# Study of Biometric Datum of Green Manure Crops in the Process of Biological Soil Reclamation on the Territory of Coal Producer Ojsc "Mine No 12"In The Kemerovo Region

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**Abstract.** The article presents the results of a study of green manure crops of different kinds, it is determined that the best growth results were obtained with incorporation of hydrogel in the substratum, and particularly in the clay, so as due to the amount of moisture in the substratum, clay is more hygroscopic and physico-chemical properties of hydrogel significantly increase moisture capacity of the substratum. Sowing field germination of all crops is much higher in the clay then in soil. Territories with the hydrogel usage showed a greater plant density per $1m^2$. Almost all crops with the major growth of herb were sowed in the clay with hydrogel addition, the crops height increased by 2.5 times. The only exception was Rye, the difference in height between its plants in "soil + hydrogel" and "clay+hydrogel" was less than 1%. It was registered that the root growth of Phacelia in "clay+hydrogel" increased by 2.5 times. While the root growth of Rump, on the contrary, increased in mellow soil with hydrogel by 43%. Other kinds of crops did not perform any difference in their root length. The increase of herbage in mixtures of green manure crops was negligible, whereas mono-sowing of such crops as Esparcet, Rump and Buckwheat showed the greatest increase of herbage in comparison to the soil lots and other sowing variants. The greatest increase of herbage among lots without hydrogel addition was performed on the clay ones: Esparcet - 250%, Buckwheat - 172% Rump - 123% Phacelia - 77.5%. The best results of herbage accumulation were showed by Esparcet, Buckwheat, Rump, Phacelia.

## 1. Introduction

The main objectives of biological reclamation are resumption of the process of soil formation, increase of self-purification soil capacity and reproduction of biocenoses. In order to develop effective methods of biological reclamation it is very important to study the processes of vegetational cover evolution in various natural areas and technological conditions. Formation of vegetational cover on the dumps of overburden operations is very slow. It takes from 5 to 10-15 years because of the complex, time-varying dump relief, lack of nutrients for rock development, water and heat unstable mode [1].

The rate of soil and soil layer formation depends on the properties of parent rock material, water and heat conditions, topography and natural climatic conditions of the area, vegetation composition of species and duration of the natural land reclamation [2,3].

The most effective method of biological reclamation of disturbed areas is the creation of a multi-species vegetation cover including perennial grasses and resistant species of bushes and trees. Multistage structure of disturbed land protects it from erosion and deflation, while leaf litter and root systems give a large increase of organic substance [4,5].

Experimental studies, carried out by soil scientists in the Kemerovo region for 40 years, show that the full restore of soil functions is impossible to get in the historically foreseeable future. The maximum score of the experimental stages was 90%, and the average fertility of reclaimed land was about 30% [6,7].

Particularly relevant issue for the reclamation of the Kemerovo region, where natural cover is permanently destroyed by mining, road construction, building of industrial and other objects. On average the annual area of disturbed lands in the region reaches 1118 hectares. According to estimates of the Institute of Coal and Coal Chemistry SB RAS the coal mining companies have violated 9.17 ths. km, which is 9.6% of the total land fund of the Kemerovo region. Moreover, new licenses to industrial land usage are issued every year. If this situation does not change, in a few decades Kuzbass won’t have any coal mining unaffected land area. The problem is complicated by the fact that most of the disturbed areas occupy the highly productive soils of great economic importance [8,9,10].

The aim of this research was to study the biometric characteristics of the green manure crops (traditional and non-traditional) in different conditions.

The research objectives were:

1. To determine the crop density.
2. To determine the crop height.
3. To measure crop root length in different experimental conditions.
4. To study changes of herbage of green manure crops.

The object of the study was traditional and non-traditional green manure plants.

The subject of the research was vegetative reclamation technology.

## 2. Conditions, equipment and methods of the study

Land for reclamation is located in the South part of the forest-steppe zone of the region that is characterized with insufficient precipitations especially in the first summer half. Vegetation cover of the territory is the steppe vegetation with predominance of grain and herbaceous species.

Land parcels for reclamation are located on the claim of the strip mine, and surrounding territories belong to urban locality of the Prokopyevsky District.

OJSC «Mine No 12» is an operating coal mining enterprise in Kiselevsk, Kemerovo region.

Field of the Mine No 12 is on the southeast from the Kiselevsk’s coal deposit in Kuzbass, that is the center of Kiselevsk, the Kemerovo region, Russia.

OJSC «Mine No 12» is one of the core enterprises of Kiselevsk. Number of employees at the mine is 1755 people.

Green manure crops are a wonderful fertilizer. The organic matter, which is formed from the junction of sunlight, air and water, is much more efficient than manure. In addition, green manure crops accumulate nitrogen, phosphorus, potassium, and many macro- and microelements, while the cost of the crops is relevantly low.

The root system of green manure crops deeply hoes the soil providing an excellent water and air exchange. So these crops are also called "bio- plough".

Many green manure crops are honey plants. In addition, their root excretions are useful, e.g., excretions of mustard repel larvae of the May beetle, wireworms, and mole crickets.

## 3. Results and discussion

On June 7$^{th}$, 2016 scientists and research workers of KSAI started an experiment on the territory of coal strip mining of OJSC «Mine No12» in Kiselevsk (Figure 1).

The area of each experimental plot was 1 m$^2$. Experience was laid out in a 3-fold replication. The size of the guard band was 0.5 m. The total area of the experimental plot was 200 m$^2$.

Seeding rate of green manure: Buckwheat – 90 kg / ha; Meadow Clover – 20 kg / ha; Rye – 20 kg / ha; Rape – 20 kg / ha; Phacelia – 20 kg / ha.

Seeding rate of traditional crops: Rump – 20 kg / ha; Espartset- 20 kg / ha.

The consumption rate of hydrogel – 50 g / $m^2$.

**Figure 1** - Experimental plot OJSC «Mine No12»

On June 16th, 2016 scientists and research workers of KSAI visited the Experimental plot OJSC «Mine No12» for the third controlled time.

They studied plants density in the seedling phase on the experience lots of 1 $m^2$. Results of calculations are shown in Table 1 and Figure 2.

**Table 1** - Plants density, pcs. /$m^2$

| crop | soil | soil + hydrogel | clay | clay + hydrogel |
|---|---|---|---|---|
| Rye | 203 | 233 | 318 | 343 |
| Rape | 200 | 210 | 233 | 256 |
| Rump | 53 | 63 | 101 | 151 |
| Phacelia | 50 | 58 | 51 | 125 |
| Espartset | 41 | 68 | 101 | 153 |
| Buckwheat | 50 | 60 | 103 | 155 |
| Meadow Clover | 50 | 55 | 151 | 168 |

Field germination of all the crops is relevantly higher on the clay lots than on the soil ones. Lots with hydrogel showed greater plant density per 1$m^2$. This is due to the amount of moisture in the substratum at the sowing stage. Clay soil is more hygroscopic and physico-chemical properties of hydrogel significantly increase moisture capacity of the substratum.

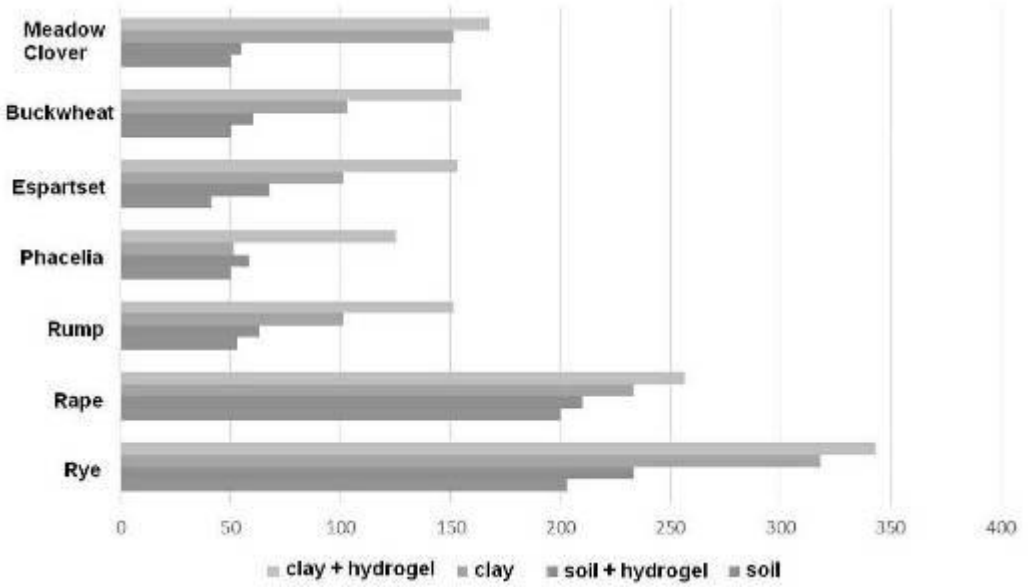


**Figure 2** – Plants density, pcs. /$m^2$

All green manure crops had low germination on the soil lots, although the introduction of hydrogel increased this index at the average by 15%. The greatest plant density on all types of the lots showed Rye and Rape. The results obtained in the course of the study, physical and chemical conditions of anthropogenic disturbed lands are optimal for these kinds of plants.

There were evaluated biometric characteristics of the plants, such as plant height and root length. Measurement of the plant parts was carried out before mowing. The results are given below in the Figure 3-6.

For all studied parameters the best values were showed by plants on lots with hydrogel. The greatest plant height was obtained on the lot "clay+ hydrogel" by Buckwheat (75.3 cm) and Espartset (57 cm). The use of hydrogel on clay substratum had a positive impact on the plants herbage.

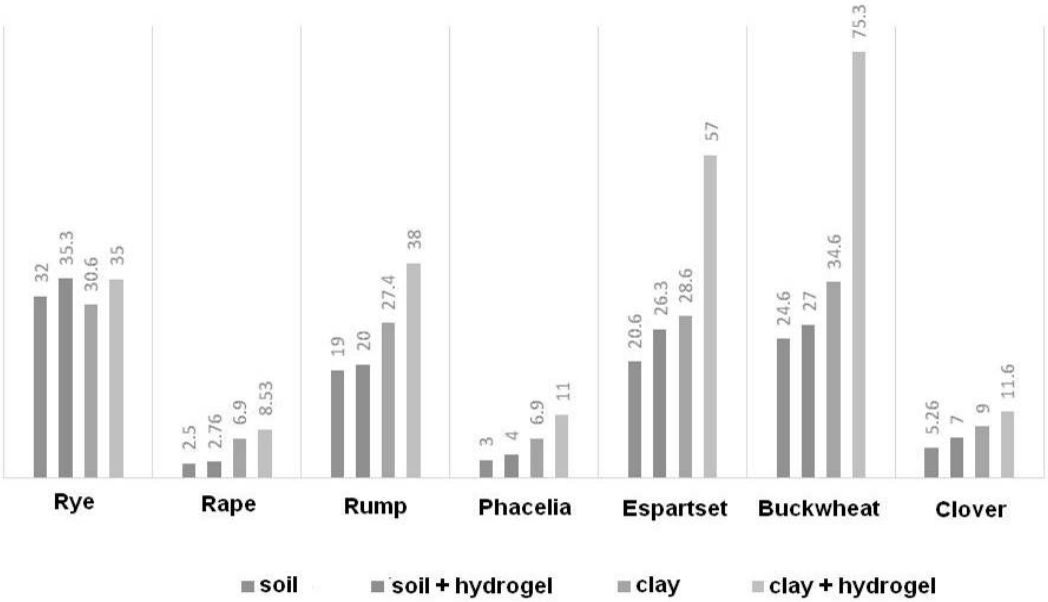


**Figure 3** – Plant height, sm

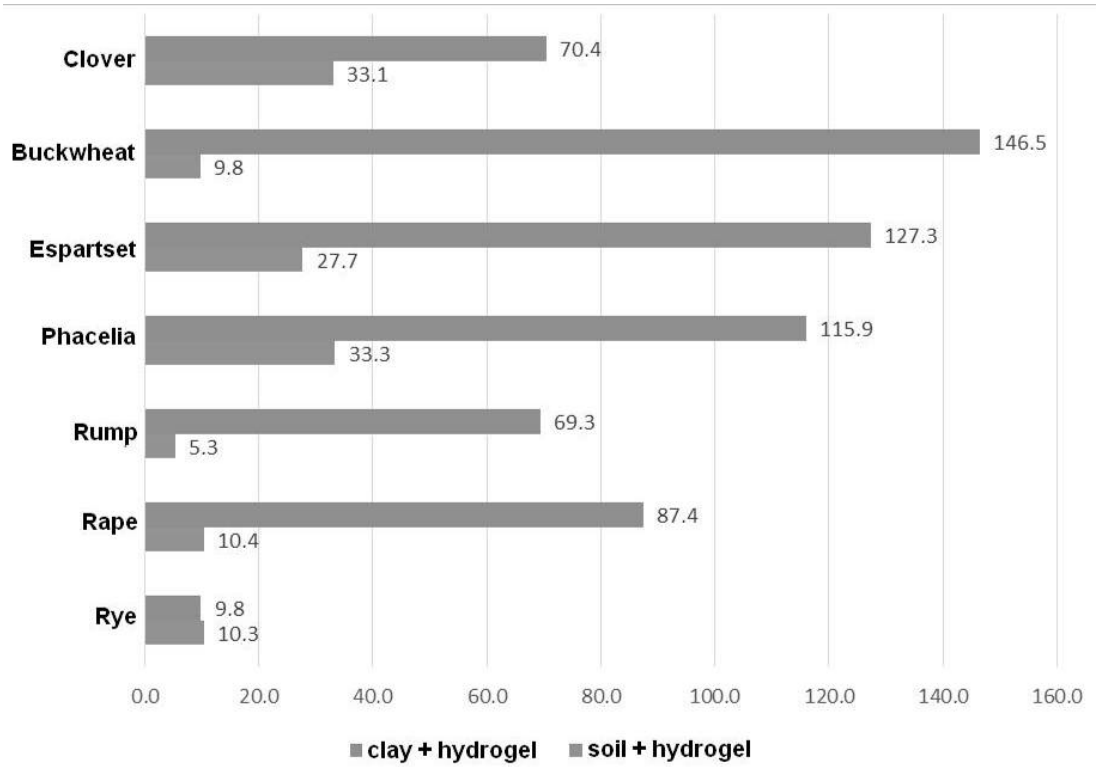


**Figure 4** – Increase of plant height on lots with hydrogel in comparison to similar lots, %

To determine the increment of plant height in percentage lots with hydrogel were compared with similar lots without hydrogel addition. Almost all crops with the major growth of herb were sowed in the clay soil with hydrogel addition, the crops height increased by 2.5 times. The only exception was Rye, the plants height in “soil + hydrogel” and “clay+hydrogel” increased by 10.3% and 9.8% respectively. While Buckwheat increased by 3 times, giving an increase in 146%, Espartset - by 127%, Phacelia – by 116%.

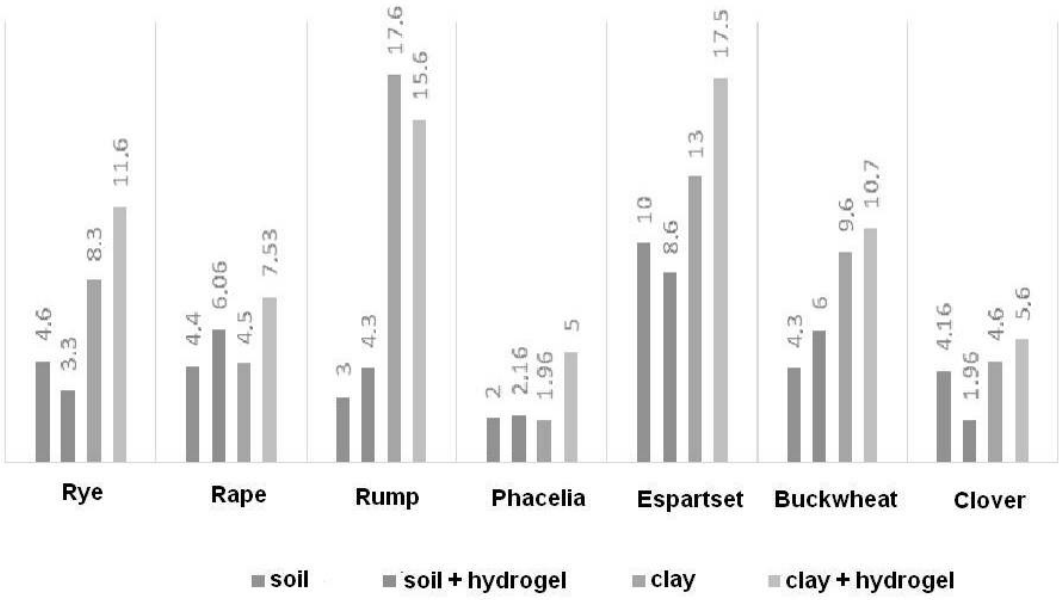


**Figure 5** - Root length, sm

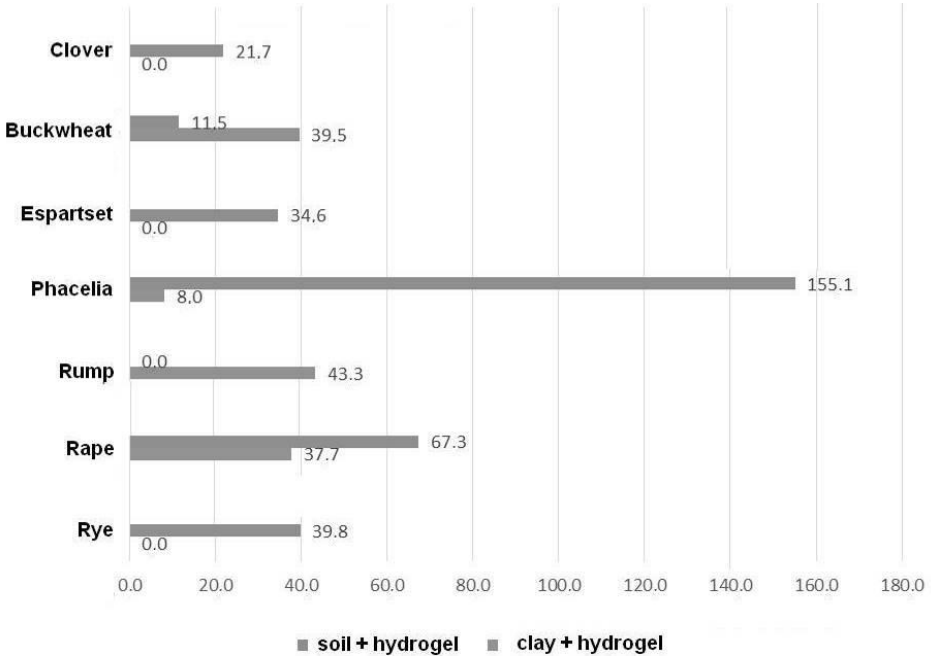


**Figure 6 –** Increase of root length in lots with hydrogel in comparison to similar lots %

The roots of green manure crops are of great importance in the restoration of physical and chemical properties of technogenically disturbed and mining soils. Plants have an impact on the soil's quality, loosen soil layers with roots, reduce leaching of mineral elements, release poorly soluble phosphates, enrich soil with potassium, and low soil pH to neutral.

Roots of such crops as Clover, Espartset, and Rye did not showed significant increase in growth on the "clay+ hydrogel" lot. This combination with hydrogel was the most favorable for Phacelia's root

growth – it increased in 2.5 times. Rump’s root, on the contrary, increased its growth on the “soil+ hydrogel” lot - by 43%.

Active growth of herbage of the crops inhibits the germination of weeds. Plowing of plants herbage improves soil structure, reduces volume weight of the plowing layer and the bulk-density of the soil. As a result plowing activity significantly increases water infiltration and water-holding capacity of the soil, thereby the land runoff of precipitation reduces and the soil moisture content increases dramatically. Therefore, life’s activity of soil microorganisms improves greatly. Moreover, plants’ stems and leaves enrich the soil with nutrients, accumulated during the growing season.

In the course of the research the crops herbage growth on different soil lots has been studied, the results are shown in Table 2.

The increase in herbage on lot with crops mixtures was 4.5% - for Rump with Espartset and 8.10% - for Buckwheat with Clover, whereas mono-sowing of such crops as Esparcet, Rump and Buckwheat showed the greatest increase of herbage in comparison to the soil lots and other sowing variants (Table 2 ). The greatest increase of herbage among lots without hydrogel addition was performed on the clay ones: Esparcet - 250%, Buckwheat - 172% Rump - 123% Phacelia - 77.5%.

**Table 2** – Increase of plants herbage

| Experimental lots | Increase | | | |
|---|---|---|---|---|
| | $g/m^2$ | | % | |
| | soil | clay | soil | clay |
| Espartset + Rump | 0.37 | 0.49 | 4.54 | 5.05 |
| Rye | 0.40 | 0.84 | 12.35 | 17.80 |
| Rape | 0.12 | 0.87 | 1.56 | 9.75 |
| Rump | 0.82 | 85.00 | 45.05 | 123.19 |
| Phacelia | 0.20 | 9.60 | 2.50 | 77.42 |
| Espartset | 5.00 | 155.20 | 15.15 | 249.52 |
| Buckwheat | 14.40 | 664.90 | 9.63 | 172.21 |
| Meadow Clover | 0.67 | 7.30 | 7.83 | 23.47 |
| Buckwheat + Clover | 14.70 | 21.30 | 10.76 | 8.75 |

## 4. Conclusions

1. The study shows that the best growth results of green manure crops of different kinds have been obtained with incorporation of hydrogel in the soil substratum, and particularly in clay, so as due to the amount of moisture in the substratum, clay is more hygroscopic and physico-chemical properties of hydrogel significantly increase moisture capacity of the substratum.

2. Sowing field germination of all crops is much higher in the clay then in soil. Territories with the hydrogel usage showed a greater plant density per 1m2. Almost all crops with the major growth of herb were sowed in the clay with hydrogel addition, the crops height increased by 2.5 times. The only exception was Rye, the difference in height between its plants in “soil + hydrogel” and “clay+hydrogel” was less than 1%.

3. The root growth of Phacelia in “clay+hydrogel” increased by 2.5 times. While the root growth of Rump, on the contrary, increased in mellow soil with hydrogel by 43%. Other kinds of crops did not perform any difference in their root length.

4. The increase of herbage in mixtures of green manure crops was negligible, whereas mono-sowing of such crops as Esparcet, Rump and Buckwheat showed the greatest increase of herbage in comparison to the soil lots and other sowing variants. The greatest increase of herbage among lots

without hydrogel addition was performed on the clay ones: Esparcet - 250%, Buckwheat - 172% Rump - 123% Phacelia - 77.5%.

Thus, on the ground of the undertaken study it can be argued that the hydrogel introduction in anthropogenic disturbed soil favorably affects the growth and development of the green manure crops.The best results of herbage accumulation were showed by Esparcet, Buckwheat, Rump, Phacelia.

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