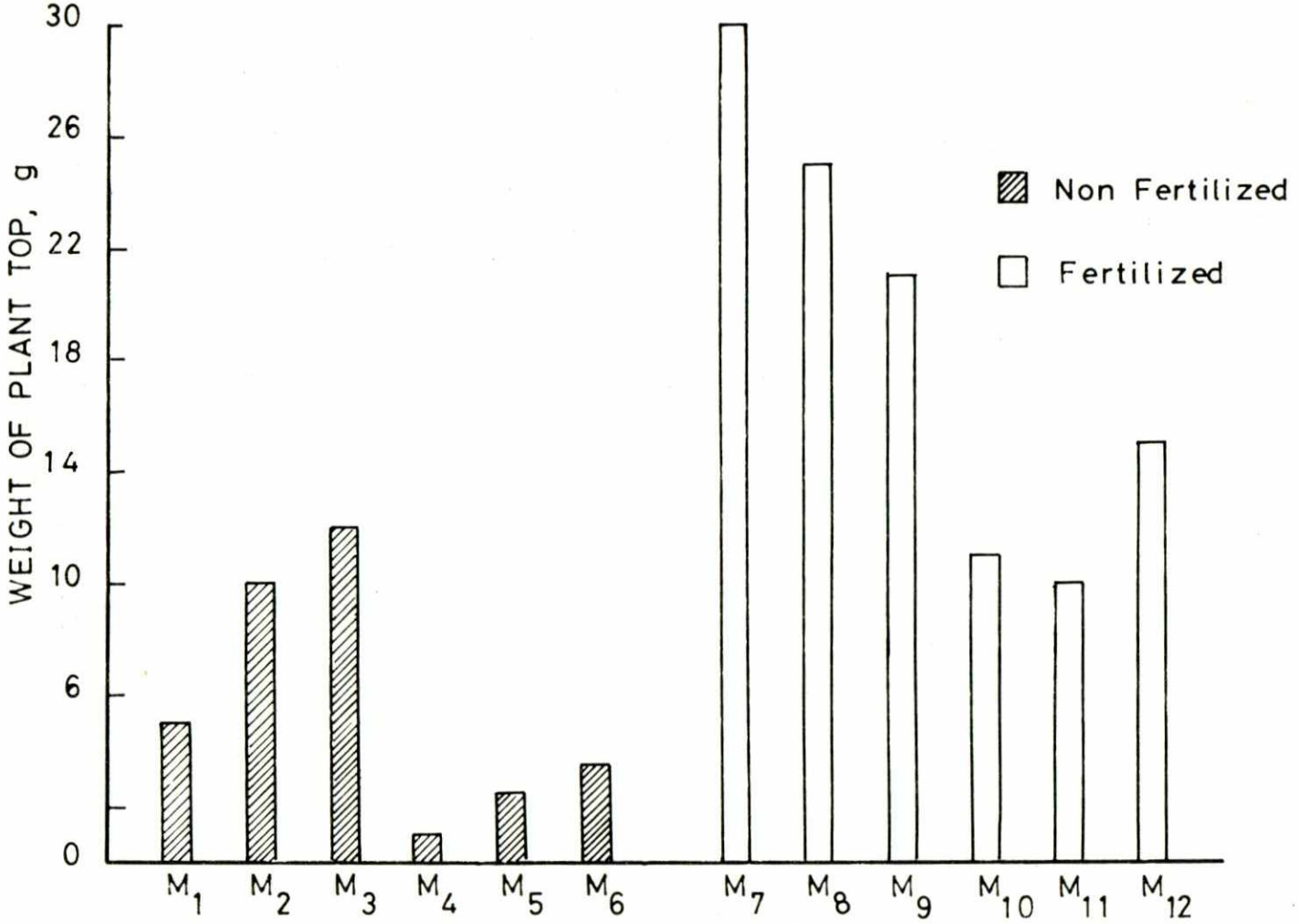

Fig. 5. Effect of different soil mixtures on the fresh weight of *E. Camaldulensis.*

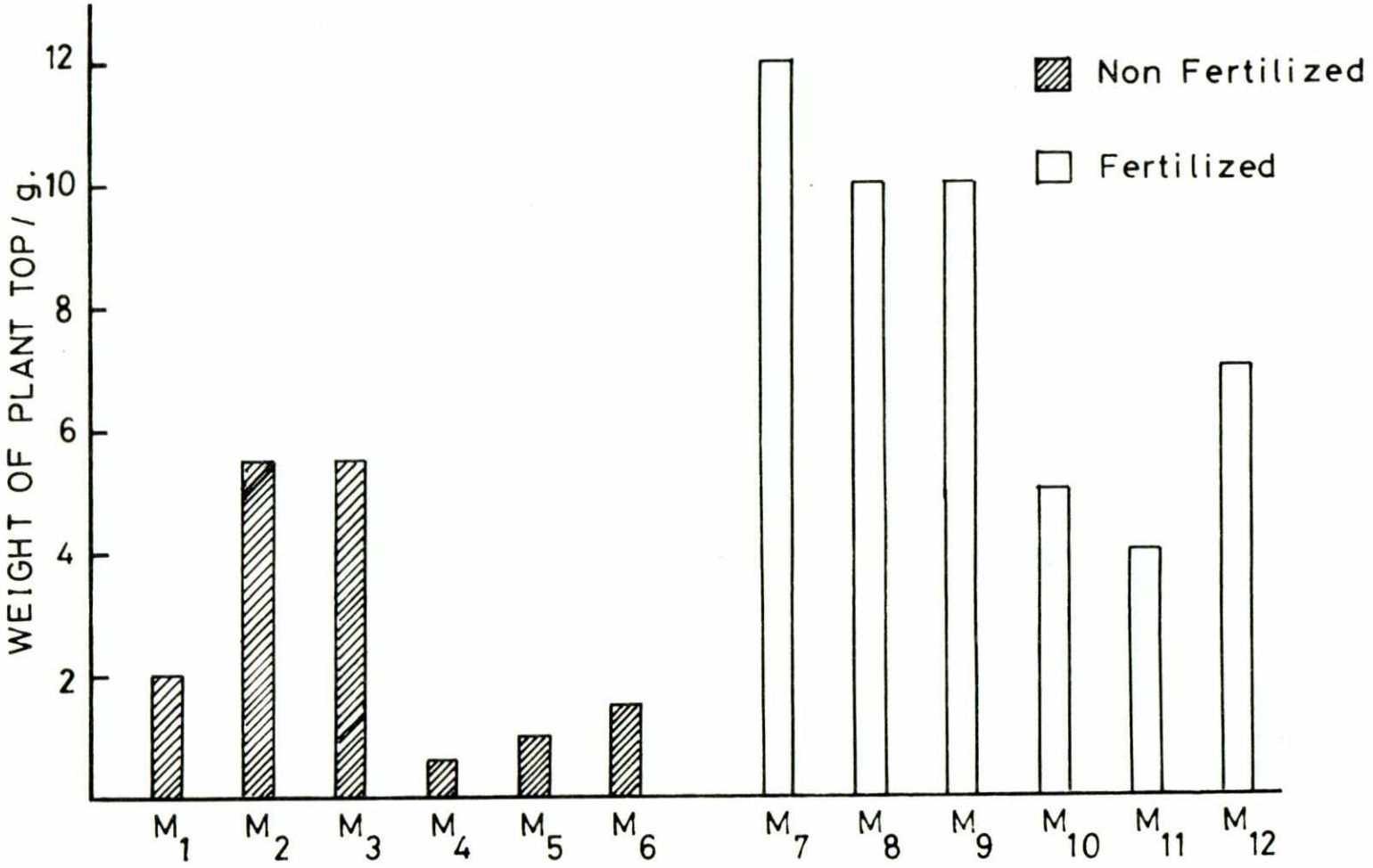

Fig. 6. Effect of different soil mixtures on the dry weight of *E. Camaldulensis.*

Table 7. Analysis of variance of the number of leaves of *Eucalyptus camaldulensis*, as affected by different soil mixtures and plant age.

S.O.V.	d.f.	S.S.	M.S.	F
Replicates	2	38.9446	19.4723	0.90$^{n.s.}$
Plant age	2	8,360.8669	4,180.4335	192.79**
Soil mixture	11	1,342.2566	122.0233	5.63**
Fert. vs. non fert.	1	308.3912	308.3912	14.22*
Within non fert.	5	322.6659	64.5332	2.98*
Within fert.	5	711.1995	142.2399	6.56**
Plant age X soil mixture	22	477.0553	21.6843	2.17*
Residual	70	700.4671	10.0067	
Total	107	10,919.5905		

n.s. Non significant at the 5% level
* Significant at the 5% level
** Highly significant at the 5% level

Table 8. Means of Fresh and Dry Weights of Tops of *Eucalyptus camaldulensis* Transplants as Affected by Different Soil Mixtures.

Soil mixture	Mean fresh weight, g	Mean dry weight, g
Sand 100%	4.73	2.19
Sand 75% + Peat 25%	9.61	4.94
Sand 50% + Peat 50%	12.17	5.41
Sand 75% + Sawdust 25%	1.30	0.59
Sand 50% + Sawdust 50%	2.53	1.12
Sand 50% + Peat 25% + Sawdust 25%	3.46	1.50
	5.63	2.63
Sand 100% + F	29.83	12.01
Sand 75% + Peat 25% + F	25.07	10.29
Sand 50% + Peat 50% + F	20.80	10.26
Sand 75% + Sawdust 25% + F	11.39	4.74
Sand 50% + Sawdust 50% + F	9.97	3.66
Sand 50% + Peat 25% + Sawdust 25% + F	15.43	6.81
	18.75	7.96
Mean	12.19	5.29
L.S.D. (0.05) for soil mixtures	10.48 g	4.02 g

Table 9. Analysis of Variance of Fresh Weight of Plant Top of *Eucalyptus camaldulensis*, as Affected by Different Soil Mixtures and Plant Age.

S.O.V.	d.f.	S.S.	M.S.	F
Replicates	2	449.8329	224.9165	5.88*
Soil mixture	11	2,752.5343	250.2304	6.54**
Fert. vs non fert.	1	1,548.8161	1,548.8161	40.47**
Within non fert.	5	926.1194	185.2239	4.84**
Within fert.	5	277.5989	55.5198	1.45$^{n.s.}$
Residual	22	841.8660	38.2666	
Total	35	4,044.2332		

* Significant at the 5% level

** Highly significant at the 5% level

n.s. Non significant at the 5% level

Table 10. Analysis of Variance of Dry Weight of Plant Top of *Eucalyptus camaldulensis*, as Affected by Different Soil Mixtures

S.O.V.	d.f.	S.S.	M.S.	F
Replicates	2	60.3833	30.1917	5.36*
Soil mixture	11	491.0960	44.6451	7.93**
Fert. vs. non fert.	1	256.1601	256.1601	45.51**
Within non fert.	5	171.9893	34.3979	6.11**
Within fert.	5	62.9466	12.5893	2.24$^{n.s.}$
Residual	22	123.8216	5.6283	
Total	35	675.3009		

* Significant at the 5% level

** Highly significant at the 5% level

n.s. Non significant at the 5% level

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تأثير خلط التربة بالبقايا العضوية على بعض الخـواص الفيزيائية للتربة ونمو النبـــات

م . سهير الافغاني د . الطاهر يحيـى

الملخـــص

تمت دراسة تأثير خلط التربة بالبقايا العضوية على بعض الخواص الفيزيائية للتربة ونمو النبات في مشتل محطات تجارب جامعة الفاتح في طرابلس — ليبيا خلال عامي ١٩٧٨ — ١٩٧٩ م .

لقد تم التركيز على خاصيتين من الخواص الفيزيائية وهما قدرة التربة على الإحتفاظ بالماء والمسامية الهوائية وكلاهما قد تأثر بعملية الخلط . وقد دلت النتائج على أن نسبة الخلط ٥٠٪ رمل+٥٠٪ بيت موس مخلوط (م$_{٣}$) قد أعطى أحسن النتائج حيث زادت قدرة التربة على إستيعاب الماء من ١٠٪ تقريباً للمخلوط م$_{١}$ (١٠٠٪ رمل) إلى ٣٥٪ في المخلوط م$_{٣}$. كما انخفضت المسامية الهوائية من ١٧٪ في المخلوط م$_{١}$ إلى حوالي ٩٪ في المخلوط م$_{٣}$. كما تشير النتائج إلى أن المخلوط م$_{٣}$ هو الأفضل والأنسب لنمو أشجار اليوكاليبتص .

وللحصول على نموات أقوى وأحسن بفضل الخلطة م$_{٩}$ والتي تحتوي على ٥٠٪ رمل+٥٠٪ بيت موس+سماد مركب+بقايا أسماك . وفي حالة استعمال نشارة الخشب كبديل للبيت موس المستورد يجب معاملتها باليوريا قبل خلطها في التربة .