USE OF MSW COMPOST, DRIED SEWAGE SLUDGE AND OTHER WASTES AS PARTIAL SUBSTITUTES FOR PEAT AND SOIL

(Proposed short title : Use of residues to replace peat and soil)

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Abstract

The use of different materials such as peat, sand or forest soil in the production of substrates for ornamental plants and for revegetating sealed landfills is a practice leading to economical and environmental problems. Therefore, the feasibility of using composted municipal solid wastes (MSW), sewage sludge and other organic wastes to produce alternative substrates for ornamental plants and to improve the revegetation of a closed landfill has been investigated.

As for substrate production, a 50% of the peat content in a common substrate used in Spanish nurseries was successfully replaced with different mixtures of MSW compost, dry sewage sludge, grape marc, rice hull and pine bark, reducing cost of substrates, not diminishing quality of plants produced, and using similar amounts of water and nutrients.

Regarding revegetation of the landfill, the usual 20-40 cm thick layer of fertile soil was successfully replaced with just 5-10 cm of non-fertile soil together with a superficial layer of MSW compost (45 t/ha) or dry sewage sludge (90 t/ha), and bushy authoctonous vegetation was introduced later as usual. Good and fast vegetal covering of the landfill

was observed after both treatments, similar to that obtained with standard and environmental aggressive revegetating procedures.

Keywords: Peat substitutes, substrates, soil reclamation, landfill, compost, sewage sludge

INTRODUCTION

Highly valuable, in both economical and ecological senses, materials as peat and natural soils are commonly used in Spain in the production of substrates for ornamental plants (Pagés & Matallana, 1984; Guerrero & Polo, 1990) or for revegetating sealed urban waste landfills (Pastor *et al.*, 1993). Nevertheless, these materials might be fully or partially replaced with various organic refuses as MSW compost, sewage sludge, pine bark, sawmill residues, grape marc, rice hull, etc., giving rise to environmental benefits, since ecosystem damages caused by soil or peat extraction are avoided, and the impact of residues accumulation is minimized (Raviv *et al.*, 1986), and economical benefits, since use of residues means lower costs than those derived from conventional materials (purchase, delivery, etc.), consequently improving competitivity of user companies (Abad, 1991).

In 1988, Bunt reviewed alternative materials for replacing soil and peat in substrate production, emphasizing the illegality of the extraction of such valuable materials. In the same way, other authors (Hanan, 1981; Bilderback *et al.*, 1982) studied hydrophysical characteristics of various alternative substrates (almond and peanut hulls, ovine manure, etc.). After studying characteristics of different alternative substrates, Raviv *et al.* (1986) reported that combinations of sewage sludge and MSW compost with other residual materials as pine bark, grape marc or rice hull are worth to be investigated because negative properties of single materials as heterogeneity, high salinity, low content of organic matter, low cation exchange capacity or high contents of contaminants can be minimized, obtaining a sound and cheap substrate instead.

During the last years, surface sealing and re-vegetation of urban landfills has become one of the most remarkable activities of environmental reclamation (Pastor *et al.*, 1993). Generally, sealing is carried out by using materials originated in quarries, or even top layers of natural soils, giving rise to a strong environmental impact. These materials are usually amended with clay, peat or forest soil, and fertilizers and mycorrhiza are also added in most cases to improve their poor characteristics. Lack of seeds, high salinity, and oligotrophic chemical conditions in sealing materials seem to be the main inconveniences for natural re-vegetation of these degraded areas and implantation of native plants is usually needed.

Recently, we have studied different characteristics of sewage sludges and MSW composts in the Mediterranean area (Roca & Pomares, 1991; Canet & Pomares, 1995; Canet, 1995) and the feasibility of using such products for revegetating degraded soils through native bushy plants introduction (García, 1989; Ingelmo, 1990; Ibáñez, 1995). Our work has been carried out in soils developed on calcareous materials (marls and clays) under dry Mediterranean climate. One of the main results of the investigations was the development of a technique for minimizing the soil needs in the revegetation of closed landfills. In this procedure, the layer of fertile soil usually added for plants to settle and develop in such a degraded substrate is replaced by a layer of dry sewage sludge or MSW compost applied to the landfill surface. The optimal thickness of the layer (1 cm) was found by Ibañez (1995) and is particularly related with the improvement of the hydrophysical characteristics of the soil.

Given this, the study we expose on these pages had two different aims. First, we investigated the feasibility of reduce the peat content in substrates for ornamental plant production by replacing it with selected organic residues. The main chemical and hydrophysical characteristics of the new substrates were evaluated, and their suitability was tested in two commercial nurseries. On the other hand, we carried out the re-vegetation of a sealed urban landfill by introducing native bushy plants after superficial applications of dry sewage sludge or MSW compost. We evaluated the results obtained with both amendments and compared them with those in landfills re-vegetated with standard procedures.

MATERIAL AND METHODS

Partial replacement of peat in substrates for ornamental plant production

Two commercial nurseries devoted to producing ornamental plants collaborated in the experiment and tested the alternative substrates in real conditions of production. One of the most usual substrates (50% peat plus 50% grape marc) used in Spanish nurseries was established as control, and the alternative substrates were made up by replacing the half of the peat content in the control with several combinations of five different residual materials : anaerobically-digested sewage sludge, fully-matured MSW compost, grape marc, rice hull, and pine bark. All of them were used in dry form. Higher rates of peat replacement were discarded in order to avoid reluctance from commercial nurseries to use substrates too different from the usual ones, although research on full replacement of peat is currently in course. Composition of all alternative substrates investigated, together with their cost is shown in Table 1. Their hydrophysical characteristics were determined according to methods described by Bunt (1988), whereas their main chemical and physicochemical characteristics were determined following the Official Methods of the Spanish Ministry of Agriculture (M.A.P.A., 1986).

Different species of plants were grown for evaluating the suitability of substrates: *Nerium oleander* and *Rossmarinus officinalis* in Nursery I, and *Cupressus sempervirens* and *Rossmarinus officinalis* in Nursery II. For each individual species, the experimental design consisted of four random blocks containing 30 pots (17 cm wide and 17 cm long) per substrate. All experimental pots were fertirrigated as usually in each nursery. Ten months after planting, plant heights were measured. According with each nursery's criteria, percentages of 1st quality *R. officinalis* plants were also determined. Statistical significance of results obtained was assessed through multiple ANOVA (F and Duncan's multiple range tests) at the 95% level of probability.

Revegetation of a sealed urban landfill

The study was carried out in a domestic waste landfill located at Benisanó (Valencia, Spain) and sealed in October 1994. This landfill had been excavated over marls and clays under a dry temperate-Mediterranean climate environment (annual average precipitation and temperature equal to 532.7±581.2 mm and 16.3±5.6ºC, respectively; n=30 years). The sealing was made by means of the addition and compacting of a 20-30 cm thick layer of marls and clays. Later, a new 5-10 cm thick layer of the same material was added, and then loosened by tillage in order to help the re-vegetation. Once sealed, the landfill site occupied 0.5 ha approximately, and owned a sunny overall slope (5.5% mean slope, 203ºN pointed).

Taking into account shape, size and slope distribution of the landfill site, this was divided into ten 450-m^2 rectangular plots, longitudinally arranged. Four plots were covered with an 1-cm thick (90 t/ha) layer of dry anaerobically-digested sewage sludge, and four were covered similarly with matured MSW compost (45 t/ha), whereas two plots remained untreated as control for evaluating if the results depended on the treatments or were caused by the characteristics of the material used in the sealing. The sludge used had 28.6% of organic matter, 2.02 of N, 2.71 mg/kg of Cd, 496 mg/kg of Cr, 549 mg/kg of Cu, 138 mg/kg of Ni, 338 mg/kg of Pb, and 1730 mg/kg of Zn, whereas the MSW compost had 57.1% of organic matter, 2.05% of N, 2.06 mg/kg of Cd, 58 mg/kg of Cr, 581 mg/kg of Cu, 62 mg/kg of Ni, 436 mg/kg of Pb, and 1180 mg/kg of Zn. These organic amendments were manually applied and spread on the soil surface, with no later tillage.

All plants used for revegetating the site were introduced manually as seedlings. *Atriplex halimus* (an autochthonous halophyte fodder shrub) was the most introduced plant, with a rate of 950 plants/ha. Other native species implanted in the landfill were *Rosmarinus officinalis*, *Erica multiflora*, *Rhamnus lycioides* (all three with a rate of 225 plants/ha), *Coronilla juncea*, *Coronilla vimminalis* (leguminous plants, with a rate of 150 plants/ha), and *Tamarix africana* (an halophyte ornamental shrub, with a rate of 33 plants/ha). The only non-autochthonous plant introduced was *Atriplex nummularia*, a drought-resistant fodder shrub from Australia, and the rate used was 225 plants/ha.

Composite soil samples were randomly taken (0-10 cm depth) in the three treatments (sludge, compost and control) one year after revegetation, and their main analytical characteristics were determined following the Official Methods of the Spanish Ministry of Agriculture (M.A.P.A., 1986). Survival, height and cover of all implanted species were also measured at that date, according to formulas by Phillips & MacMahon (1981). Spontaneous plants were inventoried 20 months after the treatments application, using random 60-m^2 subplots within the 450-m^2 experimental plots, and the cover reached by these plants was also measured. Over 20 landfills revegetated by standard procedures were visited, and different engineers were also consulted in order to evaluate the performance obtained in the revegetation of our sealed landfill.

RESULTS AND DISCUSSION

A. Use of peat-alternative substrates

The main hydrophysical characteristics of the substrates prepared are shown in Table 2. The highest particle and bulk densities were found in S1, S3, S4 and S7 substrates, in which peat were replaced by sewage sludge, but their total porosities were lower than in the control and acceptable according to ranges proposed by Bunt (1988). No remarkable differences occurred in air space, easily available water, and water buffering capacity. All peat-alternative substrates showed higher microporosities than control. This fact is especially interesting, since increases in microporosity improve rewettability of substrates due to both a raise of their water holding capacity and also a reduction of drainage (Beardsell *et al.*, 1982).

The main chemical and physicochemical characteristics of substrates are listed in Table 3. Values of pH in the saturation extract ranged from 6.91 to 8.13, the control being the lowest. Electrical conductivities were very high, with the exception of the control which gave a relatively low value. All these conductivities were however much lower at the end of the experiment due to leaching. Despite this last fact, all substrates gave conductivity values much higher than those proposed for an ideal substrate (Bunt, 1988). Boron levels were similar in all the cases, ranging from 1.03 to 1.58 mg/l. These values may be toxic for sensitive species (Ayers & Wescot, 1985). Total organic matter was higher than 60% in all substrates, the control giving the highest level. Total nitrogen contents were moderate, ranging from 1.50 to 2.05%. Heavy metals contents in all substrates (Table 4) were lower than limit values in sewage sludge intended for agricultural use (CEC, 1986).

Table 5 shows the most remarkable results regarding substrates suitability. All peat-alternative substrates gave significantly lower heights of *N. oleander* plants than control. As for *C. sempervirens*, the highest value corresponded again to the control, but S3 and S7 substrates gave rather similar heights. In the case of *R. officinalis*, S1 substrate showed very high values in the two nurseries, whereas S6 substrate seemed to be the worst product. Very similar results were observed for the percentages of 1st quality plants of *R. officinalis* in the two nurseries: the best values were obtained using S1 substrate, and the worst ones using the S6.

B. Revegetation of a sealed urban landfill

The main chemical characteristics of soil in the landfill site after treatments are shown in Table 6. These data can be valuable to assess the fertility condition of the soil and the real chances for its revegetation. Thus, the amount of humic acids in compost-treated plots almost doubled that observed in the other treatments. Organic and mineral nitrogen contents were clearly higher in organic treatments than in the control, as expected. In these cases, the higher application rate needed to set up an 1-cm thick layer of sludge (90 t/ha versus 45 t/ha of MSW compost) accounted for the higher values observed for this treatment, since both organic amendments had similar contents of nitrogen.

As expected, heavy metal contents in soils treated with organic amendments were higher than in the control plots. Nevertheless, maximum levels allowed by European Communities (CEC, 1986) were not exceeded. The highest values were found in the sludge-treated soil because of the higher metal contents in that amendment, and the higher rate of application used.

Survival percentages of introduced plants are displayed in Table 7. Organic treatments produced higher survivals of halophyte species than the untreated control. As for the other species, MSW compost treatment gave the highest values, excepting the case of *C. juncea*, since more plants survived in untreated plots. All these values were clearly higher than those reported by Herrera *et al.* (1993) after using different revegetation techniques on Mediterranean desertified ecosystems. Nevertheless, the survival percentages we found in the sludge-treated soil were lower than those Ibañez (1995) reported after applying a similar revegetation treatment. This could be caused by higher phytotoxicity of the sludge used or by the severe drought of 1995 (only 140 mm of water were measured in the landfill through a pluviometer). In addition to scarce rainfall, disposition of sludge-treated plots and slope distribution into the landfill made arrival of runoff water from outside rather difficult.

Cover percentages and heights of introduced *A. halimus* plants are shown in Table 8. Values of cover were higher and their variability was lower in the organically-treated plots. Highest height values and lower deviations were obtained with compost treatment. Data variation between transecta were caused by different routes of runoff water according to the slopes distribution into the landfill. The best values of cover and plant height were obtained in the compost-treated plots due to the higher fertility this amendment produced in soil and the optimal situation of these plots for runoff water accumulation. In this way, MSW compost seemed to be idoneous for landfill revegetation since it gave rise to higher amounts of *A. halimus* biomass than the untreated control, and even improved the survival of the other native species. As Le Houerou (1992) reported, saltbushes as *Atriplex* spp. can play a remarkable role in reclamation of Mediterranean arid ecosystems because of their use as fodder, thus contributing to the maintenance of biogeochemical cycles.

Finally, an inventory of spontaneous vegetation into the landfill is listed in Table 9. The highest cover percentage was observed in compost-treated plots, but the highest diversity occurred in the control. This lower number of species into the organically-treated plots can be caused by negative effects on germination and early development because of ammonia released during amendments decomposition or the heavy metal contents in that materials. The strong development of *B. fruticulosa* into the organically-treated plots was remarkable and probably caused by a quick response of this ruderal species to the improvement of soil fertility. Seeds produced by *A. halimus* introduced plants only germinated and settled in the organically-treated plots. This is an interesting fact, since further implantations are thus not needed thereafter, and successive croppings of these plants may help to remove contaminants out the landfill.

Later visits to landfills revegetated through environmental aggressive, standard procedures, and discussions with engineers from companies devoted to soil reclamation showed the soundness of the results obtained with the application of organic residues.

CONCLUSION

The prepared peat-alternative substrates showed a good suitability for production of ornamental plants, since height and quality of plants were similar or even better than those obtained with the control substrate. An interesting cut (from 20 to 40%) in relative cost was achieved, and the amounts needed of water and nutrients were similar.

With regards to the revegetation of a sealed landfill, the ecologically aggressive standard procedures of revegetation were successfully avoided by replacing the commonly used layer of fertile soil with an 1-cm thick superficial layer of sewage sludge or MSW compost. The vegetal cover of the landfill grow faster and better using these organic treatments, and the development of spontaneous vegetation was also favoured. MSW compost seemed to be the best treatment, since cover and percentage of survival of introduced plants were higher than those of the other treatments. Visits to other landfills revegetated through standard procedures and discussion with specialists also showed the soundness of the results obtained by using organic wastes.

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Table 1. Composition of the substrates used in the study

Substrate	**Composition**	**Relative cost**
S1	0.25A+0.25B+0.5D	71
S2	0,25A+0,25C+0.5D	80
S3	0.25A+0.25B+0.25D+0.25F	71
S4	0.25A+0.25B+0.25D+0.25E	60
S5	0.25A+0.25C+0.25D+0.25F	80
S6	0.25A+0.25C+0.25D+0.25E	68
S7	0.25A+0.125B+0.125C+0.5D	75
control	0.5A+0.5D	100

A: Sphagnum moss peat; B: anaerobically-treated sewage sludge; C: matured MSW compost; D: uncomposted grape marc; E: uncomposted rice hull; F: uncomposted pine bark. All proportions are given in dry weight basis. Alternative substrates were made by replacing 50% of the peat content in the control by residual materials. All costs include 1000 ptas/m^3 for mixing up. 100% equals 5800 ptas/m^3.

Table 2. Main hydrophysic characteristics of substrates

Substrate	Particle Density (kg/m^3)	Bulk Density (kg/m^3)	Porosity (% v/v)	Airspace (% v/v)	Easily Available Water (% v/v)	Water Buffering Capacity (% v/v)	Microporosity (% v/v)
S1	1760±98	275±26	84.8±2.3	31.3±6.1	24.2±7.2	12.1±6.8	17.3±5.8
S2	1650±56	203±34	87.7±2.5	31.9±6.4	28.7±6.5	12.1±5.4	15.1±5.2
S3	1745±83	278±51	85.5±2.3	30.6±5.8	22.4±7.8	12.5±6.9	20.1±6.3
S4	1790±102	245±26	85.6±2.7	35.5±5.7	21.6±3.5	11.3±6.1	17.4±5.4
S5	1658±61	210±29	88.1±2.4	30.1±6.0	27.0±6.9	14.1±6.7	16.0±5.8
S6	1655±51	170±38	87.5±3.1	35.7±6.8	25.5±6.5	12.5±5.2	13.8±4.1
S7	1725±44	258±31	86.3±2.4	29.3±5.6	27.8±6.4	12.3±5.9	16.9±5.5
control	1558±46	140±24	89.8±2.6	34.8±6.4	29.2±6.9	13.0±6.9	12.8±7.1

Table 3. Main analytical characteristics of substrates

Substrate	**Saturation extracts**			**Total contents**	
	pH	**Electrical conductivity (dS/m)**	**Boron (mg/l)**	**Organic matter (%)**	**Nitrogen (%)**
S1	7.97	10.49	1.19	64.1	1.62
S2	7.75	8.14	1.12	80.0	2.05
S3	7.77	6.92	1.03	64.2	1.50
S4	7.80	9.24	1.39	61.8	1.62
S5	7.58	7.19	1.09	79.3	1.59
S6	8.12	8.13	1.26	79.2	1.79
S7	8.13	8.17	1.30	71.4	1.89
control	6.91	1.79	1.58	88.5	2.02

Total contents expressed in dry weight basis.

Table 4. Heavy metal content in substrates (mg/kg)

Substrate	Cd	Cr	Cu	Ni	Pb	Zn
S1	3.35	888	215	79.2	229	798
S2	1.05	312	119	23.3	274	270
S3	3.85	1013	216	91.3	245	927
S4	4.05	1130	215	96.5	264	1020
S5	1.15	261	105	22.2	143	227
S6	1.40	444	132	34.4	179	384
S7	1.45	414	123	39.8	110	366
control	0.40	147	30	9.1	19	109

All results expressed in dry weight basis.

Table 5. Most relevant results regarding to substrates suitability: height and quality of three different plants on two comercial nurseries.

Substrate	**Final Height (cm)**				**1st Quality Plants (%)**	
	N. oleander Nursery I	*C. sempervirens* Nursery II	*R. officinalis* Nursery I	*R. officinalis* Nursery II	*R. officinalis* Nursery I	*R. officinalis* Nursery II
S1	32.8ab	55.5ab	41.0e	44.2c	27.5b	27.8c
S2	36.3c	54.0a	37.3a	41.6b	25.5b	23.0ab
S3	30.7a	58.4bc	-	-	-	-
S4	-	-	40.5de	39.7ab	26.3b	26.3bc
S5	34.0b	55.1ab	-	-	-	-
S6	-	-	37.8ab	38.9a	23.0a	20.5a
S7	34.4bc	57.0abc	39.1bc	43.6c	25.5b	26.3bc
control	42.0d	59.6c	39.3cd	44.7c	27.3b	26.5bc

- : Substrate not tested.

Duncan´s Multiple Range Test: values in the same column followed by same letter are not significantly different at the 95% level of probability.

Table 6. Main chemical characteristics of landfill soil after treatments

	Sewage sludge	**MSW compost**	**Control**
Humic acids (%)	0.30	0.53	0.26
Organic N (%)	0.37	0.26	0.18
$N\text{-}NH_4^+$ (mg/kg)	55	0	0
$N\text{-}NO_3^-$+$N\text{-}NO_2^-$ (mg/kg)	467	251	79
Cd (mg/kg)	2.26	0.487	0.601
Cr (mg/kg)	118	35.1	14.6
Cu (mg/kg)	164.8	80.3	21.1
Ni (mg/kg)	40.2	13.9	6.94
Pb (mg/kg)	111.4	65.2	56.9
Zn (mg/kg)	554.5	199.5	75.5

All results expressed in dry weight basis.

Table 7. Number of plants and survival percentage of the bush plants introduced in the landfill, one year after treatments

Species	**Sewage sludge**		**MSW compost**		**Control**	
	plants	**% survival**	**plants**	**% survival**	**plants**	**% survival**
Atriplex halimus	177	89.8	177	85.3	85	80.0
Rosmarinus officinalis	42	2.4	42	23.8	21	4.8
Erica multiflora	49	2.0	49	10.2	23	4.3
Rhamnus lycioides	48	4.2	45	26.7	21	23.8
Coronilla juncea	37	16.2	29	34.5	11	81.8
Coronilla vimminalis	22	40.9	20	70.0	12	66.7
Tamarix africana	6	50.0	6	66.7	3	66.7
Atriplex nummularia	42	40.5	31	38.7	19	26.3

Table 8. Cover (%) and height (cm±variation coefficient as percentage) of *Atriplex halimus* in the landfill (four horizontal transecta and three vertical treatments)

Transectum	**Sewage sludge**		**MSW compost**		**Control**	
	Cover	**Height**	**Cover**	**Height**	**Cover**	**Height**
1	33.0	1.21±39	42.6	1.45±28	7.1	0.72±46
2	20.1	0.90±48	44.4	1.53±18	35.2	1.32±40
3	15.5	0.69±46	29.5	1.10±47	10.7	0.79±66
4	15.8	0.74±59	17.5	0.86±43	1.2	0.38±71
Overall	*21.1*	*0.89±47*	*33.5*	*1.24±32*	*13.6*	*0.80±51*

Table 9. Inventory of the spontaneous vegetation (6/6/1996). Covers of the observed species (%).

FAMILY	SPECIES	Sewage sludges				MSW compost				Control	
		1	2	3	4	1	2	3	4	1	2
Cistaceae	*Helianthemum lavandulifolium*, Miller	-	-	-	-	-	-	-	-	-	0.5
Compositae	*Anacyclus valentinus*, L.	1.0	6.0	2.5	4.0	6.0	8.0	+	17.0	28.0	18.0
	Atractylis humilis, L.	-	-	-	-	-	-	-	-	-	+
	Inula viscosa, (L) Aiton.	-	-	-	-	-	-	-	-	+	+
	Onopurdum acanthium, L.	-	3.0	-	-	-	2.5	-	-	0.5	-
	Pallenis spinosa, (L) Cass.	-	-	-	-	-	-	--	-	-	+
	Sonchus tenerrimus, L.	-	-	-	-	-	0.5	-	-	-	-
Chenopodiaceae	*Atriplex halimus*, L.	9.0	5.0	6.0	20.0	8.0	22.0	11.0	24.0	0.5	+
	Chenopodium album, L.	12.5	1.5	1.5	2.0	3.0	3.0	8.0	2.0	-	+
	Chenopodium polyspermum, L.	1.0	1.0	+	-	1.0	2.0	-	+	-	+
Cruciferae	*Brassica fruticulosa fruticulosa*, Cyr	26.0	35.0	40.0	40.0	35.0	32.0	30.0	25.0	-	2.0
	Carrichtera annua, (L) D.C.	-	-	-	-	-	-	-	-	1.5	2.1
Dipsicaceae	*Scabiosa stellata*, L.	-	-	-	-	-	0.5	-	-	-	-
Euphorbiaceae	*Euphorbia pinea*, L.	-	-	-	-	-	-	-	-	-	0.5
	Euphorbia squamigera, Loisel	-	1.5	-	-	1.0	-	0.5	2.0	0.5	7.0
Graminae	*Brachypodium retusum*, (Pers.) Beauv.	-	-	-	-	-	0.5	-	-	1.0	-
	Cynodon dactylon (L.), Pers.	-	-	-	-	-	0.5	-	-	1.0	-
	Lamarckia aurea, (L.), Moench.	-	-	-	-	-	+	-	-	+	-
	Lolium multiflorum, Lam.	1.5	3.0	-	-	1.0	-	-	-	-	-
	Piptatherum multiflorum, (Cav.) Beauv.	2.5	27.0	+	0.5	40.0	20.0	24.0	20.0	35.0	15.0
	Stipa capensis, Thumb.	-	-	-	-	-	+	-	-	6.5	20.0
	Stipa offneri, Breistr.	-	-	-	-	-	-	-	-	+	-
Labiateae	*Marrubium vulgare*, L.	-	-	-	-	-	2.5	-	-	+	-
	Teucrium polium, L.	-	-	-	-	-	-	-	-	-	+
Liliaceae	*Asparagus horridus*, L. fil.	-	-	-	-	-	-	-	-	+	+
	Asphodelus fitulosus, L.	-	-	-	-	-	0.5	-	1.0	-	-
Malvaceae	*Malva sylvestris*, L.	2.0	1.5	7.0	17.0	2.0	+	13.0	-	-	-
Plantaginaceae	*Plantago lagopus*, L.	-	-	-	-	-	-	-	-	+	-
Scrophularariaceae	*Misopates orontium* (L.) Rafin.	-	-	-	-	-	-	-	-	2.5	+
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	-	-	-	-	-	-	-	-	-	+
Umbeliferae	*Eryngium campestre*, L.	-	-	-	-	-	-	-	-	-	+
	Foeniculum vulgare, Miller	-	0.5	-	-	-	1.0	-	-	-	-
	TOTAL COVER:	55.5	85.0	57.0	83.5	97.0	95.0	86.5	91.0	76.0	65.1
	NUMBER OF SPECIES:	8	11	7	6	10	16	7	8	15	18

-: not observed; +: observed, but without reaching remarkable amounts. 1, 2, 3, and 4 are the 60 m^2 subplots of each treatment.