FINAL RESEARCH PROJECT REPORT ON USING SHEEP WOOL FERTILIZER ON SOIL REHABILITATION AT SALKHIT GOLD AND SILVER MINING

DELL

PROJECT NAME: Using sheep wool fertilizer on soil rehabilitation at Salkhit gold-silver mining

Contract number:	№ЭСР/ХААИС/01-2021
Reporting period	2021.06.12-2021.12.17
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Reported to	“Erdenes Silver Resources” LLC

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ONE. INTRODUCTION

Quality of post-mining rehabilitation is important to reduce the risk to the environment and public health. Organic fertilizers are important for the restoration of soil the original state, structure, nutrients and moisture of the soil after mining. Organic fertilizers made from 100% sheep wool, which are not harmful to the environment and are environmentally friendly, are being produced and introduced in our country.

Erdenes Silver Resource LLC, located in Gurvansaikhan soum, Dundgovi aimag, is a state-owned mining and manufacturing company. The state-owned company aims to show that mining projects can be developed with the skills of Mongolian management and experts. In addition, a request was made to the research organization to determine in detail how “Sheep wool organic fertilizer” affects the soil rehabilitation of the mine, focusing on setting appropriate standards for the local and environment in which the project is being implemented.

A team of professional researchers conducted a study to test the organic fertilizer made of sheep wool for the biological rehabilitation of the soil at the Salkhit silver-gold mining of Erdenes Silver Resource LLC.

1.2. BRIEF INTRODUCTION TO SALKHIT GOLD-SILVER MINING

“Erdenes Silver Resources” LLC is the developer of “Salkhit gold and silver mining” project and operates in the exploration area of 2887.75 ha in Gurvansaikhan soum of Dundgovi aimag, 280 km south of Ulaanbaatar and 75 km east of Dundgovi aimag center.

Soil, weather condition and vegetation

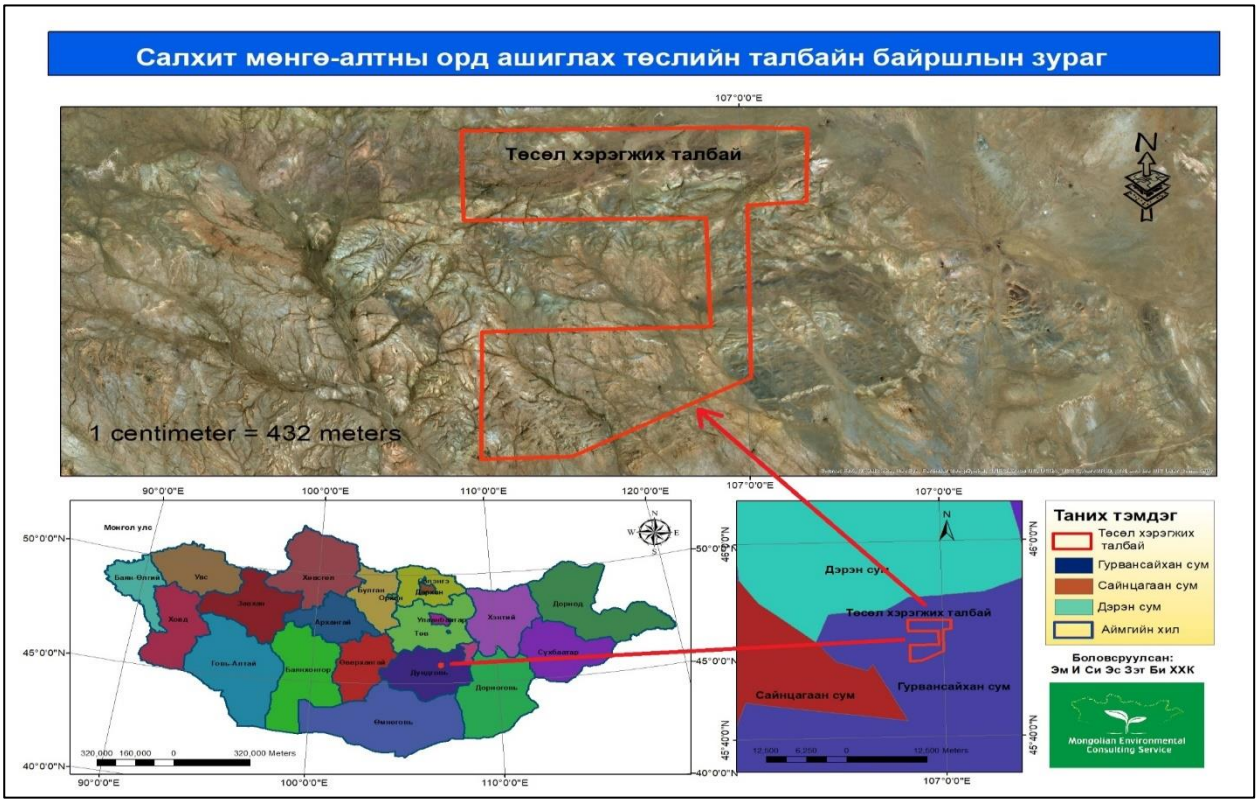


Fig 1. Experimental field location of Salkhit gold-silver mining

Gurvan Saikhan soum belongs to the steppe region of Eastern Mongolia and, in terms of geomorphology, belongs to the Onon Balj basin. It has a cool, extreme continental climate, with four distinct seasons of the year, less snow in the winter, much drier, and more windy in the spring. The average annual rainfall is 100 mm.

The geographical ecosystem of Gurvansaikhan soum is dominated by rocky mountain slopes, small mountain slopes, hills, low plains, depressions and valleys. The Gobi desert is dominated by brown desert soils. The mechanical composition of the soil is sandy and loamy.

In terms of vegetation-geographical zoning, it belongs to the desert steppe zone of Dornogovi and is dominated by *Stipa* genus grass and *Allium polyrrhizum Turcz. ex RgL*.. There are plant communities such as *Carex dichroa Freyn- Festuca brachyphylla Schult. Et Schult. F; Carex dichroa Freyn- Stipa baicalensis Roshev; Cleistogenes squarrosa (Trin.) Keng- Stipa baicalensis Roshev; Anabasis aphylla L. - Stipa baicalensis Roshev; Anabasis aphylla L. - Allium polyrrhizum Turcz. ex RgL- Stipa baicalensis Roshev; Dasiphora fruticosa (L.) Rydb- Stipa baicalensis Roshev; Salsola passerina Bge- Stipa baicalensis Roshev.*

The territory of the Dundgobi aimag is characterized by a natural zone, with the steppe zone in the north and the desert steppe zone in the south. In terms of climate, Mongolia, like the rest of Mongolia, has a harsh continental climate, but it is relatively warm.

The winters are warm and snowy, the summers are relatively hot and rainy, and there are many stormy days in spring and autumn, belongs to the micro-region with hot dry conditions.

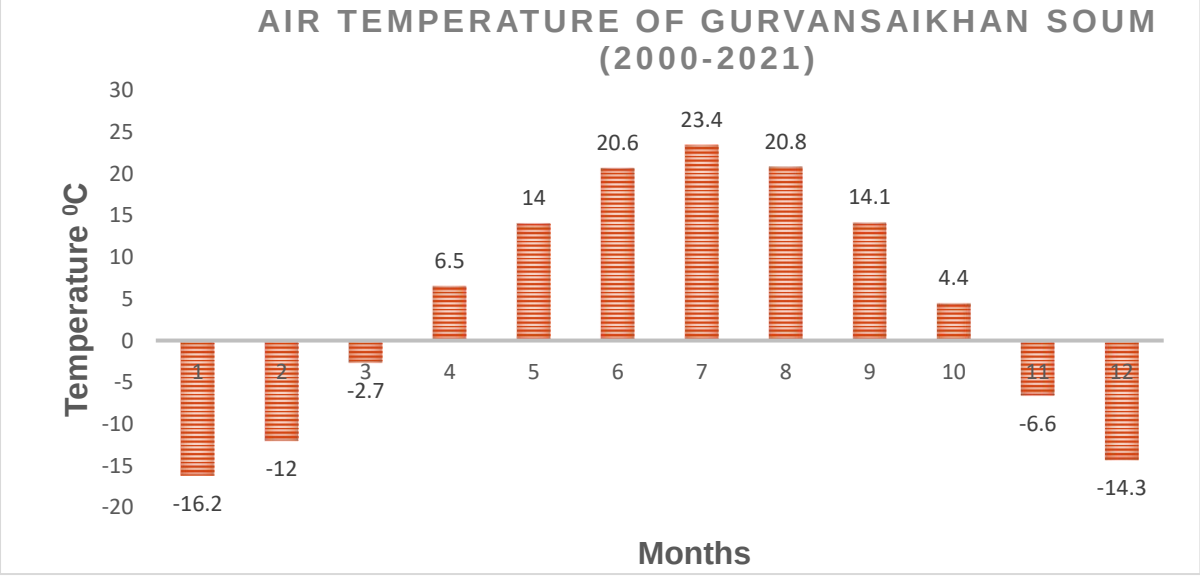


Fig. 2 Air temperature of Gurvansaikhan soum

Fig 2. The long-term average of air temperature is -16.2 ^{0}C in January and 23.4 ^{0}C in July, that shows that air temperature is more stable in winter and summer.

The long-term average air temperature of Gurvansaikhan soum in September in the last 30 years between 1991-2021 is 13.1-14.4^{0}C (Fig 3).

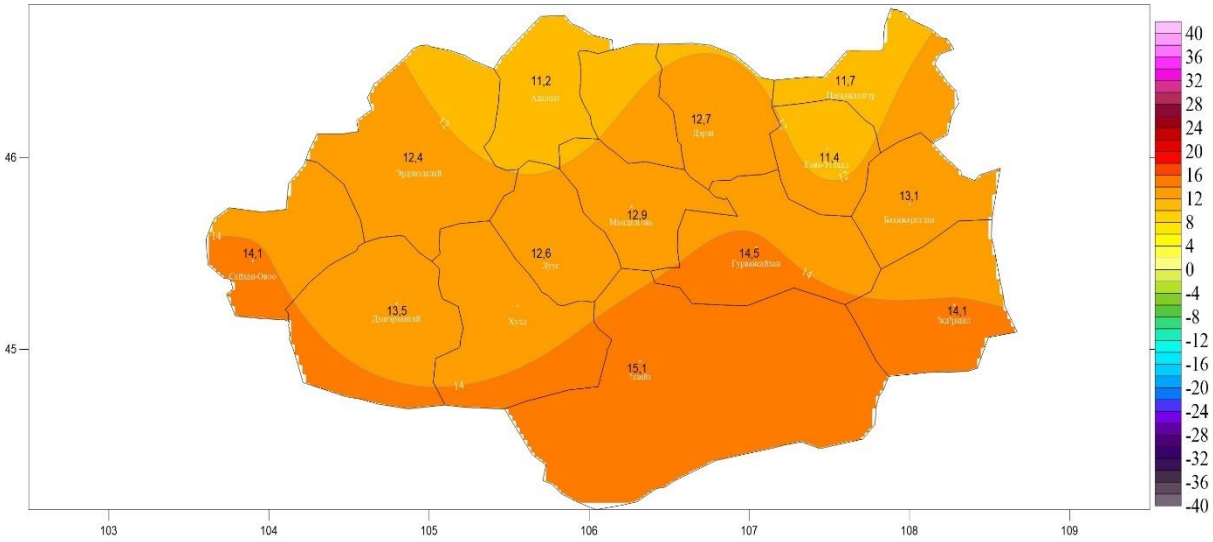


Fig 3. **Air temperature changes in spatial distribution**

The average annual soil surface temperature is 3.2°C, and in January, the lowest absolute temperature is -44.6°C, and the highest maximum temperature is 64°C in July. The first period of freezing on the soil surface occurs in early September and the last period in mid-May. It freezes to a depth of 3.2 m. Comparing soil temperature between annual air temperatures, soil temperature fluctuations are 2.0^0C (Figure 4).

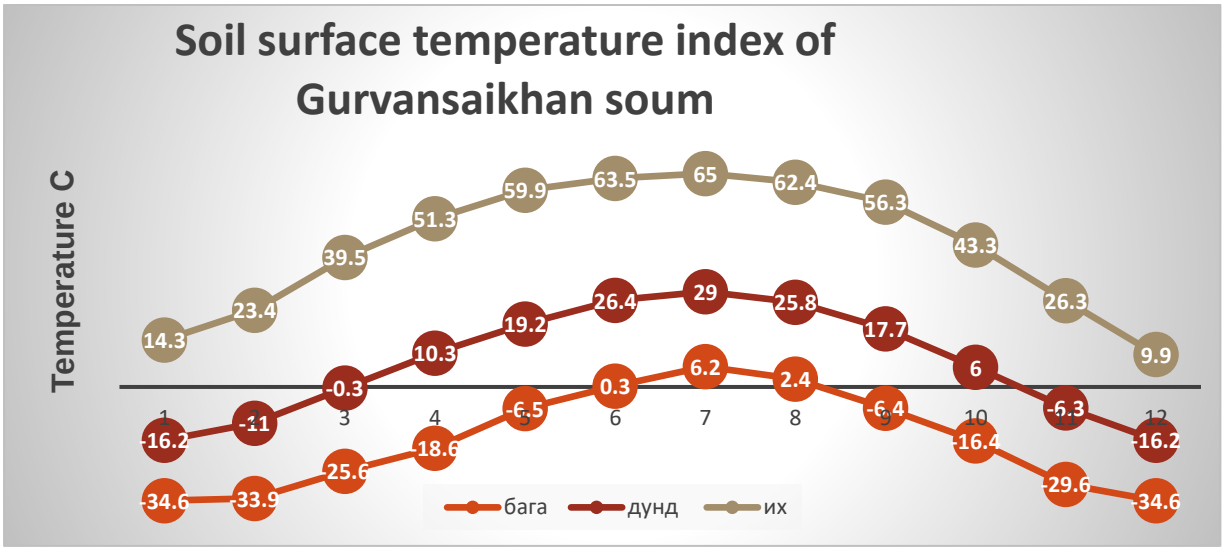


Fig 4. **Annual changes of soil temperature**

According to the long-term average precipitation of Gurvansaikhan soum, 46.5-195 mm of precipitation fell. The first snow falls in the last ten days of November, and the snow cover is formed in mid-December, stays for 40 days, the snow starts to melt in mid-February, the last snow falls in the last ten days of April, and the snow melts by

the end of April. The thickness of snow is 1-4 cm, reaching 5-10 cm in some areas and density of snow is 0.08-0.17 g / cm^3 in some areas (Figure 4).

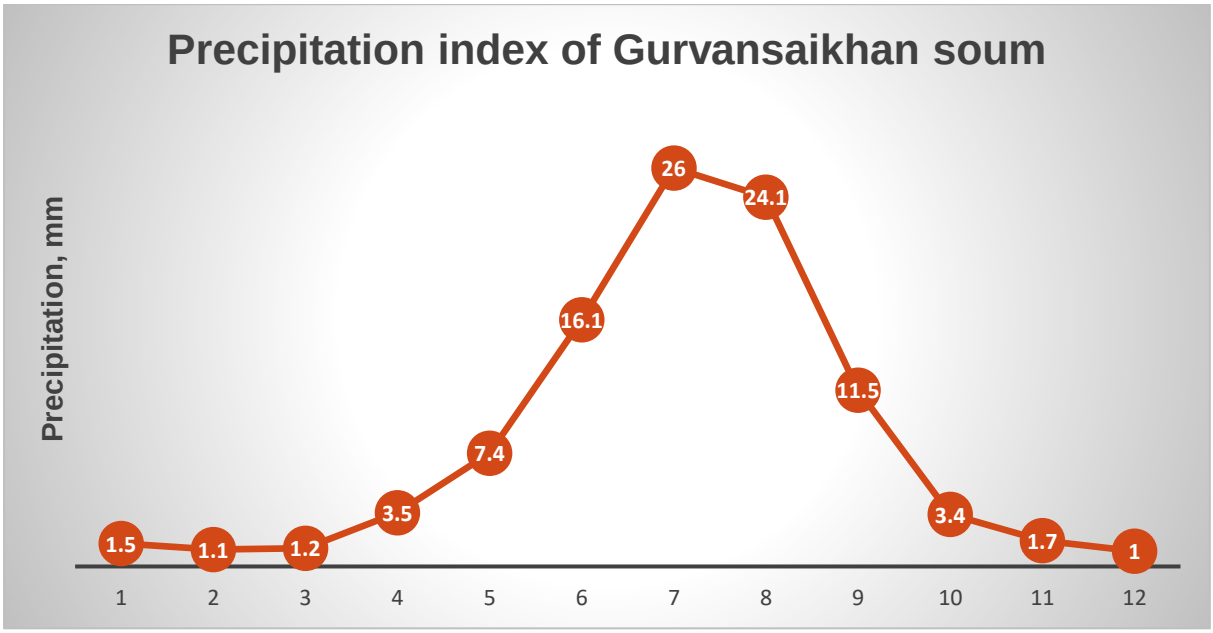


Fig 5. Yearly precipitation

The average wind speed in the study area is 3.7 m/sec for many years, that indicates the region is windy and unstable, and the maximum wind speed reaches 34 m/sec due to the mountainous terrain affected by the local physical geography system is observed. The average number of days with dust storms per year is 22 days, and the number of days with snowstorms is 10 days. The area is dominated by westerly winds in all seasons, and wind from north, west, south is dominated in the warmer months.

According to the long-term average, the wind speed will reach 4.5 m/sec in the study site, which is 2.1 m/sec higher than the summer season, and the number of days with strong winds (15 m/sec) is estimated to be 1 per 5 days. Gurvansaikhan soum areas are considered to be unstable in terms of wind storms, with maximum wind speeds of 32-34 m/sec in spring and autumn (Figure 6).

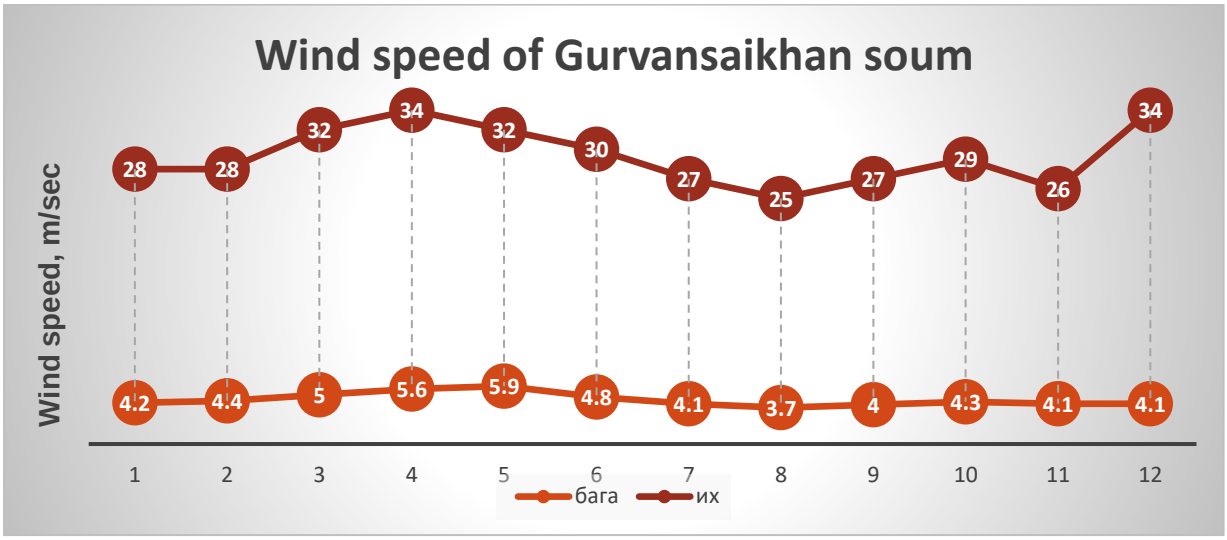


Fig 6. **Wind speed**

1.3. VEGETATION AND PLANT SPECIES OF THE STUDY FIELD

The following results are shown in the analysis of the vegetation cover and its condition in the vicinity of Salkhit silver deposit of Erdenes Silver Resource LLC, Gurvansaikhan soum, Dundgovi aimag, Mongolia. The region belongs to the Dornogovi Desert steppe of Mongolia and is dominated by rocky mountains, slopes, hills, plateaus, lowlands and valleys.

In terms of vegetation in this region, desert steppe vegetation is predominant in *Stipa Krylovii Roshev.*, *Allium polyrrhizum Turcz. ex RgL.,* and *Anabasis brevifolia C. A. Mey.*, and *Stipa glareosa P. Smirn* and *Caragana gobica Sancz.* play a sub-dominant communities. Follow the light brown saline soils of some desert steppes of the Gobi *Arinatherum splendens (Trin.) Nevski* and *Iris bungei Maxim* vegetation is observed.

Since the region is bordered by two flora-geographic districts of the Mongolian flora, several species of the *Caragana Lam.* observed in and around the mine. *Caragana stenophylla Pojark* and *Caragana microphylla Lam.*, Which form the main species in the Middle Khalkha steppe of Mongolia, are common in the mine area, and include *Allium polyrhizum Turcz. Ex Regel* and *Stipa krylovii Roshev* to form vegetation patterns of the main dry steppe communities. Along with *Caragana leucophloea Pojark* and *Caragana pygmaea (L.) DC*, *Anabasis brevifolia CA Mey* and *Stipa caucasica subsp. Glareosa (PA Smirn.) Tzvelev* form the main descriptive community of the desert steppe and occupy 75-85% of the total survey area as a basin belonging to the Dornogovi desert steppe district of Mongolia. The following table lists the main plant species found in the region.

THE MAIN PLANT SPECIES OF SALKHIT GOLD-SILVER MINING SITE (Fig 3).

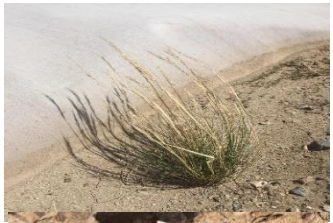
ДАГУУР ХҮЖ ӨВС-***Haplophyllum dauricum*** (L.) G. Don
Classification: perennial, semi-shrubs
Importance of nutrition: fodder plant
Characteristics: Has upright stems woody in the lower end with 10-20 cm high, grows on small deciduous shrubs, perennial shrubs. The leaves are narrow and thick, 7-12 mm long. Leaves and fruits have juice like many dots. 5 petals yellow flowers umbel like flowers.
Phenomenology: Flowers June to July and produces seed August to September.

АЛТАЙН СОГСООТ-***Heteropappus altaicus*** (Willd.) Novopokr.
Classification: annual grass
Importance of nutrition: fodder plant
Characteristics: Gentle hairy green, branched at the tip, deciduous, 30-100 cm tall stemed, slender, 2-year-old grass. Stem leaves 5-7 cm long, 5-20 mm wide, shrinking as they grow. The inside of the leaf is bright green and the back is light. The tongue-shaped flowers surrounding the basket are white.
Phenomenology: It blooms and produces seed continuously from June to September

НАРИЙН НАВЧИТ ХАРГАНА- ***Caragana stenophylla*** Pojark.
Classification: perennial shrubs
Importance of nutrition: An important plant for animal feed. It is also important against sand movement.
Characteristics: Light green bark, occasionally yellow, about 60 cm tall, many-stemmed, deciduous, alien lanceolate, 0.75-1.5 mm wide, tapered petals yellow, perennial shrub.
Phenomenology: Flowering in June-July, produces seed in August.

САЙРЫН ХЯЛГАНА-*Stipa caucasica subsp. glareosa* (P.A. Smirn.) Tzvele
Classification: perennial grasses
Importance of nutrition: forage plant that grows well from seed.
Characteristics: It grows on small dense shrubs with bearded roots that penetrate to a depth of 60-80 cm into the soil. Perennial grasses. Most of the leaves are located at the base of the bush. The leaves are curved, hard, 7-25 mm long, 1-1.8 mm wide, with single veins on the inside and dense hairs. Inflorescence on average 2–3 cm long.
Phenomenology: It regenerates in May, blooms in June-July and produces seed in August.

ДАГУУР ХАТНЫ ЦЭЦЭГ-***Cymbaria dahurica*** L.
Classification: perennial variegated grass
Importance of nutrition: Medicinal plant
Characteristics: Perennial herb with coarse-grained roots, erect, 5-15 cm tall stems, felt white hairs. The leaves are opposite, linear-lanceolate, with tapered entire edges. Nuts, single or in pairs, emerge from the middle of the middle leaf with large, yellow flowers. Fruits ovate, 8-10 mm long.
Phenomenology: Flowers in July and produces seed in August.



АММАНЫ СЭДЭРГЭНЭ- ***Convolvulus ammannii*** Desr.
Classification: Perennial variegated grass
Importance of nutrition: Medicinal and fodder plants. Grows well in arid steppe and desert areas.
Characteristics: Dry perennial, many-stemmed, 3-5 cm tall, leaves linear, flowers concave or funnel-shaped, light pink.
Phenomenology: Flowering in June, produces seed in July-August. Leaf buds are well kept in the winter.

GENERAL CONDITIONS OF MINING SITE SOIL

Digging № 6 Characterizing soil (Fig 4).

Location: 45⁰52 21 N, 107⁰ 5945,7 E

A. 0-5 cm. Light brown colored, higher density, plant root distribution is less, small pebbles 10-30%, granular structure, sandy mechanical composition, color transition is gradual, not boiled with 10% of HCl.
B. 6-15 см. Light brown colored, higher density, plant root distribution is less, small pebbles 20-30%, granular structure, sandy mechanical composition, color transition is gradual, hardly boiled with 10% of HCl.
C. 15-36. Light colored, higher density, no plant root distribution, granular structure, sandy mechanical composition, color transition is gradual, strongly boiled with 10% of HCl.

Table 1. Results of soil chemical analysis

Digging depth, cm	pH	EC	Humus, %	$CaCO_3$, %	Base, mg-eq/100 g		Nutrients, mg/100 g		
					Ca	Mg	NO_3	P_2O_5	K_2O
0-5	7.86	0.073	1.46	-	17	11	0.16	1.6	16
6-15	8.06	0.171	1.04	1.28	18	10	0.32	1.0	18
16 -36	8.08	0.186	0.58	7.36	16	9	0.45	0.6	18

Table 2. Mechanical structure of soil

Digging depth, cm	Particle size (мм/%)							Naming
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01	
0-5	12.7	37.2	23.7	10.7	7.9	7.8	26.4	Х.Ш
6-15	15.2	15.2	35.4	27.2	4.2	9.8	22.2	Х.Ш
16 -36	15.2	15.2	35.4	27.2	4.2	9.8	22.2	Х.Ш

Note: Х.Ш- хөнгөн шавранцар: Light loam

Table 3. Microbiological contamination of soil

Digging depth, cm	**(E.Coli)**	**Anaerobic titer (Cl.perf)**	**Number of microorganisms**
0-5	no	no	no
6-15	no	no	no
16-36	no	no	no

Note: no-not present

Table 4. Heavy metal analysis of soil

Digging depth, cm	Heavy metals, mg/kg					
	Cu	Zn	Cr	Co	Ni	Pb
0-5	28.2	48.2	42.2	<1.0	<1.0	14.5
6-15	28.2	40.2	46.2	<1.0	<1.0	14.5
16-36	28.2	48.2	42.2	<1.0	<1.0	14.5

Digging № 2. Soil morphological record (Fig 5).

Location: $45^{0}52$ 21 N, 107^{0} 5945,7 E

А. 0-10 cm. Brown colored, higher density, low plant root distribution, contains pebbles, low moisture, 10% granular structure, light loam mechanical composition, gradual transition of color, non-boiling with 10% of HCl.

Б. 10-39 cm. Light brown colored, higher density, low plant root distribution, contains pebbles, granular structure, light loamy mechanical structure, gradual color change, weakly boiled with 10% HCl.

С. 39-low. Light colored, higher density, no plant root distribution, no granular structure, large number of small pebbles, light loamy mechanical composition, gradual transition of color, intensely boiled with 10% of HCl.

Table 5. Result of soil chemical analysis

Digging depth, cm	pH	EC	Humus, %	$CaCO_3$, %	Base, mg-equ/100 g		Nutrition, mg/100 g		
					Ca	Mg	NO_3	P_2O_5	K_2O
0-10	8.6	1.94	1.40	-	16	11	0.86	1.2	15
11-38	8.29	1.94	1.46	0.8	14	10	0.46	1.0	17
39-low	8.81	2.15	1.08	3.2	15	8	0.46	0.8	12

Table 6. Soil mechanical structure

Digging depth, cm	Particles (mm/%)							Naming
	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01	
0-10	12.2	37.6	23.7	10.7	7.9	7.8	26.4	Х.Ш
11-38	14.2	16.2	35.4	27.2	4.2	9.8	22.2	Х.Ш
39-low	14.2	16.2	35.4	27.2	4.2	9.8	22.2	Х.Ш

Note: Х.Ш- хөнгөн шавранцар Light loam

Table 7. Microbiological contamination of soil

Digging depth, cm	**(E.Coli)**	**Anaerobic titer (Cl.perf)**	**Number of microorganisms**
0-10	no	no	no
11-38	no	no	no
39-low	no	no	no

Note: no-not present

Table 8. Heavy metal analysis of soil

Digging depth, cm	Heavy metals, mg/kg					
	Cu	Zn	Cr	Co	Ni	Pb
0-10	38.2	46.2	38.2	<1.0	<1.0	18.5
11-38	28.2	44.2	46.2	<1.0	<1.0	16.5
39-low	38.2	44.2	42.2	<1.0	<1.0	16.5

According to the results of the above analysis, the characteristics of soil are; neutral at the surface, weakly alkaline at depths below 40 cm, electrical conductivity (EC) 1.9 or unsalted, humus content 0.8-1.26 or low, no calcium carbonate, low total absorbable bases, nutrients content is low or poor, light loamy soils.

RESEARCH GOAL AND OBJECTIVES

Салхитын алт-мөнгөний ордын уурхайн хөрсний биологийн нөхөн сэргээлтэд хонины ноосоор хийсэн бордоог туршиж, хөрсний үржил шим болон ургамлын өсөлтөнд хэрхэн нөлөөлөх байдлыг тооцох зорилготой. Энэхүү зорилгод хүрэхийн тулд дараах зорилтуудыг бид дэвшүүллээ. Үүнд:

The purpose of the research is to test the use of sheep wool fertilizers in the biological rehabilitation of Salkhit gold-silver mining site and to estimate the effect on soil fertility and plant growth. To reach the goal, we have set the following goals.

Research objectives:

- To study the effects of sheep wool organic fertilizer on soil and plants, to conduct laboratory experiments and to process the results.
- To conduct field experiments on rehabilitative plants, to determine the effect of organic wool fertilizer on some indicators of soil fertility and pollution, and to compare it with other types of fertilizers,
- To determine the effect of organic wool fertilizer on the yield of rehabilitated plants and compare the results with other types of fertilizers.

TWO. RESEARCH METHODOLOGY AND ITS COMPONENTS

Research on determining effects pf wool pellet organic fertilizer at the Salkhit gold-silver mining site was done by 20 researchers from related research organizations, such as 3 times accredited, the oldest soil lab of our country “Soil and agro-chemistry laboratory” of school of Agro-ecology, MULS, Plant classification sector of Institute of Botany and Research and development center for food, agriculture and light industry. The experiment was done between 10th of June to 15th December, 2021 for 6 months.

The study was conducted in five phases: (i) preparation, (ii) field experiment, (iii) laboratory analysis, (iv) data exploration, report preparation and (v) submission of the research results.

Preparation:

During the preparation phase, the mine profile and information were reviewed, and topographic maps of M1:100.000 and meteorological background data were collected. In addition, a professional team was formed to jointly conduct field and laboratory research, and the necessary materials, tools, and vehicles were prepared.

- Research and experimental methodology has developed
- Materials for field experiment have been prepared
- 300m^2 soil for planting, field variations and irrigation equipment are prepared for field experiment.

Field experiment:

Судалгааны обьектын газрын төрх байдал, хөрс ургамлын бүрхэвч байдал, орчны хөрсний бүрхэвч, гарал үүслийн мэдээ, фото зураг цуглуулан, туршилтын талбайг сонгож, тарилсан ургамлын ургахын өмнө болон ургахын явцад хувилбар тус бүрээр хөрсний дээж цуглуулж, ургамлын биометрийн хэмжилт хийв. Ургамлын бичиглэл болон хөрсний хээрийн бичиглэл хийж туршилтын талбай бүрээс 3 давталттай хэмжилт хийж, ургамлын 40, хөрсний 150 гайруй дээж цуглуулсан.

The topography of the research field, soil and vegetation cover, soil cover, origin data, photos were collected, thus, the test site was selected, soil samples were collected for each variant before and during the growth of the plants, and cultivars biometric measurements were taken. Vegetation and soil field recordings were made and 3 repeated measurements were taken from each test site. 40 plant samples and 150 soil samples were collected during the experiment.

Laboratory experiment:

- Fertilizer testing was carried out in a pot under laboratory conditions.
- Plant biometric measurements were performed in 3 repetition for each variant.
- Soil, vegetation, sheep wool organic fertilizer nutrients, composition, plant biochemistry, soil fertility, hygiene analysis, and heavy metal comparative analysis were made in laboratory.

Reporting:

- The effect of organic wool fertilizer on biological rehabilitation was determined and the report on results were compared with other types of fertilizers.
- The use of sheep wool organic fertilizer in soil rehabilitation in the field affects the chemical and physical properties of the soil. The field experiments were developed on dosage and technologies for fertilizer application.
- The results of field and laboratory experiments were processed and compared in SPSS, R and Word programs.
- Research results and reports were discussed at the Academic Council meeting.

Research planning

Table 9. Research planning

Types of work	6	7	8	9	10	11	12
Developing experimental and research methodology							
Materials required for field testing have been prepared							
300m^2 soil for planting, field variations and irrigation equipment are prepared for field experiment							
Field sampling, vegetation and soil field experimental recording were performed in 3 repetitions.							
Materials required for laboratory tests have been prepared							
Plant seeds and fertilizers were tested in the laboratory							
Plant biometric measurements were performed in 3 repetitions for each variant							
Fertilizers, soil and vegetation were analyzed in the laboratory							
The results of field and laboratory experiments were processed and compared							
The results and report of the research were discussed at the meeting of the Academic Council							
Print the research results and report and submit it to the procuring entity							

Experimental variations

- In order to determine the general condition of the soil and vegetation, soil digging were made at 6 points, layers were monitored, digging layer samples were taken, and surrounding vegetation was recorded.
- In order to determine the effect of wool fertilizer on soil fertility, test samples should be taken monthly from each variant before planting and during plant growth.
- Plant biometric measurements were performed on a monthly basis to determine the effect of wool fertilizer on plant growth.
- In order to determine the vegetation cover of the area, 6 points representing the area during the development stages were selected, vegetation are recorded and samples were be taken.

When sowing in the experimental area, 3 parts of the selected area was manually cultivated to a depth of 0-20 cm, and the seed norm was 70 g per 1 m2 area and planted between June 10-15, 2021.

Plant biometric measurements were made 4 times during the growth with 30-day interval period.

Six variants of the test site were selected for a total of 36 plots or 300m2 with 3 repetitions, and 4 types of perennials were selected as rehabilitation cultivar. An experimental scheme is shown (Table 10).

Table 10. Allocation of test site

Variations	1	2	3	4	5	6
Field 1	WP:P:K	WP:2 tn	Con	WP:11 tn	P+K	WP:5 tn
Field 2	WP:P:K	Con	WP: 2 tn	WP: 11 tn	WP:5 tn	P+K
Field 3	P+K	WP:P:K	WP: 5 tn	Con	WP:11 tn	WP:2 tn

Abbreviations	Remarks
WP:P:K	Wool pellet+Phosphorus+Potassium
WP:2 tn	Wool pellet 2 tn/ha
WP:5 tn	Wool pellet 5 tn/ha
WP:11 tn	Wool pellet 11tn/ha
P+K	Phosphorus+Potassium
Con	Control

Introduction to sheep wool fertilizer used in the experiment

Monpellets LLC, a manufacturer of sheep wool fertilizer, is a national manufacturer of Mongolian sheep wool into high quality organic fertilizer using German technology and know-how. This granular wool fertilizer is characterized by the use of advanced technologies such as no foreign additives and chemicals, and no water. Wool fertilizers are rich in nitrogen, phosphorus and sulfur due to their long-term degradation in the soil, their ability to support plants with nutrients, their ability to absorb and retain water, their ability to provide soil moisture, improve soil structure and protect against pests (Figure 10).

Fig 7. Wool pellet fertilizer

Mineral fertilizers used in the experiment

The mineral fertilizers used in the experiment were purchased in the form of single phosphorus and potassium pellets produced in Russia (Figure 11).

Fig 8. Mineral fertilizer of phosphorus and potassium used in the experiment

Seeds selected for the experiment

Seeds of perennial plants imported from the Russian were selected and tested. These include өлөнгө, ерхөг, and хүцэнгэ (Figure 12).

Mongolian name: Дагуур өлөнгө
Latin name: Elymus dahuricus Turcz. ex griseb
Classification: Poaceae Barn, perennial
Characteristics: Pasture plants, usually eaten by large animals in spring. It can also be used to stop sand movement.
Phenomenology: Stems 50-140 cm tall. The leaves are 3-10 mm wide, stripped, partially flattened, with roughly dilated hairs on the upper and lower surfaces. The forehead is 9-18 cm long, dense and straight. The forearm is 10-15 mm long, green or bluish-pink, 2-3 at the base. The scales are 7-10 mm long, lanceolate or linear-lanceolate, gradually narrowing at the tip and ending in a 1-3 mm long stalk. The lower scales are 7-9 mm long and have short thorny hairs on the back. Sor 10-20 mm long, straight or slightly curved.

Mongolian name: Саман ерхөг
Latin name: Agropyron cristatum (L.) P. B.
Classification: Perennial, Poaceae Barn
Characteristics: Pasture plants that are well eaten by all types of livestock in all seasons. It can also be used for urban landscaping. It grows on plains, dry meadows, sandy and rocky slopes, coastal gravel and black rock.
Phenomenology: Stems numerous, straight or slightly curved around the base, long hairs tangled at the ends, densely pubescent below the inflorescence, 20-80 cm tall. The leaves around the roots are few and varied in length, sometimes without leaves. Leaves slightly detached from the stem, densely hairy on the upper surface, with long hairs following the veins, and the leaves on the stem are flat or stripped. The scales and the lower scales of the flower are slightly hairy. It is 1.5-4 cm long and 1-2 cm thick. The axis of the forearm is very short with thorns. Crush in May, the seeds are fully ripe in June and begin to sprout in September.

Mongolian name: Сибир хүцэнгэ
Latin name: Onobrychis sibirica (Sir.) Turcz. ex grossh.
Classification: Perennial herbaceous plant
Onobrychis sibirica is used to rehabilitate fallow land and, under suitable conditions, able to recover quickly, and suitable for rehabilitation as it increases soil fertility and protects the soil from salinization. The grass is branched, the leaves are triangular, the flowers are black, pink and blue, and the fruits are small, yellowish-green in color, with bean seeds wrapped in many seeds. 1000 seeds weigh up to 2 g. The root system is highly developed and can penetrate to a depth of 3-5 m. However, most of the roots are located in the topsoil.

Composition and structure of sheep wool fertilizer

The composition and characteristics of sheep wool fertilizer used in the experiment was determined by chemical 10 parameters, hygiene-3, heavy metal 6 parameters, a total of 23 parameters according to the MNS ISO 11885: 2011, MNS 5886: 2008, MNS 6819: 2020, MNS 6820: 2020, MNS 6821: 2020 standard methodology in the Soil-Agrochemical Laboratory of the University of Agriculture (Table 9).

Table 11. Chemical composition analysis of sheep wool fertilizer

pH	Salt, %	Moisture, %	Organic, %	Mineral, %	S, %	NO_3-N	Total %		
							N	P_2O_5	K_2O
8.89	0.249	5.68	44.6	55.4	2	131	9.64	0.56	2.8

Table 9 shows that the acidity of sheep wool fertilizer is strongly acidic, with a moisture content of 5.68 percent, a high total nitrogen content with 9.64 percent of total N, thus having a high nutritional value required for plants. In specific, the total nitrogen content of sheep wool fertilizer is 10 times higher than manure and humus fertilizers (0.5-1%), which are commonly used in Mongolia.

Table 12. Bacterial contamination analysis of sheep wool fertilizer

Specifications	Standard for analysis	Detection
Total number of bacteria (1g/mln)	MNS 6341:2012	Undetected

E. coli titer	MNS 5367:2004	Undetected
Anaerobic titer (Cl.perferengens)	MNS 4694:1998	Undetected

Table 10 shows that the sheep wool fertilizer did not show any hygienic or bacterial contamination, and the fertilizer is well processed and met hygienic requirements.

Sensory parameters

Smell: Smell of animal wool

Shape: oblong and pellet

Origin: 100 percent sheep wool

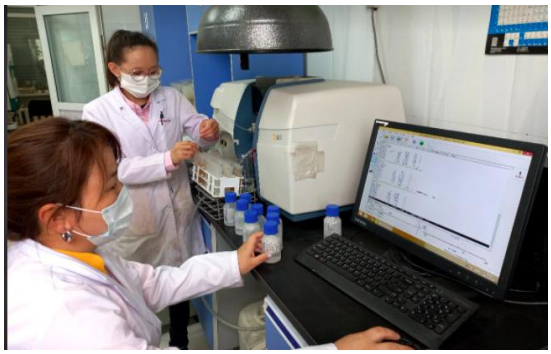
Solubility: water solubility is good

Structure: colloidal structure

Table 13. Heavy metal analysis of sheep wool fertilizer

Heavy metals, mg/kg	Detection	Acceptable amount	Harmful	Hazardous
Copper, Cu	0.073	< 100	>500	>1000
Zinc, Zn	16.7	< 300	>600	>1000
Chrome, Cr	-	< 150	>400	>1500
Cobalt, Co	-	< 50	>500	>1000
Nickel, Ni	39	< 150	>1000	>1800
Lead, Pb	3.3	< 100	>500	>1200

When determining the 6 main heavy metal pollutions according to MNS5850: 2019 standard, the detection was very small and acceptable. The highest detected metal nickel in the analysis was 39 mg/kg, which is four times lower than the maximum acceptable amount.



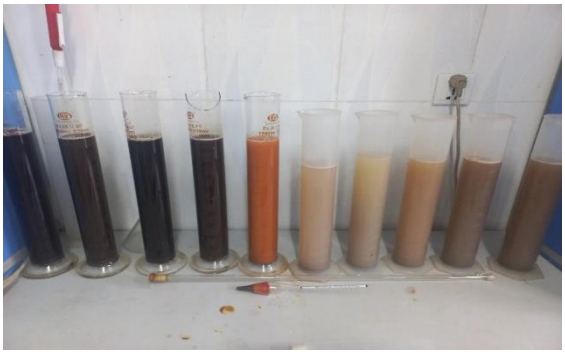


Fig 9. Detection of heavy metals on atomic absorption spectrometers

THREE. RESEARCH RESULT OF SHEEP WOOL FERTILIZER

EFFECTS OF WOOL FERTILIZER ON SOIL FERTILITY

In order to study the effect of sheep wool fertilizer on soil fertility, soil samples were taken from each variant in a sampling bag before sowing and during plant growth for the laboratory analysis. Soil analysis were done following related standards MNS 3310:1991, MNS ISO 11466:2007, MNS ISO 22036:2014, MNS 2143:2000, MNS ISO:1277:2002, MNS 6823:2020, MNS ISO 6341:2012, MNS ISO 6367:2004, MNS 4263:1995, MNS 4266:2015, ISO 7485:2000, MNS 6548:2015, MNS ISO 11885:2011 and the results of the analysis are compared and shown in the tables and graphs below.

Table 14. Soil nutritional basic parameters before planting

Parameters	Field-1		Field-2		Field-3		Average of fields	
	Average	S. D	Average	S. D	Average	S. D	Average	S. D
pH	8.03	0.10	8.03	0.10	8.03	0.10	<1.000	8.03
EC*, dsm	0.28	0.01	0.28	0.01	0.28	0.01	<1.000	0.28
Salt, %	0.09	0.00	0.09	0.00	0.09	0.00	<1.000	0.09
NO3 mg/kg	5.09	0.37	5.09	0.37	5.09	0.37	<1.000	5.09
Ca, Mg, mg/kg	2.50	4.31	27.50	4.31	2.50	4.31	<1.000	7.50
Ca, mg/kg	1.17	3.13	18.17	3.13	1.17	3.13	<1.000	1.17
Mg, mg/kg	1.33	0.76	11.33	0.76	1.33	0.76	<1.000	1.33
T-N,%	0.75	0.07	0.75	0.07	0.75	0.07	<1.000	0.75

Remarks: *EC- Electrical conductivity, SD- Standard deviation

Table 15. Statistical probability test results

	Test Statistics a,b							
	pH	EC	Salt	NO3	CaMg	Ca	Mg	Total N
Chi-Square	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
df	2	2	2	2	2	2	2	2
Asymp. Sig.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

a. Kruskal Wallis Test, b. Grouping Variable

According to the results of the analysis, the soils of the three sites selected in the experimental scenario did not differ from each other in terms of basic chemical parameters (P = <1.0000).

Table 16. Soil nutritional parameters (15 of July, 15 days after plantation)

	WP: P: K		WP:2 tn		Con		WP:11 tn		P+K		WP:5 tn		
Parameters	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	P
pH	7.94	0.13	8.05	0.06	8.06	0.05	8.16	0.00	8.06	0.05	8.02	0.05	0.0001
EC,dsm	0.28	0.01	0.28	0.00	0.28	0.00	0.30	0.00	0.28	0.00	0.28	0.00	0.0001
Salt, %	0.09	0.00	0.09	0.00	0.09	0.00	0.10	0.00	0.09	0.00	0.09	0.00	0.0001
NO3, mg	4.74	0.49	5.13	0.22	5.20	0.20	5.57	0.00	5.20	0.20	5.03	0.18	0.0001
Ca Mg, mg	2.75	1.33	2.00	5.27	6.33	4.88	8.00	0.00	6.33	4.88	3.50	4.44	0.005
Ca, mg	1.25	0.44	2.00	2.11	9.33	1.95	5.00	0.00	9.33	1.95	2.00	1.78	0.0001
Mg, mg	1.50	0.89	1.00	0.00	1.00	0.00	3.00	0.00	1.00	0.00	1.00	0.00	0.0001
Total N, %	0.70	0.00	0.77	0.07	0.75	0.07	0.70	0.00	0.75	0.07	0.81	0.06	0.0001

Table 17. Soil nutritional parameters (30 of July, 30 days after plantation)

	WP: P: K		WP:2 tn		Con		WP:11 tn		P+K		WP:5 tn	
Parameters	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D
pH	8.33	0.11	8.30	0.18	8.31	0.09	8.18	0.05	8.35	0.00	8.30	0.04
Humus, %	0.16	0.00	0.15	0.00	0.16	0.01	0.16	0.01	0.16	0.00	0.16	0.00
EC	2.2	3.81	20.89	7.72	20.96	8.31	21.92	5.83	23.62	0.00	16.86	7.29
Salt, %	7.23	1.16	6.95	2.75	7.00	2.70	7.10	1.77	7.56	0.00	5.39	2.33
NO3, mg	7.73	12.4	71.7	32.2	73.3	27.4	74.1	20.9	80.8	0.00	57.6	25.0
$P_2 0_5$, mg	1.50	0.19	1.22	0.15	1.22	0.02	1.35	0.08	1.24	0.00	1.49	0.05
Moist, %	2.75	0.44	18.11	16.9	1.68	0.94	3.54	0.23	15.68	0.00	0.74	0.58
Minerals, %	94.7	2.03	94.6	2.83	96.9	0.01	75.0	21.8	96.8	0.00	95.7	0.07
Org subs, %	5.21	2.03	5.35	2.83	3.01	0.01	24.94	21.87	3.15	0.00	4.27	0.07

Table 18. Soil nutritional parameters (August, 60 days after plantation)

	WP: P: K		WP:2 tn		Con		WP:11 tn		P+K		WP:5 tn	
Parameters	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D
pH	9.53	0.20	9.27	0.10	9.75	0.41	9.24	0.34	9.71	0.00	9.85	0.41
EC, dsm	21.64	20.51	.87	0.21	8.98	8.35	0.72	0.04	0.72	0.00	21.15	1.35
Salt, %	14.35	0.27	14.70	0.03	14.67	0.01	15.34	0.00	15.34	0.00	12.66	1.00
NO3, mg	15.40	27.93	15.75	1.58	15.72	1.32	16.26	34.26	15.96	0.00	15.79	1.43
N,%	2.10	0.30	1.82	0.30	1.54	0.59	8.33	5.98	.98	0.00	1.75	0.17
Moist, %	12.89	7.21	7.47	1.86	8.46	0.82	13.67	11.74	8.83	0.00	2.83	2.61
Minerals, %	95.52	1.24	96.95	0.26	96.38	0.34	85.56	12.03	96.44	0.00	95.86	0.82
Org subs, %	4.48	1.24	3.05	0.26	3.62	0.34	14.44	12.03	3.56	0.00	4.14	0.82

Table 19. Soil nutritional parameters (September, 90 days after plantation)

	WP: P: K		WP:2 tn		Con		WP:11 tn		P+K		WP:5 tn	
Parameters	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D
pH	8.99	0.15	9.29	0.17	9.22	0.21	8.69	0.18	9.68	0.00	9.47	0.25
EC	0.28	0.06	0.30	0.07	0.30	0.06	0.29	0.06	0.34	0.00	0.25	0.00
Mg	11.50	2.64	13.00	5.27	8.00	0.00	14.50	0.53	11.00	0.00	10.00	0.00
NO3	9.82	4.11	11.11	4.46	10.77	3.78	10.59	4.20	13.51	0.00	7.26	0.26
KCl	8.09	0.18	8.16	0.39	8.03	0.19	8.11	0.35	8.01	0.00	8.38	0.02

Table 12-17 provides an overview of how some soil chemical parameters change over the time before plantation to growth months in the six variations. Table 12 shows that all areas had the same characteristics, but changes have been appeared in the

variations, and the table and figure below show in detail how some of the soil parameters change from month to month due to fertilizer type.

Changes in soil chemical parameters and fertilizer options:

The soil pH increased statistically significantly from June to September for the total study area. For example, in June, or 15 days after fertilization, the average increased to 8.0 ± 0.1, and in September, or 3 months later, to 9.1 ± 0.5 (f = 387, p <0.0001). Wool fertilizer variants had the same effect as control and mineral fertilizers in the soil acidity, and the fertilizer variant had no significant effect on changes in the soil pH in June-September (f = 12.0, p = 0.0001).

Table 20. Changes in soil chemical parameters

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	pH	S. D	pH	S. D	pH	S. D	pH	S. D	pH	S. D	pH	S. D		
June	8.9	0.1	8.0	0.1	8.1	0.1	8.2	0.0	8.1	0.1	8.0	0.0	8.0	0.1
July	8.2	0.2	8.3	0.2	8.3	0.1	8.2	0.0	8.2	0.1	8.2	0.2	8.2	0.2
Aug	9.1	0.5	9.3	0.1	9.2	0.8	9.2	0.3	9.7	0.1	9.3	0.5	9.3	0.5
Sep	9.1	0.2	9.3	0.2	8.9	0.5	8.7	0.2	9.1	0.9	9.2	0.3	9.1	0.5
	f=94.82, p=0.0001		f=247.8, p=0.0001		f=32.425, p=0.0001		f=54.273, p=0.0001		f=46.070, p=0.0001		f=88.394, p=0.0001		f=387.1, ***	
F= 12.1 p <0.0001 ***														

Remarks: ***-P value of the total cultivation areas

The electrical conductivity of the soil changed statistically for the total area in June-September (f = 387.1, p <0.0001). The electrical conductivity of the soil increased during the first 5 days after fertilization and decreased during the first 3 months. The fertilizer variant had a significant effect on this parameter (f = 12.1, p <0.0001). Decreased in the mineral fertilizer version and decreased after increase in the wool fertilizer version (Table 19).

Table 21. Changes in soil electrical conductivity

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	EC	S. D	EC	S. D	EC	S. D	EC	S. D	EC	S. D	EC	S. D		
June	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0	0.3	0.0
July	24.2	3.2	2.9	7.7	24.0	8.0	21.9	5.8	24.6	3.4	25.0	6.9	23.8	6.0
Aug	20.8	1.3	0.9	0.2	13.5	9.4	0.7	0.0	13.9	9.7	**25.9**	9.3	15.1	1.1
Sep	0.3	0.1	0.3	0.1	0.4	0.2	0.3	0.1	0.3	0.1	0.2	0.0	0.3	0.1
	f=3323.2, p=0.000		f=312.6, p=0.000		f=478.54 p=0.000		f=640.94, p=0.000		f=2888.5, p=0.000		f=818.8, p=0.000		f=387.1, ***	
F= 12.1 p <0.0001 ***														

In terms of soil salinity, there was a statistically significant increase in June-August. In particular, it increased to an average of 7.9 ± 0.1 in June-July and 15.3 ± 0.7 in July-August (f = 0.812, p <0.651). Therefore, in all variations, increase of salinity recorded comparing to the control.

Table 22. Changes in soil salinity

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	Salinity	S. D	Salinity	S. D	Salinity	S. D	Salinity	S. D	Salinity	S. D	Salinity	S. D		
June	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1
July	7.8	1.0	6.9	2.7	7.9	2.5	7.1	1.8	7.9	1.1	7.9	2.2	7.7	7.8
Aug	14.5	0.3	14.7	0.0	13.7	1.3	15.3	0.0	15.0	0.7	14.4	1.3	14.6	14.5
Sep	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.1
	f=3438.4, p=0.000		f=255.8, p=0.000		f=279.9, p=0.000		f=673.2, p=0.000		f=2566.5, p=0.000		f=798.9, p=0.000		f = 3809, ***	
f = 0.812, p=0.651														

NO_3 form of nitrogen in the soil increased statistically all the areas in June-September, but in August, in the variations with 5 tons of wool fertilizer and 11 tons of wool fertilizer increased more than other variations (f = 1.05, p = 0.324) and decreased in other months. In terms of soil calcium content, it increased in 6-8 months and reached an average of 20.8 ± 2.7 (f = 10.81, p <0.0001). It is also increased in the variations of 5 ton and 11 ton fertilizer.

Table 23. Changes in soil nitrogen, NO_3

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	NO3, mg/kg	S. D	NO3, mg/kg	S. D	NO3, mg/kg	S. D	NO3, mg/kg	S. D	NO3, mg/kg	S. D	NO3, mg/kg	S. D		
June	4.7	0.5	5.1	0.2	5.2	0.2	5.6	0.0	5.2	0.2	5.0	0.2	5.1	0.4
July	82.3	10.4	71.0	32.1	83.9	26.9	741.3	20.5	84.2	11.0	85.6	23.5	81.7	210.5
Aug	15.8	26.8	15.5	1.6	15.0	7.0	16.5	34.3	16.7	37.3	16.0	41.6	15.2	39.6
Sep	5.1	2.0	5.6	2.2	10.4	7.6	5.3	2.1	4.3	1.8	3.0	0.6	5.5	4.1
	f=3631.9, p=0.000		f=18.78, p=0.000		f=399.8, p=0.000		f=29.275, p=0.000		f=2959.5, p=0.000		f=819.1, p=0.000		f=4365, ***	
f = 1.05, p=0.324														

The magnesium content of the soil decreased statistically in July and increased in August for 2 tonnes of wool fertilizer variation. The mineral fertilized version was slightly increased than the wool fertilized version (f = 257.0, p <0.0001).

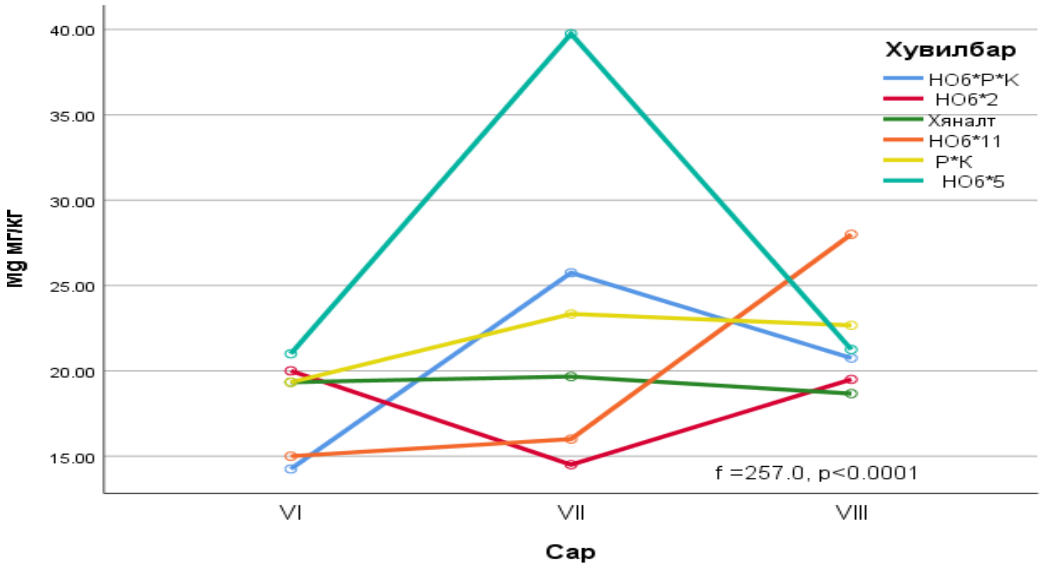


Fig 10. Magnesium content changes in the soil

In terms of total soil nitrogen content, the maximum increase was 8.3 ± 6.0 for the 11 ton variant of wool fertilizer, and the mixed version for organic fertilizers and mineral fertilizers was higher than for the single mineral version (f = 257.0, p <0.0001).

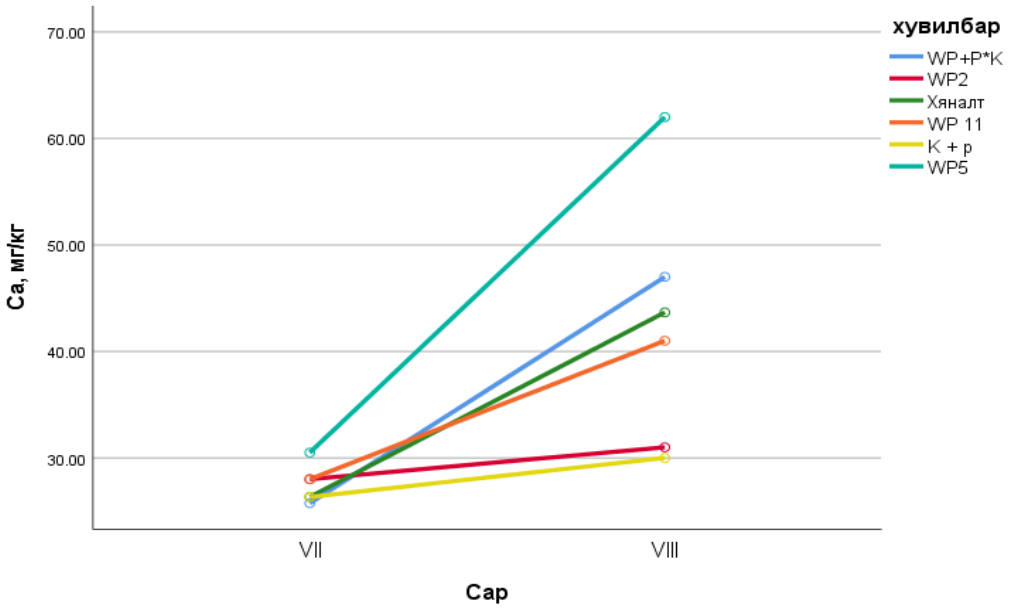


Fig 11. Calcium content changes in the soil

In terms of field moisture, the moisture content increased statistically significantly in July-September, specifically by 11 ton and 5 ton variations (f = 5.1, p <0.0001) (Graph 1). Soil moisture content was not significantly affected by mineral fertilizer alone or the P-K fertilizer option.

Table 24. Soil moisture changes

Months	WP:P:K		WP:2 tn		Con		WP:11 tn		P+K		WP: 5 tn		Average	
	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D	Moist, %	S. D		
July	8.0	5.7	18.1	17.0	2.5	1.4	**3.6**	0.3	5.6	7.4	**4.2**	3.1	6.5	8.2
Aug	8.8	6.5	7.5	1.9	6.5	2.4	**13.7**	11.7	9.2	1.9	**6.6**	3.1	8.4	5.6
Sep	1.2	0.2	1.4	0.1	1.6	0.2	**1.1**	0.4	1.7	0.4	**1.3**	0.3	1.4	0.4
	f=10.5, p=0.003		f=8.2, p=0.019		f=29.5, p=0.000		f=9.77, p=0.012		f=10.6, p=0.004		f=35.1, p=0.000		**f=46.1, *****	
f = 5.1, p<0.0001														

Changes of soil organic substance content and fertilizer variations

Soil organic matter was increased statistically for the all experimental area in June-August. In particular, it increased to an average of 7.2 ± 0.6 in June or 5 days after fertilization, and to 20.3 ± 1.5 in September, 3 months later (f = 307, p <0.0001). Wool fertilizer variations had a greater effect than control and mineral fertilizers (f = 16.4, p = 0.0001). Fertilizer variations had a significant effect on changes in the soil acidity (pH) from June to August.

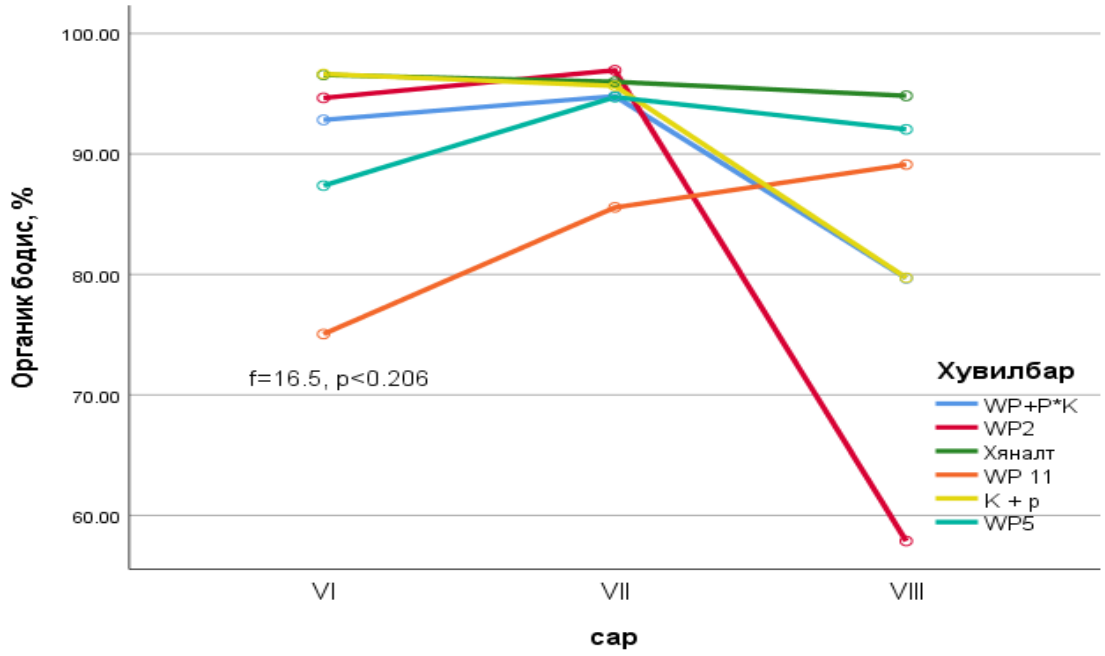


Fig 12. Organic substance content changes in the soil

***Changes in soil mineral content and experimental fertilizer variations*:**

Soil minerals decreased statistically from July to September in the total study area. Specifically, it decreased to an average of 92.8 ± 0.6 in July or 30 days after fertilization, and to 79.7 ± 1.5 in September or 3 months later (f = 20.4, p <0.0001).

Sheep wool fertilizer variations had a greater impact than control and mineral fertilizers (f = 16.4, p = 0.0001).

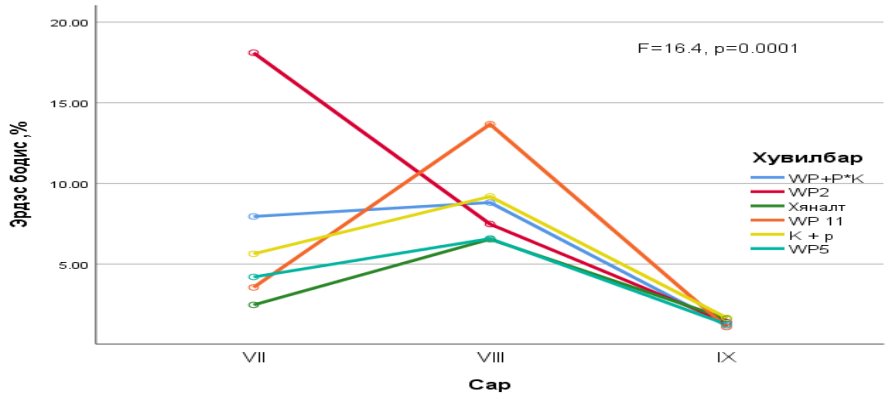


Fig 13. Soil mineral content changes in the soil

Table 25. Changes in soil minerals

Phosphorus															
	July	1.7	0.3	1.2	0.2	1.3	0.1	1.3	0.1	2.1	0.9	1.5	0.3	1.6	0.5
	Sep	4.5	0.6	4.1	0.2	4.7	0.5	3.9	0.1	4.6	0.3	4.4	0.3	4.4	0.5
	p value	f=1410.8, p=0.000		f=558.0, p=0.000		f=691.1, p=0.000		f=1639.1, p=0.000		f=207.9, p=0.000		f=1044.7, p=0.000		**F=3414, *****	
		f = 7.47, p<0.0001													
Mash															
	July	1.7	0.4	1.4	0.2	1.7	0.9	1.7	1.0	2.1	0.6	1.8	0.5	1.7	0.7
	Sep	1.5	0.9	1.9	0.9	1.7	1.6	0.7	0.6	2.6	0.5	1.9	1.3	1.8	1.2
	p value	f=0.98, p=0.334		f=2.77, p=0.130		f=0.001, p=0.972		f=58.7, p=0.000		f=5.455, p=0.035		f=0.09, p=0.766		f=0.002, p=0.946	

f = 3.7, p=0.004*

Correlation between fertilizers

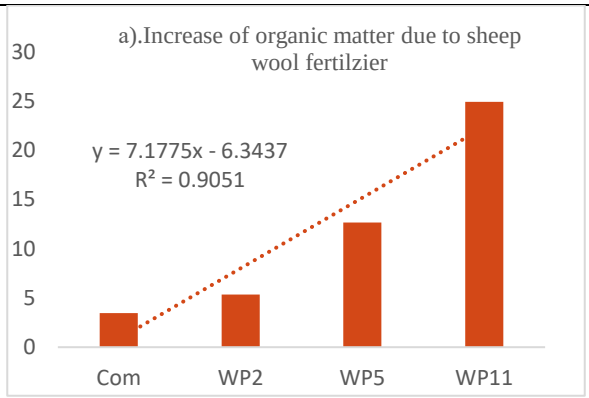
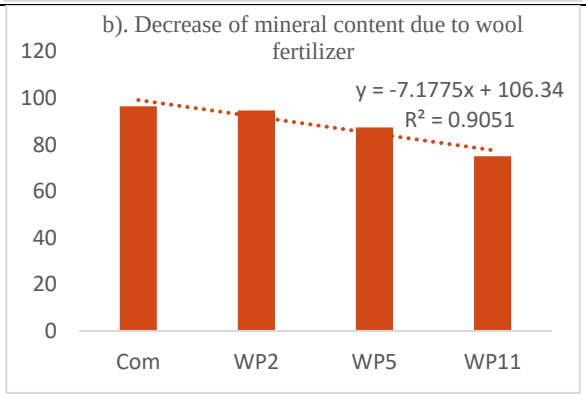
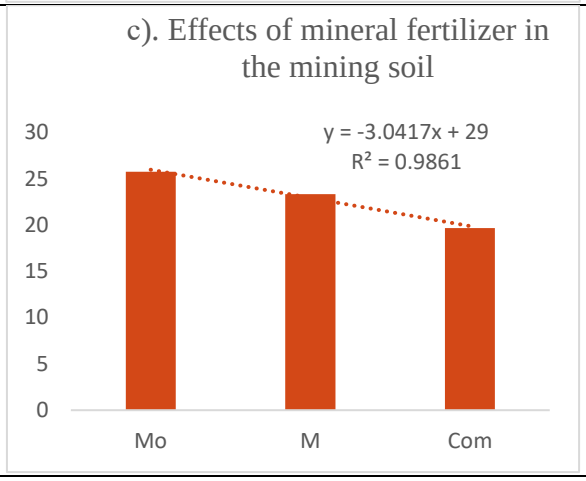
	The content of organic matter increases statistically depending on the doseage of wool fertilizer.
	Depending on the dose of wool fertilizer, the content of minerals against organic matter decreases.
	Wool fertilizers have a better effect on soil fertility than mineral fertilizers R=0.9 P<0.005

Fig 14. Correlation between fertilizers applied in the experiment

3.5 Wool fertilizer effect on plant growth

The table below shows that in the first month of the growing season of perennials, in July, no effect of fertilizer was observed on the growth of *Onobrychis sibirica (Sir.) Turcz.* ex grossh. and *Agropyron cristatum (L.) P. B.,* and it is effective on *Elymus dahuricus Turcz. ex griseb.* In the middle and last months of the growing season, the effect of fertilizer is observed on both three types of perennials.

Table. 26 The effects of fertilizer on each variation

	M+O		WP 2		Con		WP 5		M		WP 11		
O.s	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	Ave	S. D	P
VI	2.81	1.83	3.92	1.43	3.21	1.73	4.00	0.67	3.69	1.20	3.44	2.28	0.403
VII	4.80	3.25	6.60	1.60	5.17	3.98	7.15	1.47	6.53	1.70	4.58	3.03	**0.078**
VIII	3.00	7.42	21.95	16.06	17.20	18.53	23.50	4.70	1.10	16.95	13.80	16.37	0.531
IX	7.24	8.00	15.63	7.68	14.64	5.63	20.13	7.91	5.47	3.70	15.02	5.69	**0.322**
f=67.56, P=0.0001													
E.d													
VI	5.48	1.18	6.54	1.81	5.24	1.66	5.45	1.86	6.03	1.95	5.11	1.85	**0.273**
VII	1.00	3.63	11.55	1.92	11.40	2.92	11.45	1.67	11.53	3.50	10.73	3.57	0.966
VIII	2.68	6.92	22.25	9.19	17.40	7.69	28.40	10.47	19.43	5.85	20.85	7.60	**0.028**
IX	5.22	6.30	32.17	14.10	26.40	10.22	35.74	12.92	30.02	11.36	27.86	8.24	**0.101**
A.c		f=292.156 P=0.0001											
VI	8.85	2.30	10.08	2.89	7.21	3.19	11.45	3.70	8.63	5.33	9.20	2.61	**0.073**
VII	12.88	1.29	17.00	10.13	12.43	10.26	23.30	7.23	19.60	8.31	6.65	9.82	**0.000**
VIII	24.85	8.71	22.50	9.74	18.73	6.96	27.70	9.73	24.33	5.25	24.13	7.71	**0.117**
IX	20.81	6.03	19.69	11.14	19.97	7.90	27.33	9.43	23.13	5.37	24.67	8.91	**0.130**
f=92.78 P=0.0001													

O.s; Onobrychis sibirica (Sir.) Turcz. ex grossh-Хүцэнгэ
E.d; Elymus dahuricus Turcz. ex griseb-Дагуур өлөнгө
A.c; Agropyron cristatum (L.) P. B-Саман ерхөг

Wool fertilizers have a positive effect on plant growth. In July, there was little statistical impact on *Elymus dahuricus Turcz. ex griseb* and *Onobrychis sibirica (Sir.) Turcz. ex grossh*. From the values shown in the table, values of P≤0.4 and less are considered significant.

Table 27. Names of plants grown in the experimental area

№	Талбай -1 1.1	Талбай-2 2.1	Талбай-3 3.1
1	O.Arenaria	O.Arenaria	Agropyron desertorum
2	A. desertorum	A. desertorum	Elymus sibiricus
3	e.sibiricus	e.sibiricus	Bromus inermis
4	B.inermus	B.inermus	Onobrychis aremaris
5	C.songarica	CH.album	Chenepodium album
6	Ch.album		Atriplex sibirica
7	salsola colina		carex
8	Bassia dasyphylla		Salsola colina
9	Plantago salsa		Шоргор лууль
10	Fagopyrum tataricum		deistoyches songarica
11	Axigris prostrate		
	1.2	**2.2**	**3.2**
1	O.Arenaria	O.Arenaria	Onobrychis arenaria
2	e.sibiricus	A. desertorum	Agropyron desertorum
3	A. desertorum	e.sibiricus	Elymus sibiricus
4	B.inermus	bassia dasyphylla	Bromus inermis
5	A.sibirica	CH.album	A.sibiricus
6	Axigris prostrate	Atriplex sibirica	Chenepodium album
7	C.songarica		Шоргор лууль
8	Ch.album		carex улалж
9	Шоргор лууль		Clestogenis songarica
10	Ch.aristatum		Salsola colina
11	Fagopyrum tataricum		Bassia dasyphylla
12	salsola colina		
13	Amaranthus rutroflexus		
	1.3	**2.3**	**3.3**
1	O.Arenaria	O.Arenaria	Onobrychis arenaria
2	e.sibiricus	A. desertorum	Agropyron desertorum
3	A. desertorum	e.sibiricus	Elymus sibiricus
4	A.sibirica	A.sibiricus	Bromus inermis
5	salsola colina	Ch.album	carex улалж
6	Ch.album		A.sibiricus
7	C.songarica		Chenepodium album
			Шоргор лууль
			Convolvulus ammonii
			Salsola colina
			Clestogenis songarica
	1.4	**2.4**	**3.4**
1	O.Arenaria	O.Arenaria	Agropyron desertorum
2	e.sibiricus	A. desertorum	Elymus sibiricus
3	A. desertorum	e.sibiricus	Bromus inermis
4	Brassica juncea	A.sibiricus	Chenepodium album
5	C.songarica	Brassica juncea	Clestogenis songarica
6	Potentilla bifurca	Ch.album	alriplex sisirica

7	Шоргор лууль		Clestogenis songarica
8	A.sibirica		
	1.5	**2.5**	**3.5**
1	O.Arenaria	O.Arenaria	Agropyron desertorum
2	e.sibiricus	A. desertorum	Elymus sibiricus
3	A. desertorum	e.sibiricus	Bromus inermis
4	Ch.album	B.inermis	Clestogenis songarica
5	Шоргор лууль	Ch.album	Chenepodium album
6	B.inermus	At.sibirica	alriplex sisirica
7	C.songarica		Salsola colina
			Тодорхойгүй зүйл
	1.6	**2.6**	**3.6**
1	O.Arenaria	O.Arenaria	Agropyron desertorum
2	e.sibiricus	A. desertorum	Elymus sibiricus
3	A. desertorum	e.sibiricus	Bromus inermis
4	B.bromis	шоргор лууль	Clestogenis songarica
5	s.collina	Ch.album	Chenepodium album
6	Brassica juncea	B.dasyphyla	Chenepodium йшглгийэгт
7	A.sibirica		alriplex sisirica
8	Ch.album		Salsola colina

The table shows that plant species grew differently depending on field treatment, fertilizer dosage, and irrigation effects.

Vegetation and arig ratio of experimental site 1

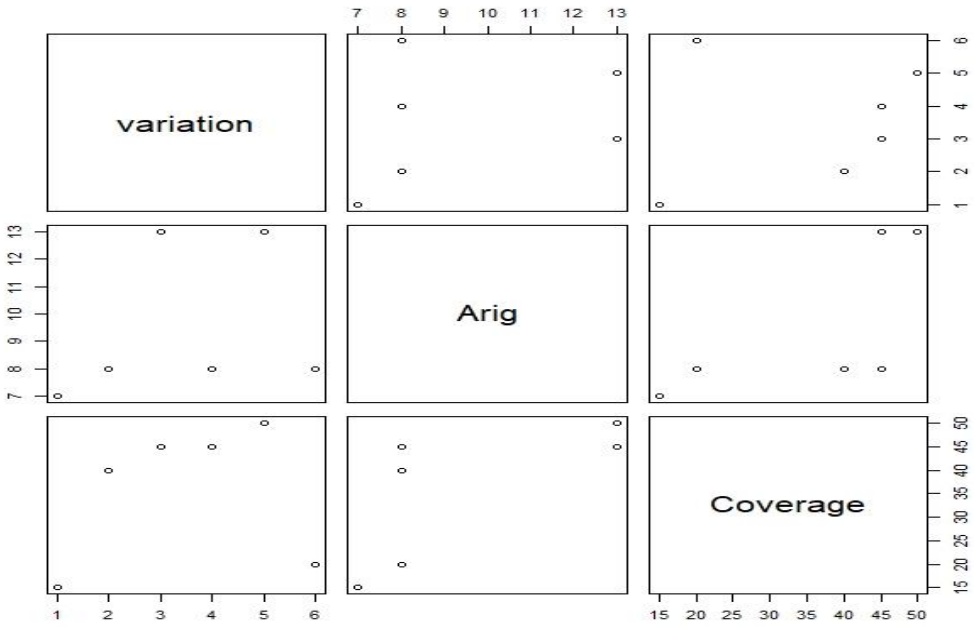


Fig 15. Vegetation and arig ratio of experimental site 1

Note
Df Sum Sq Mean Sq F value Pr(>F) variation 5 112.5 22.5 5.307e+30 <2e-16 ***
Residuals 12 0.0 0.0
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> TukeyHSD(model)
Tukey multiple comparisons of means
95% family-wise confidence level

Vegetation and arig ratio of experimental site 2

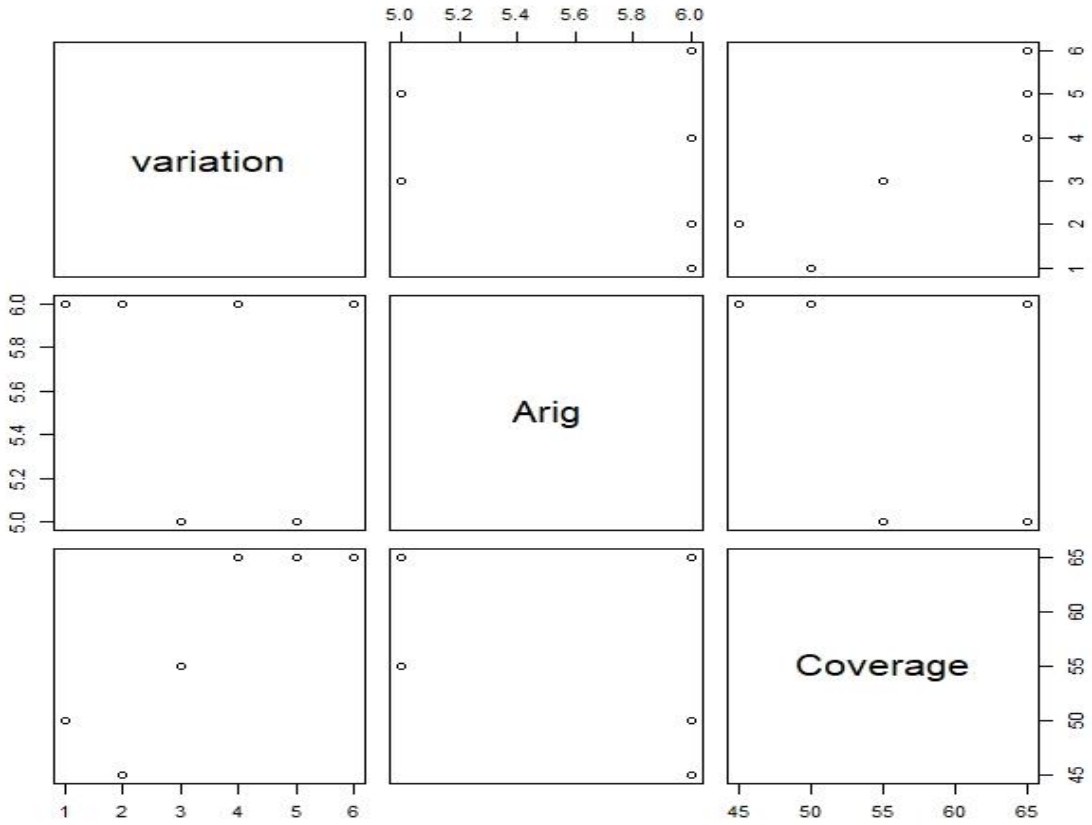


Fig 16. Vegetation and arig ratio of experimental site 2

Note
model<-aov(Arig~variation)
> summary(model)
Df Sum Sq Mean Sq F value Pr(>F)
variation 5 4 0.8 1.335e+29 <2e-16 ***
Residuals 12 0 0.0

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
Туршилтын талбай 3-н ургамлан бүрхэвч, ариг тооцсон харьцаа (зураг)

Vegetation and arig ratio of experimental site 3

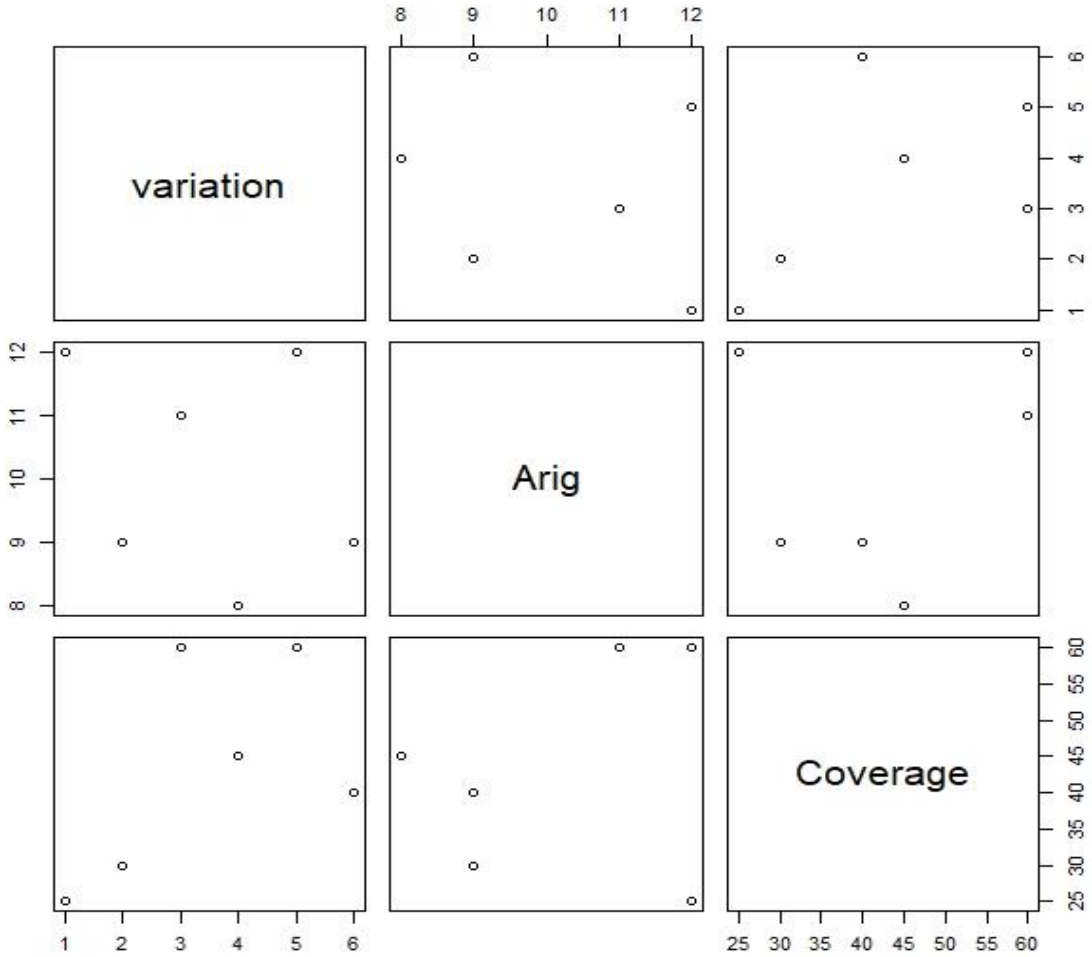


Fig 17. Vegetation and arig ratio of experimental site 3

Note

```
model<-aov(Arig~variation)
> summary(model)
            Df Sum Sq Mean Sq   F value Pr(>F)
variation    5   44.5     8.9 3.542e+29 <2e-16 ***
Residuals   12    0.0     0.0
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Differences in organic fertilizers

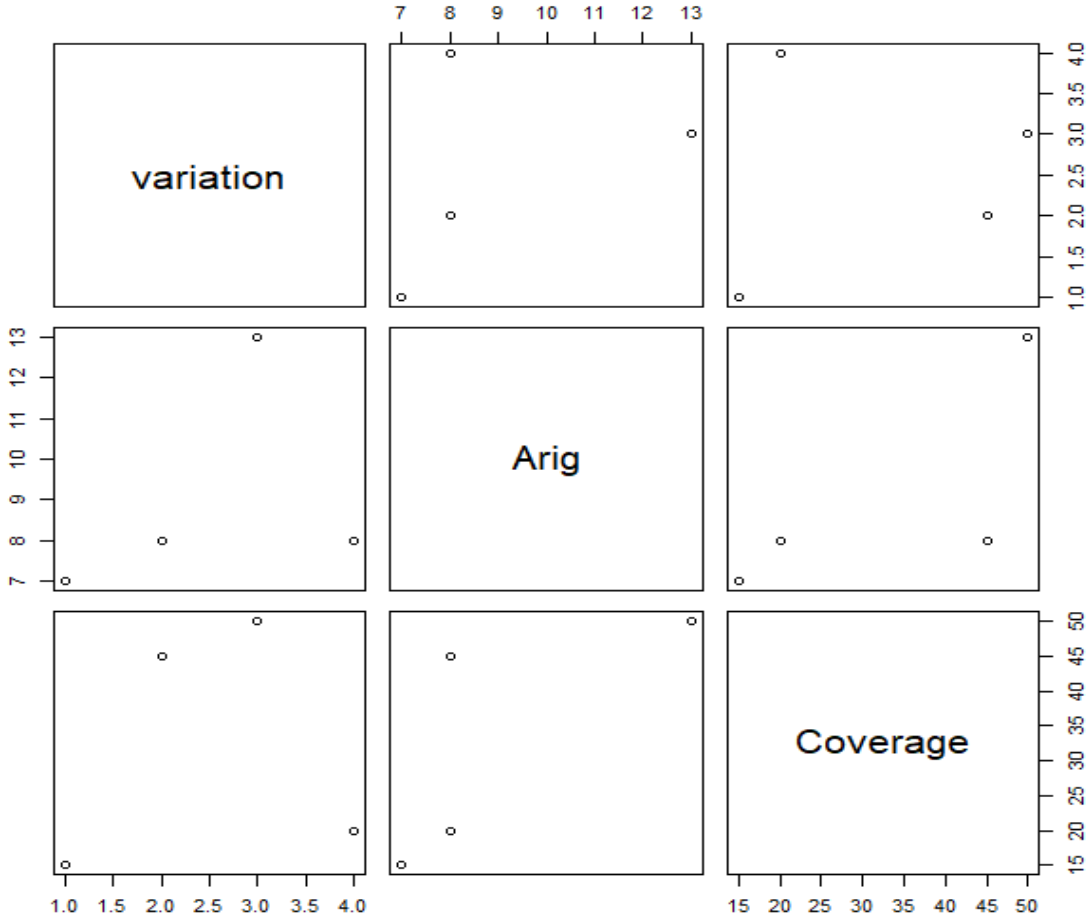


Fig 18. Differences in organic fertilizers

> P=0.0001

> TukeyHSD (model) - 95% probability

Differences in vegetation cover between wool compost and mineral fertilizer alternatives

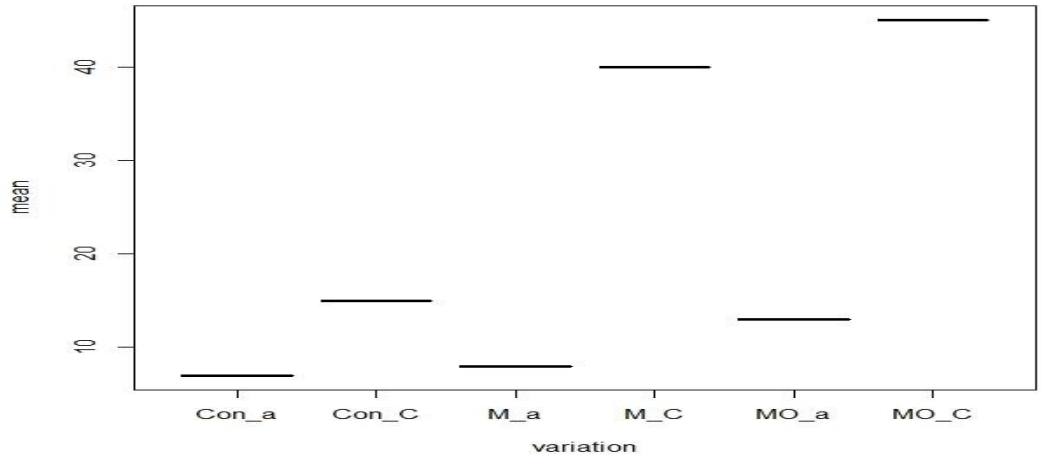


Fig 19. Vegetation cover differences

The mixed wool and mineral fertilizer (MO) version is similar to the controlled plant species, but the vegetation cover is higher than the other versions, which is statistically significant (TukeyHSD 95%).

Ecological diversity changes of plant during use of sheep wool fertilizer

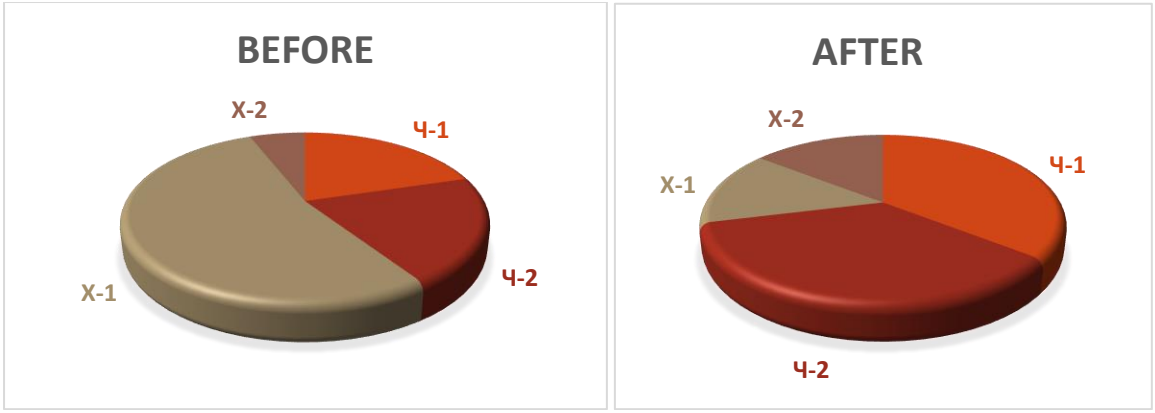


Fig 20. Plant diversity changes

Classification	
Moist like /чийгсүү/	Ч-1
Moist like and dry /чийгсэг хуурайсуу/	Ч-2
Dry /Хуурайсаг/	Х-1
Dry and moist /хуурайсуу чийгсүү/	Х-2

Note: Before the biological rehabilitation, in terms of ecological diversity, dry like plant 37.5%, moist like plant 12.5% accounted, however, after application of the wool fertilizer, dry like plant 22.1% and moist like plant diversity increased 26.0% increased respectively.

3.6 WOOL FERTILIZER EXPERIMENT ON POT

We started the wool fertilizer pot experiment in the laboratory by counting 20 seeds in each of the 6 variations and 3 repetitions. In the experiment, selected medicinal plant Bergenia crassifolia (L.) Frisch, perennial herbaceous plant. The soil used for the pot experiment was brought from the mining site in Gurvansaikhan soum, Dundgovi aimag.

Plant growth was monitored daily for the first 10 days, after which plant height was measured at intervals of 10 days for 3 months, number of plant and plant height were recorded.

Pot experiment scheme

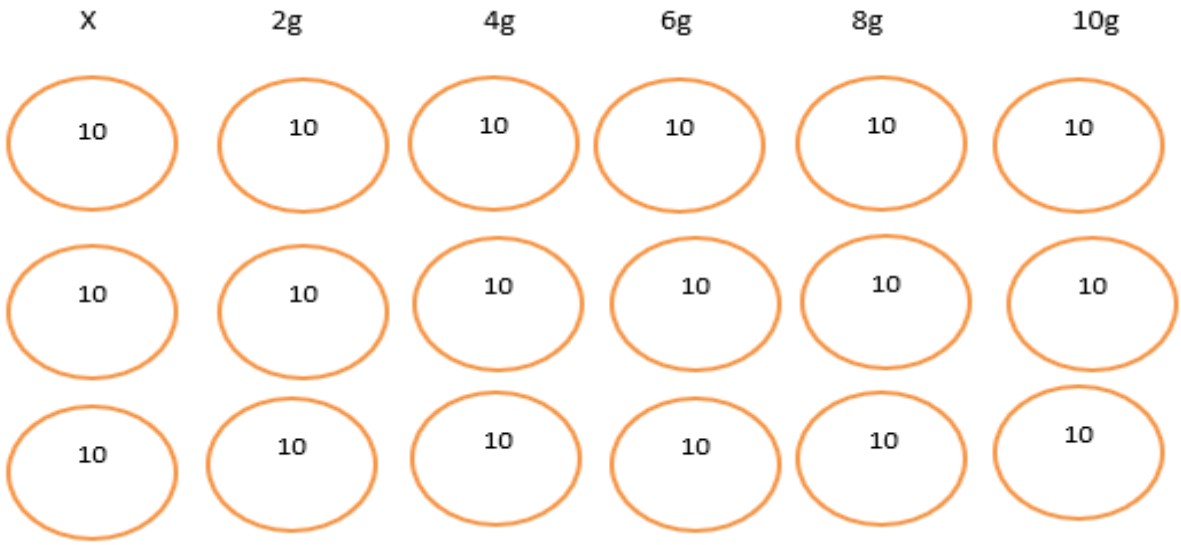
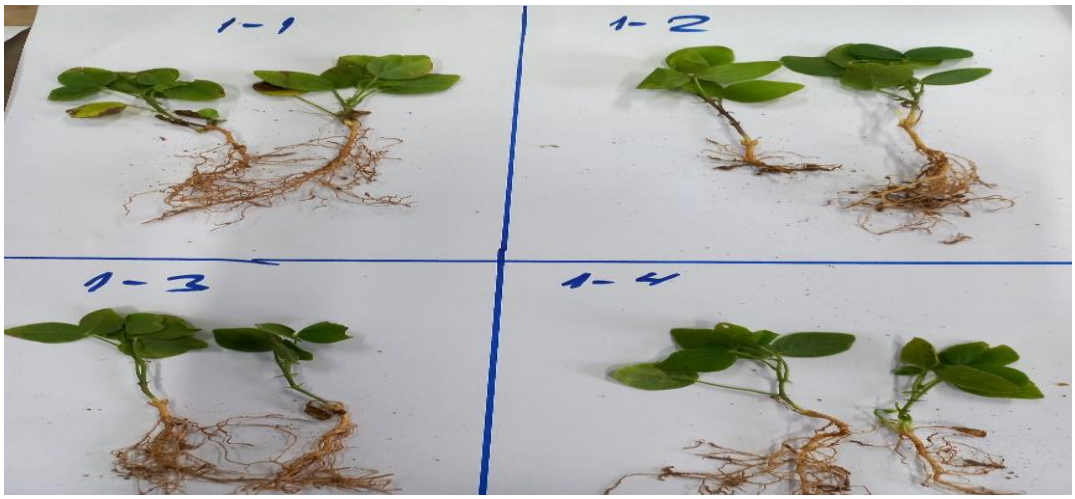


Fig 21. Pot experiment scheme



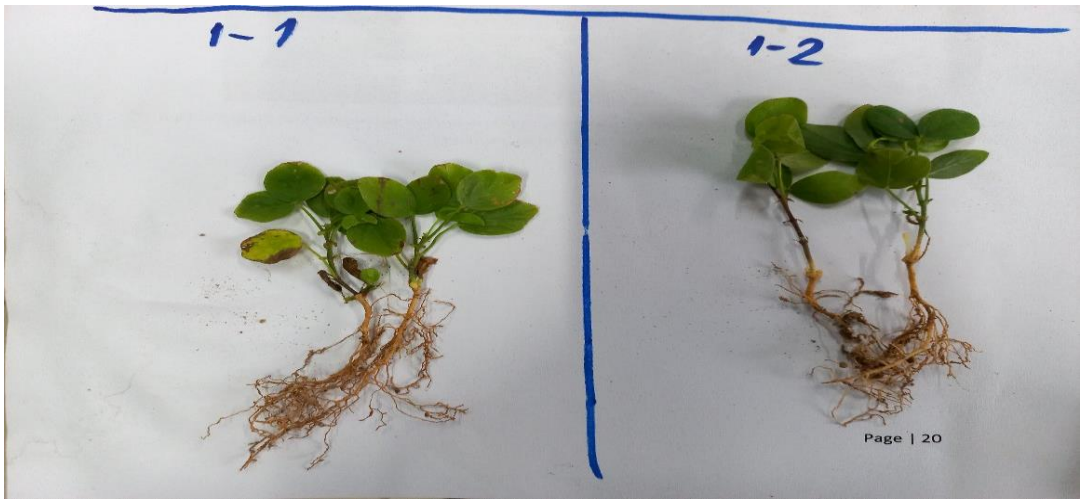


Fig 22. Pot plant growth

Figure 18 as the amount of wool fertilizer increases, the height of the plant increases and the leaves of the plant do not rot and become bright green and moist.

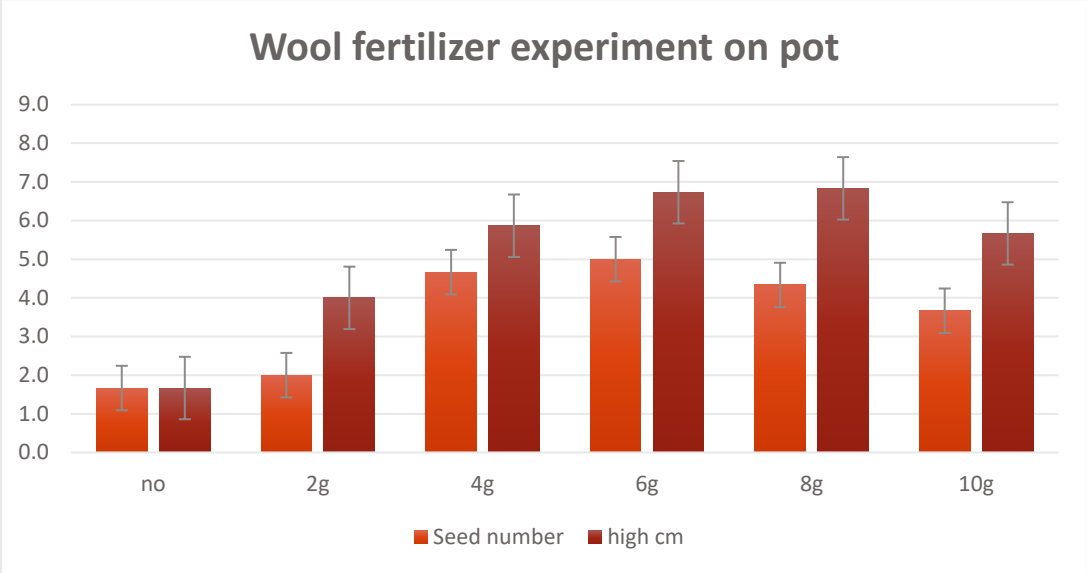


Fig 23. Wool fertilizer experiment on pot, 6 variations.

CONCLUSION

- According to the results of our study, the application of wool fertilizer for mining site biological rehabilitation in doses of 2 tons, 5 tons and 11 tons had positive effect on soil nutrition and plant growth statistically significant ($p < 0.0001$).
- It is suitable to apply wool fertilizer at a dose of 2 tons in irrigated conditions and 5 tons in non-irrigated conditions.
- Appropriate mixes of wool fertilizers and mineral fertilizers can have better result.

RECOMMENDAIONS FOR PRODUCTION

1. Sheep wool fertilizer is the modern technology fertilizer and is produced from 100 percent sheep wool, which is an annual renewable raw material.
2. Production with innovative technology is carried out in a dry method that does not harm the environment, does not use water and does not mix any other additives. This is primarily a production that is critical to reducing carbon dioxide (CO_2) emissions into the environment.
3. Sheep wool contains keratin. Keratin plays an important role in the development of plant-cellular structures, binds to the substances that support it, and has the ability to excrete excess substances.
4. Sheep wool compost is gradually decomposed into the soil and has a long-term effect on plant growth.
5. Other commonly used organic and mineral fertilizers are not able to act like keratin absorb water, release nutrients and promoters for a long time, which binds and regulates. Sheep's wool manure retains soil moisture in a balanced way, absorbs 3.5 times more water than its own weight, and releases accumulated water and moisture when needed.
6. Sheep wool organic fertilizer is a high quality fertilizer containing high amount of nitrogen and potassium. Nitrogen is an important element in plant cells (cytoplasm) and green tissue, which are important for plant nutrition and protein production. Potassium helps plant cells to grow, enlarge, and build up pressure.
7. Due to the high nitrogen content of sheep wool fertilizer, it is suitable to apply 5 tons on sandy soils and 2 tons on light loamy soils.
8. It is suitable to be used as a basic fertilizer before planting and sprayed before tillage.

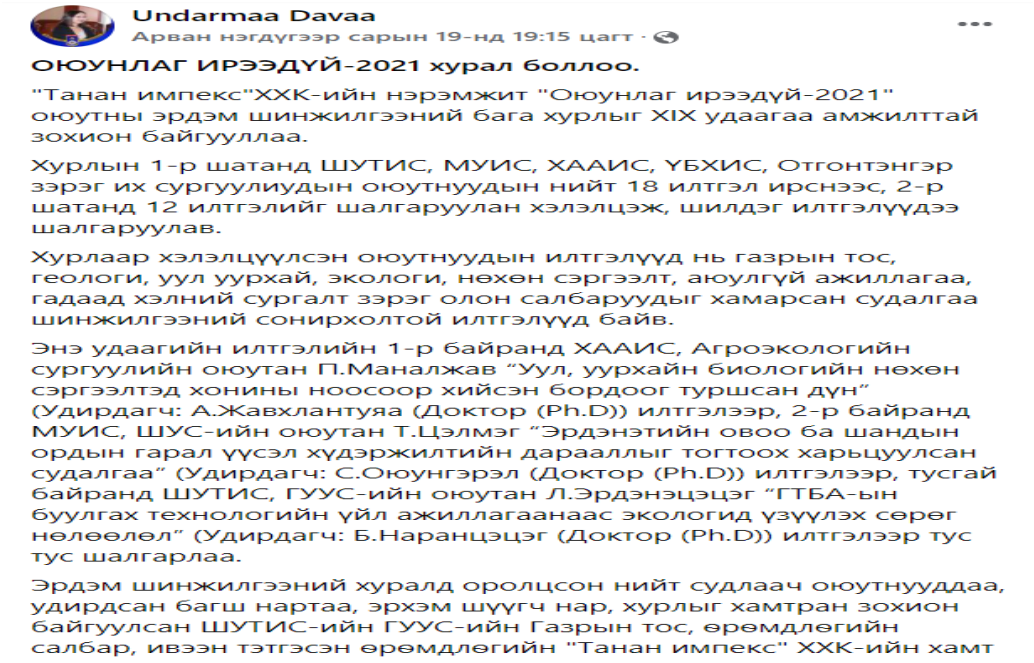
APPRECIATION

I would like to express my sincere gratitude those who shared their financial assets and knowledge in conducting this research project, to B.Tsogbadrakh, Director of Monpellets LLC; G.Ankh-Amgalan and Namsraijav, Environmental Specialist of Erdenes Silver Resource LLC; Dr. Nakamaru, researcher of Tokyo University of Agriculture, Japan; researchers from Mongolian University of Agricultural Sciences; Ch.Dugarjav and their team from the Institute of Botany; and D.Battsetseg from the Research and development center for food, agriculture and light Industry.

APPENDIX

According to the test results in a pot, the 6 g version has the highest and most plants, while the 4 g version has a higher and more plants than the control, which is suitable for 4-6 g in a pot plantation.

The results of the research were discussed in university student presentations and won first place



Undarmaa Davaa
Арван нэгдүгээр сарын 19-нд 19:15 цагт ·

ОЮУНЛАГ ИРЭЭДҮЙ-2021 хурал боллоо.

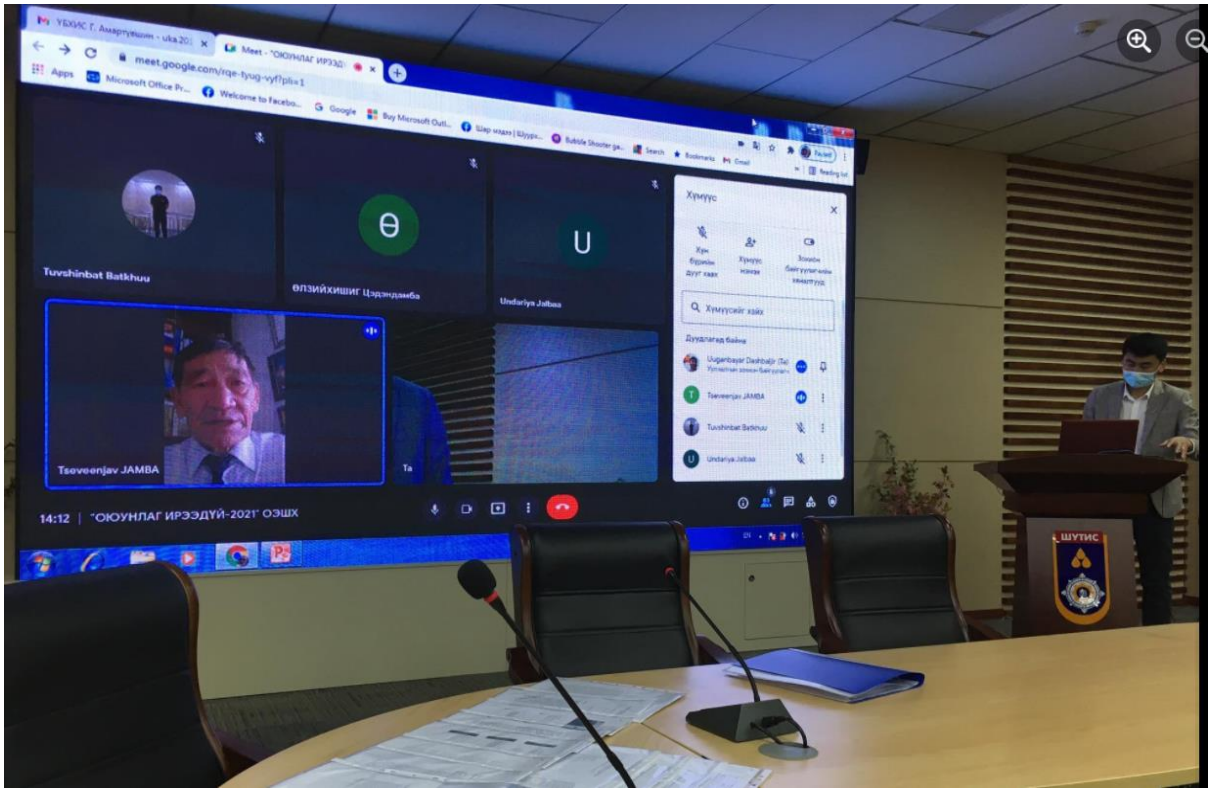
"Танан импекс"ХХК-ийн нэрэмжит "Оюунлаг ирээдүй-2021" оюутны эрдэм шинжилгээний бага хурлыг XIX удаагаа амжилттай зохион байгууллаа.

Хурлын 1-р шатанд ШУТИС, МУИС, ХААИС, ҮБХИС, Отгонтэнгэр зэрэг их сургуулиудын оюутнуудын нийт 18 илтгэл ирснээс, 2-р шатанд 12 илтгэлийг шалгаруулан хэлэлцэж, шилдэг илтгэлүүдээ шалгаруулав.

Хурлаар хэлэлцүүлсэн оюутнуудын илтгэлүүд нь газрын тос, геологи, уул уурхай, экологи, нөхөн сэргээлт, аюулгүй ажиллагаа, гадаад хэлний сургалт зэрэг олон салбаруудыг хамарсан судалгаа шинжилгээний сонирхолтой илтгэлүүд байв.

Энэ удаагийн илтгэлийн 1-р байранд ХААИС, Агроэкологийн сургуулийн оюутан П.Маналжав "Уул, уурхайн биологийн нөхөн сэргээлтэд хонины ноосоор хийсэн бордоог туршсан дүн" (Удирдагч: А.Жавхлантуяа (Доктор (Ph.D)) илтгэлээр, 2-р байранд МУИС, ШУС-ийн оюутан Т.Цэлмэг "Эрдэнэтийн овоо ба шандын ордын гарал үүсэл хүдэржилтийн дараалаллыг тогтоох харьцуулсан судалгаа" (Удирдагч: С.Оюунгэрэл (Доктор (Ph.D)) илтгэлээр, тусгай байранд ШУТИС, ГУУС-ийн оюутан Л.Эрдэнэцэцэг "ГТБА-ын буулгах технологийн үйл ажиллагаанаас экологид үзүүлэх сөрөг нөлөөлөл" (Удирдагч: Б.Наранцэцэг (Доктор (Ph.D)) илтгэлээр тус тус шалгарлаа.

Эрдэм шинжилгээний хуралд оролцсон нийт судлаач оюутнууддаа, удирдсан багш нартаа, эрхэм шүүгч нар, хурлыг хамтран зохион байгуулсан ШУТИС-ийн ГУУС-ийн Газрын тос, өрөмдлөгийн салбар, ивээн тэтгэсэн өрөмдлөгийн "Танан импекс" ХХК-ийн хамт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Undariya Jalbaa
Tseveenjav JAMBA
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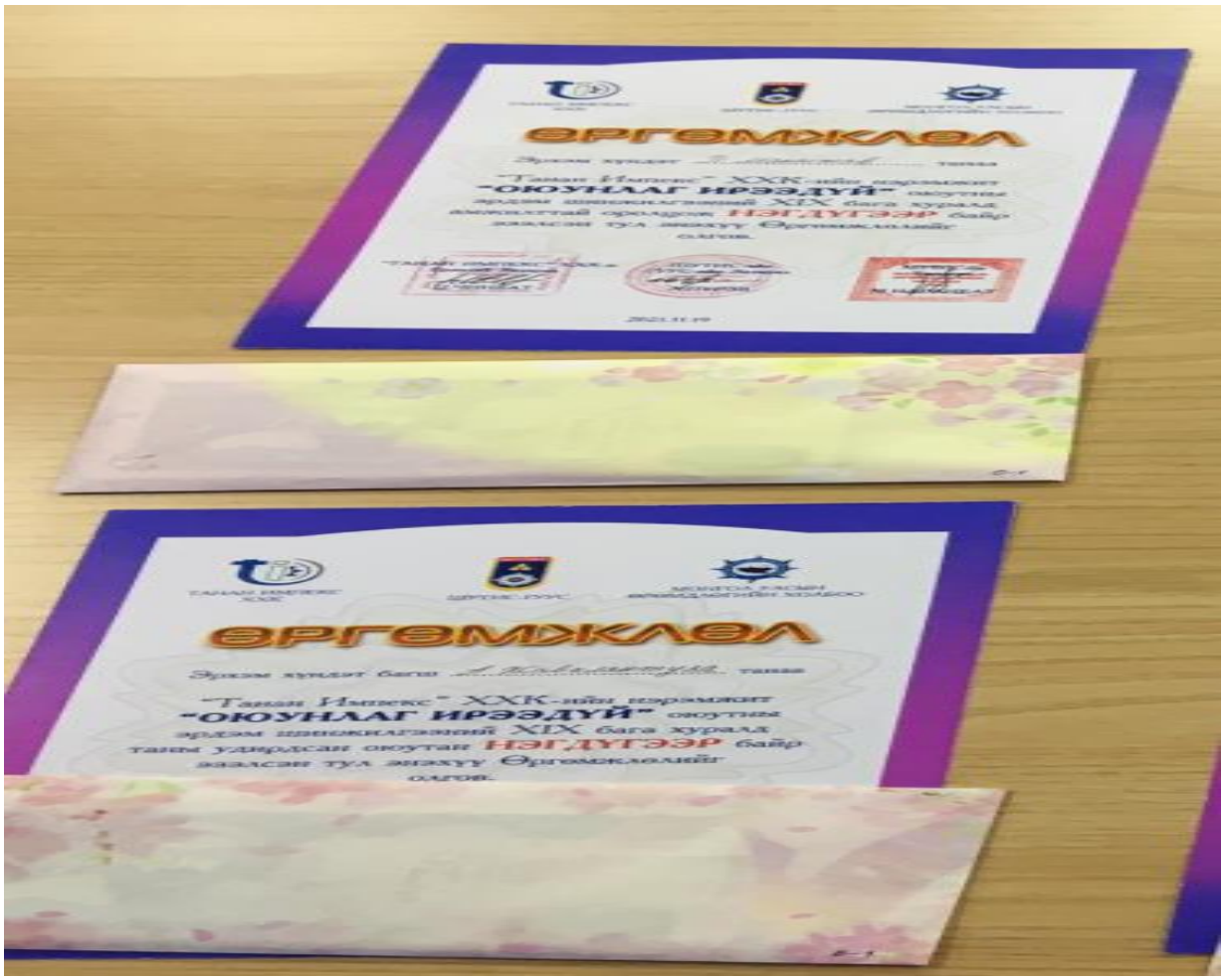
ШУТИС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"ОЮУНЛАГ ИРЭЭДҮЙ"
НЭГДҮГЭЭР
ӨРГӨМЖЛӨЛ
"ОЮУНЛАГ ИРЭЭДҮЙ"
НЭГДҮГЭЭР

Photo reporting

Field visit team on July

Field work

The cutting of soil in the experimental field

Field visit team on June

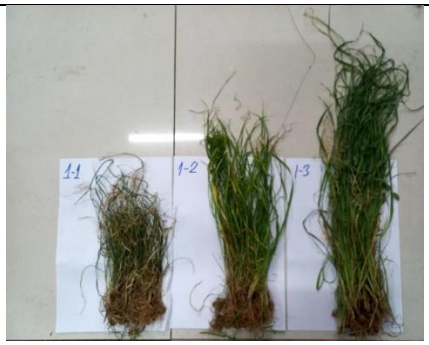
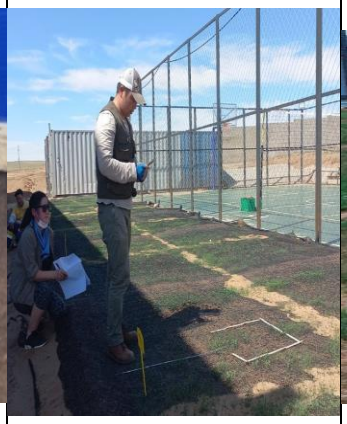
Soil cultivation and seedling

Field visit team on August

Field visit team on September

Plant growth in 3 experimental fields

Of the three experimental fields, the first area, where fertilizers were tested under irrigated conditions, had the best effect on plant growth. The second area represents the irrigated area that has been technically rehabilitated and the plant growth is average. The third area is the least irrigated area in its natural state and has the lowest growth.

	During plantation	*Growth*	
Filed 1			
Filed 2			
Filed 3			

Field experiment procedure and plant growth

LITERATURE REVIEW

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