Results of a study comparing planting time and biomass yield of green manure crops in the steppe zone of Mongolia

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Abstract

Due to the crop monoculture system which has been 60 years continuously played in a key role in the crop sector Mongolia, soil erosion and its fertility decline have been becoming one of the main pressing issues in all crop zones. The main solution of restoration of soil fertility in the steppe zone of Mongolia is not only to reduce bare fallow but also urgently need to apply green manure in all regions. Our study has focused on identifying the appropriate timing to cultivate green manure crops in the Eastern steppe region of Mongolia and to determine the convenient alternatives of crops with a high yield of biomass to use for green manure.
We determined the most convenient time to use crop biomass for green manure is between 22-27th.July for the green manure crops cultivated on the 20th of May.
For the crops cultivated on the 30th of May green manure time can be determined between 2-6th. August and for the crops cultivated on the 10th of June the convenient time would be between 10-13th.August.
We prioritized the best option of the crop alternatives based on the 3 years average yield of green mass and concluded that field pea and oat mixture, Sudan grass, and fodder pea mixture can be one of the convenient options for green manure in the steppe zone of Mongolia. According to our study results, convenient alternatives with the highest root mass were yellow clover (27.5-60.5c/ha) and white lupine (27.5-61.4c/ha).
In terms of biomass, the convenient alternatives with the highest biomass were the following crops planted on the 20th of May such as mixture of field pea and oat (82.5-112.2c/ha), fodder pea and Sudan grass (67.4-97.0c/ha), as well as Sudan grass (57.1-110.0c/ha. It is considered that in the steppe zone green manure crops can be used for green manure if the biomass of the crops can exceed 40c/ha. [1] *The appropriate timing of the planting period should not be later than the 30th of May.*

Keywords*: bare fallow, root mass, green mass, flowering period, planting time*

Introduction

Over the last 40 years, soil fertility of arable land of crop sector has declined 2-3 times due to human activity, and currently, 90% of the country's arable land of Agriculture have been affected by soil erosion. [2] Single crop farming of bare fallow and wheat is the main reason for the rapid deterioration of soil fertility and long-term erosion. Supporting the restoration of soil fertility by replacing bare fallow land with green manure has become an urgent issue of the Mongolian crop sector.
According to the survey, in the situation of agricultural production in Mongolia, an annual average of 1.09 t/ha of humus is lost from the depth of 0-20 cm of short-term crop rotation of soil.[3] The nationwide soil monitoring study was held from 2009 to 2011 and researchers emphasized that over 70% of the country's 579.3 thousand hectares of arable land have less than 2.5% humus.[3] This indicates that the soil fertility of arable lands in our country has significantly decreased. The researchers L.Badarch and R.Baljinnyam emphasized that the importance and advantages of green manure in all their study results and books. The novelty of their study is that they identified the crops that can be used for green manure in the central crop zone where soil erosion is in a very critical situation. The main goal of our research work was to choose the types of green manure crops suitable to grow in the steppe zone of Mongolia, to determine the first and second-year wheat yields after green manure, and to calculate its economic efficiency of all options. In the frame of our research work the green and root mass of all selected green manure crops were studied.
According to our study, we determined the convenient types of crops with the highest biomass for green manure in the steppe crop zone and the appropriate time to plant crops. We determined changes in post-green manure wheat yield and soil fertility indicators such as soil humus, N, P, K and calculated the economic benefits of green manure crops for the first time in Mongolia. This article provides a partial comparison of similar studies, except for the selection of the appropriate timing for planting green manure crops in the steppe zone, the selection of crop types, and the biomass study.
According to the results of the study of the researchers H. Blanca & R.Lal (2011) in developing countries and least developed countries, soil erosion rate increases to 40-50t/ha, and during dust storms, it increases to 100t/ha and soil degradation in agro-ecosystems is 500-1000 times faster than natural ecosystem degradation.[1] In our

country, as defined by the researchers D.Tsermaa, D.Dorjgotov, U.Bekhtur, J.Gardkhuu, J.Amgalan, and A.Choijamts concluded that the amount of arable land with the highest soil erosion doubled in size and soil humus content dramatically decreasing and average content of humus in a soil is less than 2%.[2] Mongolian researchers are emphasizing that the priority issue for the crop sector is to replace bare fallow with green manure. Usage of the biomass of green manure crops not only increases the organic matters in the soil but also reducing soil erosion and soil runoff by 43% compared with previous years. The history of green manure in the Middle East, which began 6,000 years ago, has gained momentum among farmers in medieval Europe and continues to be a major theme of the 21st century.[4] Currently, alfalfa, buckwheat, beans, mustard, sorghum, Sudan grass, fodder peas, oats, soybeans, clover, sweet clover, canola, rye are widely used for green manure all over the world. The main role of green manure crops is to accumulate air, nitrogen in the soil and increase the organic matter in the soil, and main green manure crops can leave an organic mass of 13-68 c/ha in the soil. It is estimated that 40-60% of the total nitrogen in these crops remains in the soil.[5] To improve soil fertility, increase wheat yield our study was conducted in 2013-2015.

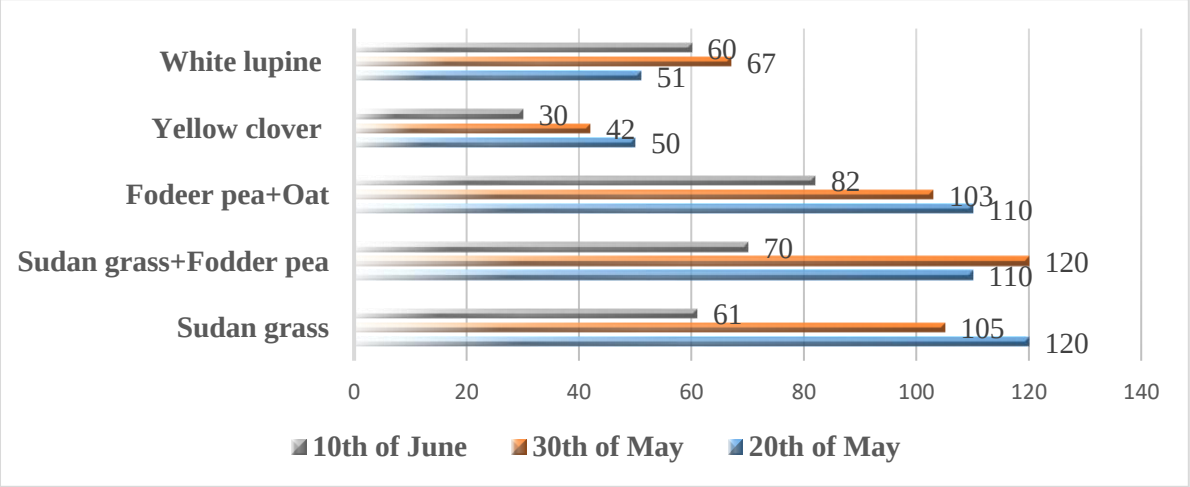
Survey Methodology

We conducted field experiments in the area of "Enkh Nogoon Tal" LLC, Umnudelger soum, Khurkh village, Yargait ar, Khentii aimag during the 2013-2015 plant growth period. To determine the effect of planting time on the biomass yield of green manure crops, we placed the following alternatives of crops such as Sudan grass, Sudan grass 50% + fodder pea 50%, fodder pea 50% + oat 50%, yellow clover, and white lupine in 3 different periods 54 plateau. The size of each plateau was 3 m long and 2 m wide. Total 6 sq. m. The total study area was 954 sq. m. In the field study, the phenomenological observations were studied by the VIR method, the green mass by weight method, the plant root distribution by the index method, and the mass by monolith method. Height and biometric measurements of green manure crops were made at the beginning of the flowering period each year and a 1 square meter sample was taken from each alternative. The measured average values of 3 years were concluded in this paper. The dry weight of the plant's yield of 1 square meter was converted in 1 c/ha yield.

Results of a study on the use of green manure crops in growth and biomass yield study fertilizers

Within the scope of the research, green manure crops such as Sudan grass, Sudan grass, and fodder pea mixture, yellow clover, and white lupine were placed in alternatives for green manure planted 3 different periods, May 20, May 30, June 10. Crops growth and biometric studies were conducted, the growth period was studied, and the maximum possible biomass size was determined. Based on the international experience that it's effective to choose the early and middle flowering period to select the best time to use green manure crops for green manure.[1] The suitable time to use crops for green manure cultivated on the 20th of May was between 22-27th of July, and for the crops cultivated on the 30th of May it was between 2-6th of August, and the for crops cultivated on 10th of June, it was between 10-1th of August. The flowering stage of green manure crops varied depending on the time of planting, and the study concluded that the best time to use crops for green manure was between the 20th of July 20 to August 10. Although the growing season of green manure depends on the climatic conditions of the year, note that all variants were consistent with the 3-year flowering period of the study, in line with the general climatic characteristics of Mongolia.

Green manure crops' average annual biometric measurements are shown in the following graph.



Graph 1. Growth of green manure crops height, cm (2013-2015)

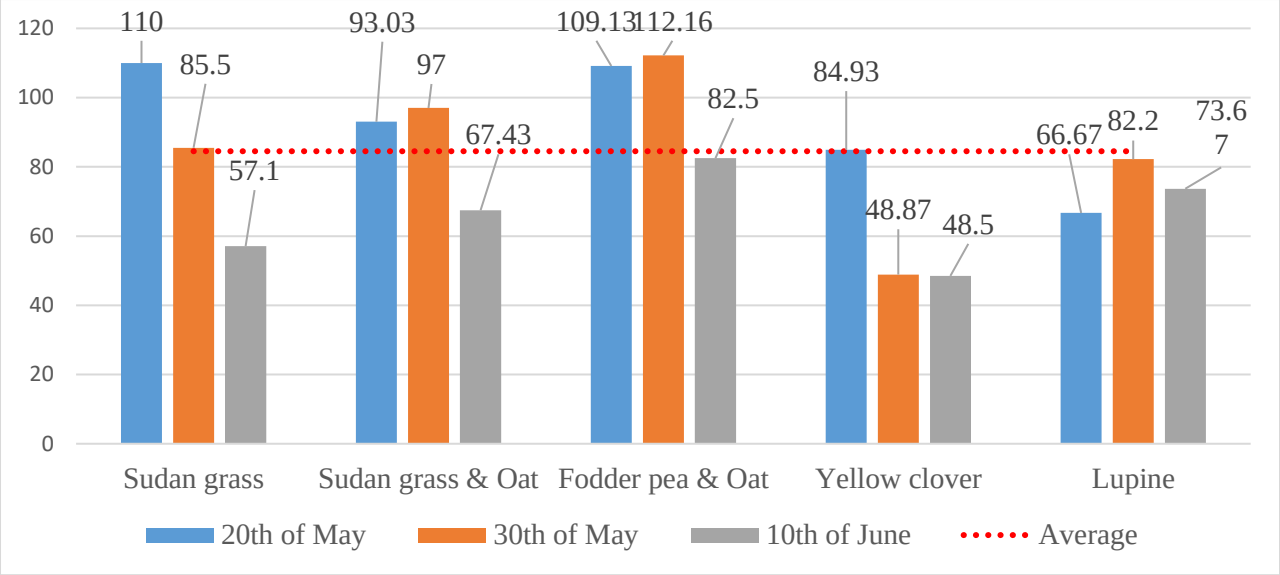
Green manure crops height average was 88.2cm on 20th of May, 84.4cm on 30th of May, and 60.6cm on 10th June. The standard errors in measuring the height of the green manure crops were $S.E = 8.61 - 15.5$.
The standard error on 30th of May was lowest comparing 20th of May and 10th June. Height of the green manure crops and time of planting variance analysis result: Planting time has an influence to green manure crops height. $F_{cal} > F_{sign}$: 5.45 > 3.47.

The average height of oat and fodder pea was 82-110 cm, Sudan grass 61-120 cm, Sudan grass and fodder pea mixture 82-110 cm, and the crops cultivated on the 20th of May were the highest of growth.
In the case of legumes, such as yellow clover and white lupine, growth was relatively low at 50-70 cm in the region, and the best time to plant white lupine had determined not later than the 10th of June, and for the yellow clover, this time was not later than May 30. Climate characteristics of the steppe region such as strong winds, scarce rainfall, and unstable heat supply, influenced crop growth.
The green mass, root mass, and biomass of green manure crops were studied and the maximum biomass delivery time was determined and the options were evaluated. All crops were used for fertilization at the end of the flowering stage, which is considered a convenient time when crops use less soil moisture, produce the highest biomass, and nitrogen. [6] Green manure crops were sampled from the beginning of flowering to ripening, shredded, buried, and used for fertilization.

Table 2. Biomass of green manure crops, c/ha (2013-2015)

	Green mass			Root mass			Biomass		
Variants	V.20	V.30	VI.10	V.20	V.30	VI.10	V.20	V.30	VI.10
Sudan grass (Sorghum sudanense)	55.3	54.6	31.6	54.7	31.0	25.5	110.0	85.5	57.1
Sudan grass (Sorghum sudanense) + fodder pea (pisum arvense) mix	50.9	47.4	37.0	42.1	49.6	30.4	93.0	97.0	67.4
Fodder pea (Pisum arvense)+Oat (*Avena sativa)* mix	63.7	75.1	48.0	45.4	27.0	34.5	109.1	102.2	82.5
Yellow sweet clover (*Melilotus officinalis*.L)	24.4	21.5	21.0	60.5	27.4	27.5	84.9	48.9	48.5
White lupin (Lupinus albus. L)	28.4	36.6	46.2	38.2	45.60	27.5	66.7	82.2	73.7
HCP =0.05	$HCP_{0,5} = 11.7$ c/ha			$HCP_{0,5} = 5.56$ c/ha			$HCP_{0,5} = 13.2$ c/ha		

According to our study results, convenient alternatives with the highest root mass were yellow clover (27.5-60.5c/ha) and white lupine (27.5-61.4c/ha).
In terms of biomass, the convenient alternatives with the highest biomass were the following crops planted on the 20th of May such as mixture of field pea and oat (82.5-112.2c/ha), fodder pea and Sudan grass (67.4-97.0c/ha), as well as Sudan grass (57.1-110.0c/ha*)*



Graph 2. Biomass of green manure crops, c/ha (2013-2015)

Green manure crops biomass average was 92.7cm on 20th of May, 94.9cm on 30th of May, and 65.8 cm on 10th June. The standard errors in measuring the biomass were $S.E = 5.9 - 13.8$.
Biomass of the green manure crops and planting time variance analysis result: Planting time has an influence to green manure crops biomass $F_{cal} > F_{sign}$

Based on our study results of average yield, we determined that the convenient alternatives with the highest yield of biomass and fodder pea + oat (112.16c/ha), Sudan grass + fodder pea mixtures were prioritized. While comparing 3 years' average of root mass, sweet clover, and white lupine were the best alternatives with the highest yield. The biomass of fodder pea and oat mixture as well as, Sudan grass cultivated on the 20th of May were the best options compared with other alternatives. The Kamyshinskaya 51 varieties of Sudan grass had the highest biomass cultivated on the 20th of May and the highest yield of biomass was 110.5 c/ha. (F 8.9 > F sign 5.59) The highest biomass yield of the yellow clover was 84c/ha planted on the 20th of May. The highest biomass yield of the fodder pea oat mixture was 109 c/ha, planted on the 20th of May. The highest biomass yield of Sudan grass and oat mixture was 97 c/ha planted on the 30th of May and the white lupine's largest biomass yield was 82.2 c/ha planted on the 30th of May.

Two-factor variance analysis was used to determine the effect of planting time and variants on the biomass of green manure crops.

Variance	**SS**	**df**	**MS**	F_{cal}	F_{sign} $P = 0.95$
Planting date (S^{date})	$Q_1 = 14423$	$k_1^{date} = 3 - 1 = 2$	$S_1^2 = \frac{14423}{2} = 7211$	$F_{date} = \frac{7211}{306} = 23.5$	3.40 /k1=2, k2=24/
Varients ($S^{crop}_{varient}$)	$Q_4 = 3528$	$k_3 = 4 - 1 = 3$	$S_4^2 = \frac{3528}{3} = 1176$	$F_{varient} = \frac{1176}{306} = 3.84$	3.40 /k1=2, k2=24/

From the above table, we concluded that both planting time and crop alternatives had a significant impact on increasing the biomass yield of green manure. With a probability of 0.95, the calculated values of the groups (F_{date}=23.5, $F_{varient} = 3.84$) were higher than the theoretical criteria ($F_{cal} = 3.40$).

We calculated the correlation coefficients to determine the effect of sowing time on the biomass yield of green manure crops. Coefficients of correlation were early time effect ($r = 0.23$), medium time ($r = 0.21$), and late time ($r = -0.44$).

Biomass yields of the green manure crops tend to increase in the early and medium time, and biomass yields tend to decrease with late planting time. In terms of biomass, sudangrass and fodder pea mixture, fodder pea and oat mixture, and lupine were convenient options for planting time.

Based on the results of the study, we analyzed the correlation between biomass, green mass, and root mass. Correlation coefficients of green mass, root mass, and biomass are compared in the following figures.

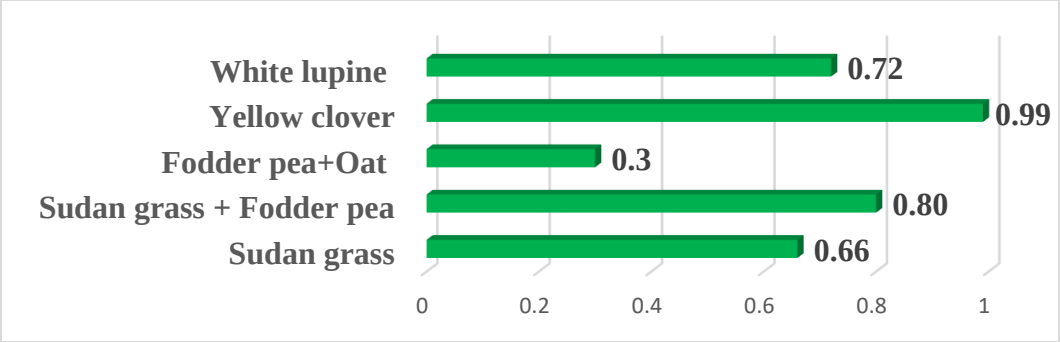


Figure 1. Green mass & Root mass correlation

Green mass and root mass correlation: All coefficients were positive ($r = 0.3 - 0.99$) in all variants. Correlations of green mass and root mass of yellow clover ($r = 0.99$), sudangrass and fodder pea mixture ($r = 0.80$) , and white lupine ($r = 0.72$) were higher than the other variants.

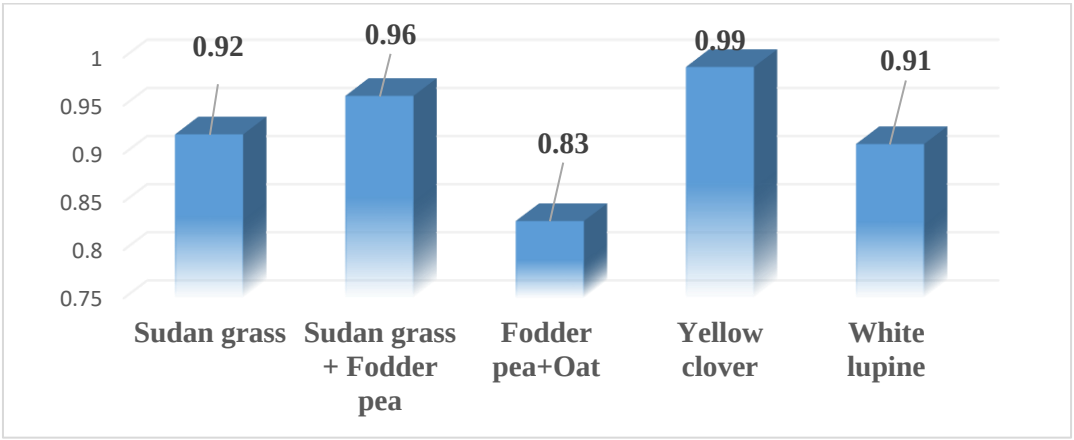


Figure 2. Biomass & Root mass correlation

Correlation of biomass and green mass: All coefficients were positive ($r = 0.77 - 0.99$) in all variants. Correlation of biomass and green mass of yellow clover ($r = 0.99$), white lupine ($r = 0.94$), and Sudan grass and fodder pea mixture ($r = 0.93$) were higher than other variants.

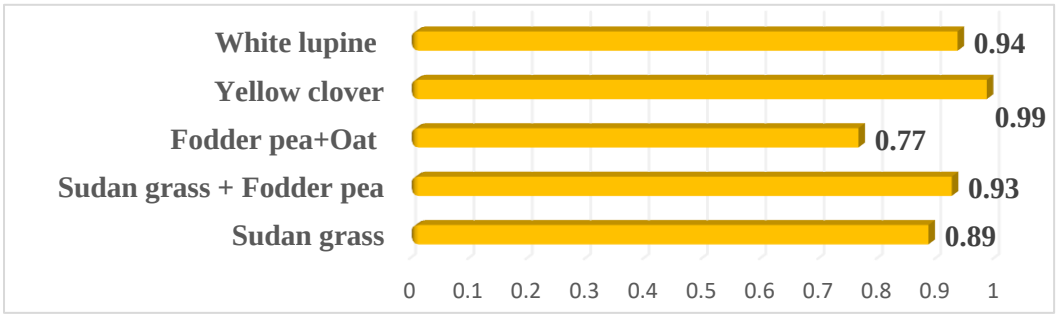


Figure 3. Green mass & Biomass correlation

Correlation of biomass and root mass: All coefficient were positive ($r = 0.83 - 0.99$) in all variants. Correlation of biomass and root mass of yellow clover ($r = 0.99$), Sudan grass and fodder pea mixture ($r = 0.96$), and Sudan grass ($r = 0.92$) were higher than the other variants.
In the steppe zone, precipitation is a major factor influencing biomass yields. Biomass yield and precipitation correlation ($r = 0.23$) were positive.$F_{cal} > F_{sign}$: 1.28> 0.29. Biomass and air temperature correlation ($r = 0.10$) were positive. An increase of 1 mm in precipitation increases the biomass yield by 0.38 c/ha ($coefficient = 0.38$).

Discussion

According to the results of the study of Canadian researcher Cherr, J.M.S, Scholberg, and R. McSorley (2006) emphasized that if crops are used for green manure after the flowering period most of the nitrogen that accumulates in the plant is stored in the seeds and it is not dissolved well.[7] On the advice of a researcher A.M.Berzin in the regions where the growing period is short and the fertile layer is thin, the best time to use crops for green manure is in August and needs to plow conventionally.[8] According to the results of the study, R.Baljinnyam (1992) found that growing yellow clover for green manure can release the field in the last ten days of July, while fodder peas can release in ten days in mid-July.[9] Comparing with the below-stated research results we determined that the deadline to use crops for green manure in the steppe region must not exceed the 10th of August. We also concluded that the convenient time for planting green manure crops must not exceed than 30th of May. According to a recent study, U.Boldsaikhan (2014) on improving soil fertility by rotating legumes 31.8-82.1 c/ha of organic mass was created by rotating alfalfa, clover, peas, lentils, and rapeseed.[10] According to our research results of the study root mass of yellow clover was 27.5-60.5 c/ha. As defined by the researcher A.I.Stepeeiv (2002) yellow clover and fodder pea is a convenient option in the region with the lowest rainfall. According to our research results of the study above mentioned green manure crops root mass can exceed up to 67.0 c/ha and of biomass up to 95 c/ha. According to our study, the average biomass of white lupine was 66-73 c/ha, and depending on weather conditions it can rise to 131 c/ha.[11] Researchers E.C.Vaisman, Martin.H.Entz, Keith.C Bamford of Canada emphasized that the green mass of green manure crops can exceed up to 30c/ha in northern Canada. In the regions with similar climatic conditions at the same latitude as Mongolia , the Montana USA, green mass of green manure crops can exceed an average of 40 c/ha. [12] In the steppe zone of our country biomass of green manure crops can reach up to 48-131 c/ha of an average 83c/ha, and green mass of an average 44 c/ha.

Conclusion

According to the results of the study, we are concluding the following:

1. Convenient planting time in the eastern region of green manure crops is 20th. May.
2. Convenient alternatives in the region with the highest yield of biomass are fodder pea and oat mixture (109 c/ha), Sudan grass and fodder pea mixtures (97c/ha).

Gratitude

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