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Original Article

Yield of white clover and orchard grass cultivated in mining passives adding black earth and compost as a substrate

Produtividade de trevo-branco e capim-dos-pomares cultivados em passivos de mineração com adição de terra preta e composto como substrato

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Abstract

Mining environmental liabilities generate environmental pollution. The objective of the present study was to determine the yield of white clover (Trifolium repens) and orchard grass (Dactylis glomerata) cultivated in mining environmental passives adding black earth and compost as a substrate in the Buenaventura Julcani Huancavelica Company. The treatments were the combinations: 4: 3.1: 3.1: 3:1.1 kg of RP: RP, TN: RP, C: RP, TN, C respectively. They were distributed in four treatments with twelve experimental units for each species of leguminous and gramineous grass, we worked according to the completely randomized design (DCA) with a 2 x 4 factorial arrangement, the experimental unit being a treatment with twelve repetitions. The variables evaluated were: germination percentage (TG) and stem survival percentage (TST). For the statistical analysis, the SPSS software was used.

Keywords: white clover, orchard grass, cultivated pastures, mining environmental liabilities, pollution.

Resumo

O passivo ambiental da mineração gera poluição ambiental. O objetivo do presente estudo foi determinar a produtividade de trevo-branco (Trifolium repens) e capim-dos-pomares (Dactylis glomerata) cultivados em passivos ambientais de mineração adicionando terra preta e composto como substrato na Empresa Buenaventura Julcani Huancavelica. Os tratamentos foram as combinações: 4: 3,1: 3,1: 3:1,1 kg de RP: RP, TN: RP, C: RP, TN, C respectivamente. Foram distribuídos em quatro tratamentos com doze unidades experimentais para cada espécie de leguminosa e gramínea, trabalhou-se segundo o delineamento inteiramente casualizado (DCA) com arranjo fatorial 2 x 4, sendo a unidade experimental um tratamento com doze repetições. As variáveis avaliadas foram: porcentagem de germinação (TG) e porcentagem de sobrevivência do colmo (TST). Para a análise estatística foi utilizado o software SPSS.

Palavras-chave: trevo-branco, capim-dos-pomares, pastagens cultivadas, passivo ambiental da mineração, poluição.

1. Introduction

Peru's main economic axis is mining activity, this activity generates mining environmental liabilities (PAM) which presents a major problem at the national level. Due to the aforementioned problem, there is a need to find alternative solutions and one of them may be to cultivate plant species such as white clover (*Trifolium repens*) or orchard grass (*Dactylis glomerata*) among others that would help reduce the degree of contamination contained in PAM. In this sense, Solís-Oba et al. (2020) states that white clover (*Trifolium repens*) and orchard grass (*Dactylis glomerata*) have a high germination rate, so it would be advisable to cover uncultivated land. Many investigations show that extreme temperatures, the availability of nutrients and pasture ecosystems are changing, the importance of grasses in cold areas are usually called C3 and in warm areas C4; however, in the face of climate change, its behavior may be variable (Ventura Ríos et al., 2020). When cultivating these forage grasses, the pH and temperature must be taken into account, since these grasses will adapt to different climatic changes. In this regard, Contreras Tapia et al. (2021) maintains that mining activity generates a great impact on the country's economy. At the same time that it generates problems of an ecological and social nature, the inadequate management of environmental liabilities of the mining tailings type contain a high percentage of toxic substances such as heavy metals that are generated through mining activity operations.

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The cultivation of fodder requires basic care to achieve better yields, but there are pastures that adapt to acid soils with low fertility (Brenes-Gamboa, 2018). Therefore, the PAM are those infrastructures, effluents, emissions, remains or waste deposits produced in the mining operation, which constitute a permanent and potential risk to the health of the population (Gutierrez Torres and Valqui Rojas, 2021). It is important to mention that white clover (*Trifolium repens*) tends to dominate in associated meadows over time due to its stoloniferous growth habit, obtaining a greater advantage compared to orchard grass (*Dactylis glomerata*) that are tillered and erect (Ventura Ríos et al., 2020; Ministry of Education and Science, 2007). Likewise, the cultivation of forage pastures has the following advantages; Irrigation is easy and simple to carry out, it allows to moisten the soil evenly, the excess water applied can be quickly drained. it requires less labor than other methods (Mamani Mamani et al., 2011). In addition, with the cultivation of forage pastures, the reduction of pollutants will be achieved, with lower economic cost (Ledesma Velita, 2018; Aceituno Huacani et al., 2020). The PAM are generated in an uncontrolled way in the mining activity, where there is a need for restoration, mitigation or compensation for environmental damage or unmanaged impact, caused by informal mining activities in the exploitation, generating significant contamination to bodies of surface water and soil, a resource of great importance for the livelihood of the population. In this sense Ledesma Velita (2018) affirms Since ancient times and up to the present, mining activity has been linked to the essential economic development of peoples, communities or countries, thus being a global economic livelihood. Likewise, Gutierrez Torres and Valqui Rojas (2021) mentions that environmental liabilities are all those alterations to the environment caused by companies in the physical or biological environment of an ecosystem. Consequently, the objective of the research was to evaluate the performance of white clover (*Trifolium repens*) and orchard grass (*Dactylis glomerata*) cultivated in mining environmental liabilities of the company Buenaventura Julcani Huancavelica as an alternative of new methodologies to provide a solution to the PAM.

2. Materials and Methods

2.1. Scope of study

The study was carried out in the Buenaventura Julcani Company of the district of Ccosaccasa Huancavelica-Peru, 64 kilometers (km) southeast of the city of Huancavelica, at an altitude between 4200 - 4550 meters above sea level (masl), with a average annual temperature 10 and -5.5 °C. The sampling was carried out in November 2021.

2.2. Population and sample

For the study, mine tailings pool number 9 with an area of 199,750 m^2 was considered. The study area was evaluated prior to the identification of 6 sampling points, from which 5 kilograms (kg) per point were taken, making a total of 30 kg of tailings, which were taken at random, belonging to the Julcani - Buenaventura Mining Unit. from the Population Center of San Pedro de Mimosa of the District of Ccochaccasa Huancavelica-Peru, each sample being labeled and transferred in hermitic bags. Likewise, the black earth without organic matter of 10 kg was transferred from the town of Yaurichuccho to 10 (km) from the city of Huancavelica. Finally, the 10 (kg) compost was transferred from the solid waste treatment plant of the Provincial Municipality of Huancavelica.

2.3. Land preparation

The combination of the Rp, Tn and C substrates was carried out carefully for each treatment. The homogenization work was carried out with the help of the iron tool. For Tn and C, screening was carried out with the objective of achieving a germination of homogeneous pastures.

2.4. Substrate preparation

Substrate distribution was carried out with the help of an electronic scale for each treatment as follows: Treatment (T1) = Witness 4.0 kg of pure tailings (Rp) was used, treatment (T2) = 3.0 kg of Rp plus 1kg of Tn, treatment (T3) = 3.0 kg of Rp plus 1 kg of compost (C) and treatment (T4): 2.0 kg of pure tailings (Rp) plus 1 kg of black earth (Tn) and 1kg of compost (C).

2.5. Planting process

Prior to the sowing process, approximately 200 seeds were counted for each experimental unit of each treatment, after that, it was sown according to the bowling method. The size of the experimental unit was 20 x 20 centimeters (cm).

2.6. Seedling watering

The irrigation was homogeneously inter-daily with a watering can to all the experimental units, the water was harvested in buckets of 18 liters (L) product of the fluvial precipitation during the period of execution of the experiment.

2.7. Germination and survival evaluation

At 18 days after cultivation, the germination of the pastures in each experimental unit was observed, which were meticulously counted. In addition to this, the persistence of each grass was observed during the months of November 2021 to April 2022, which were recorded in a notebook.

2.8. Design

For the experiment, the Completely Random Design (DCA) was used (Equation 1), which consists of assigning the treatments completely, with a 2 X 4 factorial arrangement, making a total of eight treatments with twelve experimental units in each treatment, having as a model mathematician the following:

$$and\ ijk = \mu + Ai + B\ j + \left(AB\ ij \right) + \varepsilon_{ijk} \quad (1)$$

and ijk = Observation of the response variable obtained from the treatment at the i - th level of A, the j- th level of B and the k- th repetition, μ = Overall mean, A i = Effect of the ith variable (grass type), B j = Effect of the j- th variable (substrate type), AB ij = Effect of the interaction of the ith variable A and the j- th variable B y ε_{ijk} = Error.

2.9. Statistic analysis

The research was of an applicative or observational type of explanatory level with a scientific method. The results were expressed in germination and survival percentages with a 95% confidence interval using Duncan's test, for these statistical analysis procedures the MS Excel version 2019 and Info programs were used.

3. Results and Discussion

The average germination percentage of orchard grass (*Dactylis glomerata*) was 47.96% compared to the average germination percentage of white clover (*Trifolium repens*) which was 19.40%.

The percentage of germination of white clover (*Trifolium repens*) in the different treatments (T1, T2, T3 and T4), where the averages of the germination percentage of treatment 1 (Rp), treatment 2 (Rp + Tn), and treatment 3 (Rp + C) were obtained. and treatment 4 (Rp + Tn + C) were 15.83%, 27.83%, 13.17% and 20.75% respectively. Observing that T2 had better results followed by T4 treatment who showed significant statistical differences compared to T1 and T3 treatments.

Likewise, the percentage of germination of orchard grass (*Dactylis glomerata*) in the different treatments (T1, T2, T3 and T4), where the averages of the germination percentage of treatment 1 (Rp) of treatment 2 (Rp + Tn), of treatment 3 (Rp + C) and of treatment 4 (Rp + Tn + C) were 14.92%, 34.50%, 82.50% and 59.92% respectively. Observing that T3 had better results followed by treatment T4 who showed significant statistical differences compared to treatments T2 and T1 as shown in Table 1.

The germination percentage of the different treatments of the experiment depending on the substrate and the cultivated grass (white clover and orchard grass) were 14.92%, 82.50%, 34.50%, 59.92%, 15.83%, 27.83%, 13.17% and 20.75% for the treatments T1A, T2A, T3A, T4A, T1B, T2B, T3B, T4B respectively, which were ordered according to Table 2, finding that T3A turned out to be much superior compared to the other treatments followed by T4A and T2A which show superiority to the following sub treatments in the following order: T2B, T1B, T1A finally T3B Table 2.

The average survival percentage in the month of January in orchard grass (*Dactylis glomerata*) was 44.96% compared to the average survival percentage of white clover (*Trifolium repens*) which was 13.48%. Likewise, the cultivated pastures in the different treatments (T1, T2, T3 and T4) depending on the cultivated pasture and the substrate used were 11.42%, 34.33%, 78.83%, 55.08% 9.00%, 23.42%, 8.33% and 13.17% for the treatments T1 A, T2 A, T3 A, T4 A, T1 B, T2 B, T3 B and T4 B respectively, finding that T3A turned out to be much superior compared to the other treatments followed by T4A and T2A. which show superiority to the following sub treatments in the following order: T2B, T4B, T1A finally T1B and T3B as shown in Table 3.

Table 1. Seed germination 18 days after sowing

Treatment	Substratum	White clover (*Trifolium reps*) *(%)*		Orchard grass (*Dactylis glomerata*) (%)			
		SD	Duncan	Treatments	Substratum	SD	Duncan
$T2_{\_}$	Rp + Tn	27.83 ± 1.36	A	$T_{3\_}$	mop + c	82.50 ± 1.36	A
$T4_{\_}$	Rp + Tn + C	20.75 ± 2.58	B	$T_{4\_}$	Rp + Tn + C	59.92 ± 2.58	B
$T1_{\_}$	mop	15.83 ± 1.36	C	$T_{2\_}$	Rp + Tn	34.50 ± 1.36	C
$T3_{\_}$	mop + c	13.17 ± 1.36	C	$T_{1\_}$	mop	14.92 ± 1.36	D
Average		19.40 ± 1.10				47.96 ± 1.10	

SD = standard deviation; T_1 = control / pure tailings; T_2 = pure tailings plus black earth; T_3 = pure tailings plus compost; T_4 = pure tailings plus black earth plus compost; mop represents the potash fertilizers; C; compost; Letters (A, B, C) represents significance of the treatments among each other.

Table 2. Evaluation of the germination percentage in different treatments depending on the substrate and the cultivated grass.

pastures	Treatments	substrates	SD	Duncan	
ball grass	T_3A	mop + c	82.50 ± 2.21	A	
ball grass	T_4A	Rp + Tn + C	59.92 ± 2.21	B	
ball grass	T_2A	Rp + Tn	34.50 ± 2.21	C	
white clover	T_2B	Rp + Tn	27.83 ± 2.21	D	
white clover	T_4B	Rp + Tn + C	20.75 ± 2.21	F	
white clover	T_1B	mop	15.83 ± 2.21	F	
ball grass	T_1A	mop	14.92 ± 2.21		F
white clover	T3B	Rp + C	13.17 ± 2.21		F

SD = standard deviation; T_1 = control / pure tailings; T_2 = pure tailings plus black earth; T_3 = pure tailings plus compost; T_4 = pure tailings plus black earth plus compost; mop represents the potash fertilizers; C represent the compost; Letters (A, B, C, D, F) represents significance of the treatments among each other, Rp = pure tailings, Tn represents the pure tailings black earth.

Table 3. The percentage of survival of cultivated pastures

you	Substratum	White clover *and orchard grass* (*January*)			you	Substratum	White clover *and orchard grass* (*February*)			you	Substratum	White clover *and orchard grass* (*March*)			you	Substratum	White clover *and orchard grass* (*April*)		
		P	mean ± SD	Duncan			P	mean ± SD	Duncan			P	mean ± SD	Duncan			P	mean ± SD	Duncan
T_2B	mop+c	Po	78.83 ± 2.04	A	T_3B	mop+c	po	78.17 ± 1.92	A	T_3B	mop+c	Po	77.58 ± 1.90	A	T_3B	mop+c	Po	76.92 ± 1.84	A
T_4B	Rp+Tn+C	Po	55.08 ± 2.04	B.	T_4B	Rp+Tn+C	po	54.75 ± 1.92	B.	T_4B	Rp+Tn+C	po	53.58 ± 1.90	B.	T_4B	Rp+Tn+C	po	52.50 ± 1.84	B.
T_2B	Rp+Tn	Po	34.33 ± 2.04	C.	T_2B	Rp+Tn	Po	33.92 ± 1.92	C.	T_2B	Rp+Tn	po	33.58 ± 1.90	C.	T_2B	Rp+Tn	po	33.58 ± 1.84	C.
T_2A	Rp+Tn	TB	23.42 ± 2.04	D.	T_2A	Rp+Tn	TB	16.83 ± 1.92	D.	T_1B	mop	po	2.17 ± 1.90	D.	T_1B	mop	po	0.00 ± 1.84	D.
T_4A	Rp+Tn+C	TB	13.17 ± 2.04	AND	T_4A	Rp+Tn+C	TB	6.25 ± 1.92	AND	T_3A	Rp+ C	TB	1.25 ± 1.90	D.	T_1A	mop	TB	0.00 ± 1.84	D.
T_1B	mop	po	11.42 ± 2.04	AND	T_1B	mop	Po	4.00 ± 1.92	AND	T_4A	Rp+Tn+C	TB	0.00 ± 1.90	D.	T_2A	Rp+Tn	TB	0.00 ± 1.84	D.
T_1A	mop	TB	9.00 ± 2.04	AND	T_1A	mop	TB	2.92 ± 1.92	AND	T2A	Rp+Tn	TB	0.00 ± 1.90	D.	T_4A	Rp+Tn+C	TB	0.00 ± 1.84	D.
T_3A	mop+c	TB	8.33 ± 2.04	AND	T3A	mop+c	TB	2.42 ± 1.92	AND	T1A	mop	TB	0.00 ± 1.90	D.	T_3A	Rp + C	TB	0.00 ± 1.84	D.
Average TB		Po	44.92 ± 1.02	A				42.71 ± 0.96	A				41.73	A				40.75 ± 0.92	A
		13.48 ± 1.02	B.				7.10 ± 0.96	B.				0.31	B.				0.00 ± 0.92	B.	

SD = standard deviation; T_1 = control / pure tailings; T_2 = pure tailings plus black earth; T_3 = pure tailings plus compost; T_4 = pure tailings plus black earth plus compost, mop represents the potash fertilizers; C represent the compost; Letters (A, B, C) represents significance of the treatments among each other; Rp = pure tailings; P = pastures; po = ball grass; TB = white clover. Mop, muriate of potash, C, compost.

The average survival percentage in the month of February in orchard grass (*Dactylis glomerata*) was 42.71% compared to the average survival percentage of white clover (*Trifolium repens*) which was 7.10%. Likewise, the cultivated pastures in the different treatments (T1, T2, T3 and T4) were 4.00%, 33.92%, 78.17%, 54.75%, 2.92%, 16.83%, 2.42% and 6.25% for the treatments T1 A, T2 A, T3 A, T4 A, T1 B, T2 B, T3 B and T4 B respectively, finding that T3A turned out to be much superior compared to the other treatments followed by T4A and T2A which show superiority to the following sub treatments in the following order: T2B, T4B, T1A finally T1B and T3B as shown in Table 3.

The average of the percentage of survival of the pastures in the month of March in orchard grass (*Dactylis glomerata*) was 41.73% compared to the average survival percentage of white clover which was 0.31%. Likewise, the cultivated pastures in the different treatments (T1, T2, T3 and T4) were 2.17%, 33.58%, 77.58%, 53.58%, 0.00%, 0.00%, 1.25% and 0.00% for the treatments T1 A, T2 A, T3 A, T4 A, T1 B, T2 B, T3 B and T4 B respectively, finding that T3A turned out to be much superior compared to the other treatments followed by T4A and T2A which show superiority to the following sub treatments in the following order: T1A, T3B, T4B, finally T2B and T1B as shown in Table 3.

The average of the percentage of survival of the pastures in the month of April in orchard grass (*Dactylis glomerata*) was 40.75% compared to the average survival percentage of white clover (*Trifolium repens*) which was 0.00%. Likewise, the cultivated pastures in the different treatments (T1, T2, T3 and T4) they were 0.00%, 33.58%, 76.92%, 52.50%, 0.00%, 0.00%, 0.00% and 0.00% for the treatments T1 A, T2 A, T3 A, T4 A, T1 B, T2 B, T3 B and T4 B respectively, finding that the T3A turned out to be much superior compared to the other treatments followed by T4A and T2A which show superiority to the following sub treatments in the following order: T1A, T1B, T2B, T4B and T3B as shown in the Table 3.

4. Conclusions

The germination percentages of orchard grass in any of the substrates except the Rp substrate were higher than the germination percentages of white clover in the four different substrates. It can be concluded that the survival percentages of orchard grass maintained the same behavior as the germination percentage, which means that orchard grass maintained higher levels of survival than white clover in the month of January.

Similar behavior was presented for the month of February, which means that orchard grass had higher survival rates than white clover. In the month of March, the survival percentage was highly superior to the survival percentage of white clover since it reached levels of zero percent. Finally, it can be concluded that the orchard grass in the month of April showed superiority in survival compared to white clover, since the orchard grass maintained considerable percentages of survival while white clover was considered non-existent.

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