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Short-Term Landscape Restoration through Optimal Management of Stockpiled Topsoil on Plant Diversity and Growth of Tree Species

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Abstract: *Landscape restoration is a key component of a mining operation. The aim of the research is to find out if top soil depth and age of tree species could influence plant diversity and growth of selected tree species. Plots were laid using factorial in Completely Randomized Design. The factors that were considered for the experiment were topsoil depth and age of tree species. The results showed an increased plant diversity in all plots with top soil compared to the no topsoil. Within the topsoil treatments depth of 40/60 cm (T0) and 30/70 cm (T3) provided the best results in terms of plant diversity and growth of tree species. It was observed that plant diversity decreased with age which could be attributed to canopy closure. Effective number of species (ENS) generally declined with increase in age of tree species. Results also showed tree height and diameter was highest in 40/60 cm (T0) but did not differ from 30/70 cm (T3). As the years increased tree height of species also increased. Where there is a deficit in topsoil for reclamation, depth of 30/70 cm could be used for reclamation as it can enhance plant diversity and growth of tree species.*

Keywords: *Topsoil, depth, tree species, plant diversity, growth, reclamation*

1. Introduction

The direct impacts of mining disturbance to land surfaces are usually severe, with the likelihood of the destruction of biodiversity within natural ecosystems through the removal of natural soils, plants and animals (IUCN and ICMM, 2004). As a result, treatments aimed at restoring or enhancing the value of soils and areas by following necessary procedures such as improving the physical properties of the soil, regulating water conditions, soil regeneration applying technical or biological methods, strengthening embankments and road construction is very essential in mining areas (Pietrzykowski, 2014).

Ecological restoration is about a broad set of activities – enhancing, repairing or reconstructing degraded ecosystems – and about optimising biodiversity returns. In essence, the restoration of mined land is based on ecosystem reconstruction. It is usually a question of re-establishing the ability of the land to capture and retain fundamental resources – energy, water, nutrients, and species (IUCN and ICMM, 2004). Restoration planning models recognize that for most mine reclamation programs over the last 30 years, an overriding consideration has been whether topsoil has been retained or lost. This will, in all probability, determine how quickly a pre-mining ecosystem can be restored with its biodiversity regained, and whether such a restoration goal is actually realistic and sustainable (IUCN and ICMM, 2004). In mining operations, stockpiling process which involves the removal of the topsoil layer and any other soil layers necessary to get to the substance that is being mined is a routine activity. The topsoil is removed first and stockpiled in one pile and the soil layer below is also removed and stockpiled separately. This subsoil layer is referred to as the overburden. When mining operations are complete, the overburden material is reapplied and leveled and then the topsoil is reapplied and spread over the overburden material to provide a planting medium (Department of Horticulture, 1999). Topsoil is an essential component for land reclamation in mining areas. It is seriously damaged if it is not mined separately without being contaminated, eroded and protected (Ghose, 2001).

Topsoil is that uppermost layer of soil capable of growing and supporting vegetation. Soils are the single most important factor responsible for tree growth. Soils provide trees and shrubs with water, nutrients, and root anchorage. The volume of soil available can limit plantings or reduce growth and vigour of trees and shrubs. Ideal conditions require 15 to 24 inches (38.0 to 60.96 cm) of topsoil that is well drained contains nutrients required for tree growth. As topsoil depth decreases, the potential for survival and growth of woody vegetation decreases (Iles, 2001).

In some mining sites, topsoil salvaged for closure reclamation is usually not done. This has led to deficit of topsoil required to reclaim the total area disturbed. In some companies, the topsoil salvage is sometimes used as materials to raise seedlings at the nursery. This activity reduces the amount of topsoil available for growth of plants. The fear is that this practice could jeopardize reclamation efforts and landscape restoration. The amount of topsoil laid for reclamation could ultimately affect tree growth and plant diversity. Restoration practices where topsoil has been retained focus more on the spatial and temporal factors affecting species colonization and establishment; the criteria for monitoring and assessing success, particularly in the longer term; and the restoration of natural indigenous ecosystems and biodiversity values. In the restoration of sites where topsoil has been lost, the major ecological challenges are still related to the interactions between plant species and substrate – that is, re-vegetation (IUCN and ICMM, 2004). Constant monitoring of the restored ecosystems, particularly soil and plant communities, is a very important part of the reclamation process (Ludwig *et al.*, 2003).

The unanswered questions are? What topsoil level would be ideal for growth and promotion of plant diversity? Would the age and type of tree species affect growth on reclaimed site? Knowledge of these would enable mining companies to determine the amount of soil that could be used for other activities such as nursery without hampering reclamation goals. The competing use for topsoil makes the study of topsoil for reclamation efforts essential. The goal of reclamation is to return land disturbed by mining activities to a stable ecological state and productivity similar to the pre-disturbed state. This study is therefore geared at assessing the minimum amount of topsoil necessary for reclamation and how this would ultimately affect plant diversity and growth of tree species.

2. Materials and Methods

2.1. Description of Study Area

The study was carried out at Newmont Ghana Gold Limited Ahafo mines at Kenyasi. Kenyasi is the capital of the Asutifi District of the Brong Ahafo Region of Ghana. It lies between latitudes $6^{o}40^{\prime}$ and $7^{o}15^{\prime}$ North and longitude $2^{o}15^{\prime}$ and $2^{o}45^{\prime}$ West (Figure 1). The highest mean monthly temperature is about 30 ^{o}C which occurs between March and April with the lowest being 26^{o}C being in August. The average relative humidity is about 75%. The mean annual rainfall is between 130cm to 150cm.

2.2. Experimental design and analysis

The Factorial design in Completely Randomized Design was used to lay the plots. Two factors considered for the experiment were topsoil depth and age of tree species. The plot (waste rock dump) which has an area of about 5.6 ha was divided into four equal panels/plots. Each panel (plot) was 1.4 ha. In each panel different topsoil and subsoil (Saprolite) were placed at a different depth. In the case of soil depth, the treatments were at 4 levels:

Treatment One (T_1) = 0/100 cm of topsoil and subsoil respectively

Treatment Two (T_2) = 20/80cm of topsoil and subsoil respectively

Treatment Three (T_3) = 30/70cm of topsoil and subsoil respectively.

Control (T_0) = 40/60cm of topsoil and subsoil respectively.

The control treatment of 40/60cm of topsoil and subsoil respectively is the standard depth recommended by the Environmental Protection Agency (EPA) Ghana, for reclamation.

The age of tree species was also considered at three treatment levels namely: 6 months, 1 year and 4 years. All the experiment units included installation of erosion and sediment control structures such as silt fence, jute mat, and terraces since it was an erosion prone area. Tree species were planted on the plot at planting distance of 3 m by 3 m (1111 trees per hectare). Tending operations involved mainly ring weeding of native trees and mechanical removal of weeds. The test tree species planted were: *Ceiba pentandra*, *Terminalia superba*, *Cola gigantean*, *Mansonia altissima* and *Khaya anthotheca*.

The Shannon diversity index was used to compare the plant diversity among the treatment plots and calculated with the formula:

$$H' = -\sum_{i=1}^{R} p_i \ln p_i$$

Where p_i is the proportion of characters, belonging to the i^{th} type of letter in the string of interest. In ecology, p_i is often the proportion of individuals belonging to the i^{th} species in the dataset of interest.

Jost (2006) highlighted the non-linearity of Shannon diversity index and the Simpson diversity may lead researchers to grossly misinterpret the underlying diversity of the community in question. Consequently, Jost (2006) proposed that diversity values be converted into equivalent or effective numbers of species (ENS) also known as Hill numbers, which is the number of equally abundant species necessary to produce the observed value of diversity. The effective number of species (ENS) was therefore calculated as:

ENS = exp (H′) where H′ is Shannon diversity index.

This paper also considers the effective number of species to present the results on plant diversity.

3. Results

3.1. Plant Diversity in Relation to Topsoil Depth

Topsoil depth was the main subject of the investigation to find its effect on plant diversity. Consistently, the effective number of species (ENS) was lowest in the treatment that did not have topsoil (T_1) for all years (Table 1). The trend showed a fewer number of species in plots without topsoil. In the first 6 months of the study, there were no differences in effective number of species for all treatments with topsoil.

During the first year, the control (T_0) and the treatment with 30 cm topsoil and 70 cm subsoil (T_3) had the highest number of ENS (Table 1), followed by T_2 with seven for ENS (Table 1). Plant diversity in soils with topsoil addition was four times more than T_1 (no topsoil).

In the fourth year, the highest ENS was realized in T_2, followed by T_0 and T_3 (Table 1). In all cases, the values for ENS were higher in topsoil plots. As the years went by, there was a decline in ENS values relative to the first year. An indication of less plant diversity in the fourth year (Table 1). Generally, it was observed that plant diversity increased with increasing topsoil depth and declined with increasing years (Table 1).

Table1: *Plant Diversity in Relation to Topsoil Depth*

	6 Months		Year 1		Year 4	
Treatment	**Diversity**	**Ens**	**Diversity**	**Ens**	**Diversity**	**Ens**
T_0	1.71	6	2.08	8	1.99	7
T_1	1.48	4	0.70	2	0.70	2
T_2	1.77	6	2.01	7	2.15	9
T_3	1.84	6	2.08	8	1.05	3

ENS = Effective number of species

3.2. Stockpile Depth and Age on Height of Tree Species

Interaction of stockpile depth and age of tree species were significantly different ($P < 0.05$) for all tree species (Table 2). Within six months of planting tree species at the various topsoil depth, the height of *Ceiba pentandra*, *Terminalia superba, and Khaya anthotheca* did not differ significantly ($P>0.05$)

(Table 2). Within one year, the depth of topsoil significantly differed among all the test tree species. In all cases, the treatment without topsoil (T_1) had the lowest tree height. The highest tree height was recorded at T_0 for *Ceiba pentandra*, *Terminalia superba* and *Cola gigantean*. In the case of *Mansonia altissima* and *Khaya anthotheca* T_3 attained the highest height, however, it did not differ significantly from T_0 (Table 2)

Table2. *Mean height of tree species at different stockpiled depth and age*

			Year		
Species (m)	**Depth**	**6 months**	**1 year**	**4 years**	**LSD**
	T_0	0.767^g	4.557^{cd}	9.667^a	
Ceiba pentandra	T_1	0.603^g	1.800^f	5.393^c	0.9013
	T_2	0.537^g	2.720^e	6.500^b	
	T_3	0.800^g	3.567^{cd}	9.083^a	
	T_0	0.180^d	2.600^c	9.600^a	
Terminalia superba	T_1	0.500^d	0.783^d	4.840^b	0.8018
	T_2	0.707^d	2.283^c	5.540^b	
	T_3	0.160^d	2.323^c	9.000^a	
	T_0	0.487^{ef}	2.033^c	5.510^a	
Cola gigantean	T_1	0.350^f	0.700^{def}	3.247^b	1.136
	T_2	0.500^{ef}	1.530^{cd}	4.520^a	
	T_3	0.447^{ef}	1.833^{cd}	4.833^a	
	T_0	0.493^{ef}	1.307^d	4.290^a	
Mansonia altissima	T_1	0.350^f	0.770^e	2.700^c	0.410
	T_2	0.317^f	1.217^d	3.500^b	
	T_3	0.500^{ef}	2.303^c	4.270^a	
	T_0	0.453^f	1.100^e	4.503^a	
Khaya anthotheca	T_1	0.327^f	0.493^f	2.500^c	0.3732
	T_2	0.357^f	1.707^d	3.057^b	
	T_3	0.450^f	1.907^d	4.437^a	

Means of same letters within each block are not significantly different at 5%

In year 4, topsoil depth among the various tree species influenced the height of all species (Table 2).

A similar trend was realized as in year one. Tree height was highest in the control plot of T_0 for *Ceiba pentandra*, *Terminalia superba* and *Cola gigantean.* On the other hand, tree height was highest at T_3 for *Mansonia altissima* and *Khaya anthotheca* but did not differ from T_0 (Table 2).

3.3. Stockpile Depth and Age on Diameter at Breast Height (Dbh) of Tree Species

In the fourth year of planting the tree species, *Ceiba pentandra* and *Cola gigantean* had the highest diameter at breat height (DBH) at T_3, followed by T_0 which did not differ significantly ($P > 0.05$). T*erminalia superba*, *Mansonia altissima*, and *Khaya anthotheca* recorded similar results in which T_3 and T_0 recorded the highest DBH but did not differ significantly. Mean DBH of *Ceiba pentandra* and *Cola gigantean* were lowest at T_1 and T_2 but did not differ significantly during the first 6 months of tree growth (Table 3). At 6 months, no difference ($P> 0.05$) was obtained at all topsoil depths for *Terminalia superba* and *Cola gigantea* except, *Mansonia altissima and Khaya anthotheca* (Table 3).

Table3. *Mean diameter between Species, Year and Depth*

			Age		
Species (cm)	**Depth**	**6months**	**1 year**	**4 years**	**LSD**
	T_0	22.00^{de}	33.00^c	91.00^b	
Ceiba pentandra	T_1	9.33^f	24.33^{de}	27.50^d	9.096
	T_2	16.67^{ef}	26.33^d	40.33^c	
	T_3	28.00^d	35.00^c	116.00^a	

	T_0	11.00^{cd}	40.67^{b}	73.33^{a}	
Terminalia superba	T_1	8.00^{d}	14.00^{cd}	37.67^{b}	9.441
	T_2	11.00^{cd}	17.67^{c}	46.50^{b}	
	T_3	13.67^{cd}	38.67^{b}	71.67^{a}	
	T_0	11.00^{ef}	25.67^{c}	38.00^{b}	
Cola gigantean	T_1	6.50^{f}	16.00^{de}	23.67^{c}	5.358
	T_2	9.50^{f}	16.67^{d}	25.67^{c}	
	T_3	8.00^{f}	25.00^{c}	50.00^{a}	
	T_0	9.33^{d}	21.00^{b}	25.67^{a}	
Mansonia altissima	T_1	4.67^{e}	9.17^{d}	15.00^{c}	3.675
	T_2	4.50^{e}	14.83^{c}	11.00^{d}	
	T_3	11.50^{cd}	20.87^{b}	25.00^{ab}	
	T_0	7.00^{g}	23.00^{b}	28.67^{a}	
Khaya anthotheca	T_1	4.17^{h}	10.17^{ef}	13.67^{cd}	2.765
	T_2	11.00^{def}	12.0^{cde}	14.67^{c}	
	T_3	9.17^{fg}	22.83^{b}	28.33^{a}	

Means of same letter(s) are not significantly different (p= 0.05)

4. DISCUSSION

4.1. Plant Diversity in Relation to Stockpile Depth

Plant diversity of the reclaimed site was not high having obtained diversity values ranging from 0 – 1.9 with a few recording 2. The higher ENS for T_0 and T_3 is an indication of how an amount of topsoil depth could influence plant diversity. The topsoil is a store of plant genetic material and the larger it is, the more plant material available for reproduction under suitable environmental condition. An area is said to be diverse when the diversity value calculated is more than 2 and near 4. Diversity figures near zero give an indication of poor diversity meaning one species is dominant. This result also affects evenness. In effect, the species were also not evenly distributed. The value of a diversity index increases when both the number of species increases and when evenness increases. For a given number of species, the value of a diversity index is maximized when all types are equally abundant. The Diversity and Evenness Indices tested for all the depths, T_1 recorded the least values. This is a clear indication that topsoil is required for the emergence of species.

The ENS was highest at topsoil depth T_3 at 6 months. In year 1, T_0 and T_3 recorded same values but in year 4, T_2 recorded the highest ENS value. This result implies that at the early stages of emergence, increased topsoil is required for increase plant diversity. Topsoil of a depth of 40/70 cm (T_0) cm 30/70 cm (T_3) and 20/80 cm (T_2) proved to be good for early emergence of species. As the years increased, ENS were high in year One but declined in year 4. The decline in diversity could be the result of canopy closure. As canopy closes in the fourth year it affects recruitment of species. This is in conformity with the findings of Bowen *et al.*, (2002) who stated that natural recruitment of local native species appears to occur in the open inter-space of the plant community. Also, Bowen et al. (2002) found that topsoil depth was the only treatment that significantly influenced canopy cover, species diversity, species richness and above ground biomass. Species diversity significantly reduced as topsoil depth increased from 0-600 mm. In the early stages of the vegetation synanthropisation process, there is a marked increase in floristic diversity, but over time impoverishment of communities occurs and their subsequent take-over by a small group of species (Pietrzykowski, 2014).

Dimitrakopoulos & Schmid (2004) and von Felten & Schmid (2008) found that increasing soil volume enhances biodiversity effects on plant production. According to Rivera *et al* (2014), topsoil application enhanced species richness of restored embankment in relation to control. However, the depth of the spread topsoil did not significantly affect resulting plant cover, species richness or floristic composition (Rivera *et al.*, 2014). After 3 years, richness (S) significantly increased with soil depth ($P < 0.0001$), but there was no significant change in species diversity ($P > 0.1$) or composition (multi-response permutation procedure, $P > 0.2$). The lack of a depth effect on diversity resulted from the opposing effect of increasing soil depth-enhancing richness, but decreased evenness (Dornbush and Wilsey, 2010). Plants in the areas under reclamation treatment act as bio-indicators because their presence or absence and response (of individuals in the population) indicate the intensity of the ecological factor. The occurrence of plants in a given area is determined by factors such as the availability of water, temperature, solar energy, availability of nutrients and interactions. Every plant species has specific requirements for the environment. For this reason, vegetation has long been used as an indicator of habitat conditions (Pietrzykowski, 2014). The poor diversity in no topsoil treatment could be due to the lack of nutrients for plant growth.

4.2. Soil Depth and Age on Growth of Tree Species

Topsoil enhances water infiltration, plant rooting media, nutrient cycling, and as a potential source of plant propagules to increase plant community diversity. Varying topsoil and subsoil depth may influence reclamation success to a great extent. This beneficial effect is due to several factors including the higher volume explored by the roots (Zhang *et al*., 2004) and the higher soil volume with no mechanical restrictions (Whitmore *et al*., 2011) could account for the increase plant growth. However, for reclamation purposes, tree species that are capable of increasing in height within the shortest possible time is ideal. The volume of soil available can limit planting or reduce growth and vigor of trees and shrubs. As topsoil depth decreases the potential for survival and growth of woody vegetation decreases (Iles, 2001). Deeper soils, therefore, are capable of providing the available nutrients necessary for plant growth.

The study revealed that both mean heights and diameters increased with increasing topsoil depth. This result could be due to the fact that an increase in topsoil depth enhances root percolation and other microbial activities that lead to enhanced tree growth. This result is in line with a study conducted by McGinnies and Nicholas (1983) who also found a positive relationship between soil depth and root and herbage production of intermediate wheatgrass (*Agropyron intermedium*). Bowen *et al.*, 2002 also confirmed these findings, when they realized that total biomass was significantly greater at 40 and 60 cm topsoil depths compared to shallower topsoil treatments. Addition of topsoil to the original substrate in embankment will increase soil fertility and this improvement will depend on the depth of the topsoil added to the original substrate. Organic matter content, total nitrogen and assimilable phosphorus were all higher in topsoil in comparison with original embankment substrate (Rivera *et al*., 2014). Generally, 0/100cm (T_1) recorded least values throughout the study. This is an indication that topsoil is necessary to enhance growth of tree species.

The study also found no significant difference between 30cm/70cm (T_3) and 40cm/60cm (control) depth. This is an indication that topsoil depth of 30cm/70cm could replace the standard depth of the Environmental Protection Agency (EPA) (40cm/60 cm) in situations where there is inadequate topsoil for reclamation. Meanwhile, this result is in contrast with the study by Redente *et al.,* (1997) who reported no difference in aboveground production between 15 and 60 cm of replaced topsoil after 10 years in northwestern Colorado.

Afforestation is potentially the best sustainable strategy for reclaiming mine lands to their former state (Pietrzykowski, 2014). From the results, Ceiba pentandra and *Terminalia superba* recorded the highest mean heights and mean diameters throughout. This is because these species are pioneer species hence have that tendency to grow rapidly in secondary forests. These species have greater potential for use in reclamation of mined site. A study also found species diversity; richness and cover were all enhanced by shallow topsoil depth (< 200 mm) (Bowen *et al*., 2002).

A study on *Acacia saligna* showed that topsoil had negative effect on plant biomass and positive effect on Arbuscular mycorrhizal fungi percent colonization in ten-year-old stockpile (Birnbaum et al., 2017). Froisland *et al*., (1989) did not observe any deterioration in soil characteristics or growth of topsoil stored in stockpiles. The impact of storage on soil properties is dependent upon methods of topsoil stripping and storage as well as the amount of time in storage (Visser *et al*., 1984).

A study of stockpiles of different size, age, and soil type has revealed that biological, chemical and physical changes do occur, mainly as a result of anaerobic conditions within the heaps, but also as a result of mechanized handling during the stripping and stockpiling. Visible changes occur within 0.3 m of the surface of stockpiles of clayey textured soils, but only below about 2 m depth for sandy textures. These visible changes are accompanied by chemical changes, particularly in the forms of nitrogen present but also in the content of available nutrients, pH and organic matter levels (Abdul-Kareem and McRae, 1984).

5. Conclusions

It is concluded that in order to achieve optimum growth and diversity on mined lands, it is imperative to use an appreciable amount of topsoil and subsoil combinations of 30/70cm and 40/60cm. In a situation where there is a deficit in topsoil availability, the standard topsoil and subsoil combinations of 40/60cm should be replaced with 30/70cm depths in order to achieve optimum plant diversity and tree growth.

Ceiba pentandra and *Terminalia superba* recorded the highest mean heights and mean diameter at breast height throughout the years under study. These tree species have greater potential for reclamation as they grow rapidly is able to colonize the degraded landscape within the shortest possible time.

References

[1] Abdul-Kareem a Wand S. G. McRae, The effects of topsoil of long-term storage in stockpile. Plant and soil 76 (1-3): 357 – 363 (1984).
[2] Birnbaum, C., L. E. Bradshaw, K. X. Ruthrof and J. B. Fontaine, Topsoil stockpiling in restoration: Impact of storage time on plant growth and symbiotic soil Biota. Ecological restoration vol. 35 (3). ISSN 15224740 (2017).
[3] Bowen C.K., Olson R.A., Schuman G.E. and L.J. Ingram, Long-term plant community responses to topsoil Replacement depth on reclaimed mined land. ASMR, 3134 Montavesta Rd., Lexington, KY 40502 (2002).
[4] Department of Horticulture, Restoration and Reclamation Review. Student on-line Journal vol. 4 the no.7 University of Minnesota. USA, (1999).
[5] Dornbush, ME and Wilsey J. B, Experimental manipulation of soil depth alters species richness and co-occurrence in restored tallgrass prairie. Journal of Ecology 98: 117 – 125 (2010).
[6] Froisland, L. J., W.K. Tolley and M. B. Shirts,. Effect of stockpile storage on topsoil characteristics in arid climates. Bureau libraries. 4pages. NIOSHTIC no. 10005902 (1987) .
[7] Ghose, M, Management of topsoil for geo-environmental reclamation of coal mining areas. Environmental Geology 40(11-12): 1405 - 1410) (2001).
[8] Iles, J, Community Tress, Community tree Steward programme. Soils and Trees. IOWA State University Extension. Ames. IOWA (2001).
[9] IUCN and ICMM,. Integrating mining and biodiversity conservation: case studies from around the world. IUCN publications services unit. 48pp (2004).
[10] Jost, L., Diversity and entropy. Oikos 113(2): 363-375 (2006).
[11] Ludwig, J. A, Hindley, N. and Barnett, G, Indicators for monitoring mine site rehabilitation: Trends on waste-rock dumps, Northern Australia. *Ecol. Indic*., 3: 143 – 153 (2003).
[12] McGinnies, W.J., and P.J. Nicholas, Effects of topsoil depths and species selection on reclamation of coal-strip-mine spoils in northwestern Colorado, seed mixture of range grasses, forbs, and shrubs. p. 353-356. Proceedings of the XVI International Grassland Congress: held at Lexington, KY, USA. June 15-24, 1981/edited by J. Allan Smith and Virgil W. Hayes. Boulder, CO. Westview Press, (1983).
[13] Pietrzykowski, M, Reclamation and Reconstruction of terrestrial ecosystems on mined sites – ecological effectiveness assessment. Energy Vol. 2: energy coal 120 – 151. (2014).
[14] Redente, E.F., T. McLendon, and Q. Agnew, Influence of topsoil depth on plant community dynamics of a seeded site in northwest Colorado. Arid Soil Research and Rehabilitation. 11: 139-149 (1997).
[15] Rivera D., V. Mejia, B.M. Javaregui, M. Costa-Tenorio, A. I. Lopez_archillas, B. Peco, spreading topsoil encourages ecological restoration on embankment: Soil fertility microbial activity and vegetation cover. PLoS One 9 (7): e101413 (2014).
[16] Visser, S., C. L. Griffiths and D. Parkinson, Topsoil storage effects on primary production and rates of vesicular-arbuscular mycorrhizal development in Agropyron trachycaulum. Plant Soil 82: 51 – 60 (198)

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