Selection of high-yielding agrophytocenoses of annual crops for fodder lands of frontier zone

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Abstract: The studies conducted have provided data enabling one to evaluate the productivity of feed crop in the frontier zone of the West Kazakhstan Province of the Republic of Kazakhstan and the Saratov region of the Russian Federation for use in innovative technologies on feed protein production. The studies have ascertained the feasibility of cultivation of sorghum, Sudan grass and millet agrophytocenoses in the noted frontier zone instead of the conventional barley crops. Suggested croppers are distinguished by active photosynthetic activity. Over the 5-year period the average maximum leaf area of sorghum crop makes 52.0 thousand m^2/ha, crop of Sudan grass and coarse millet generate 46.0 and 42 thousand m^2/ha, respectively. And in the barley crop it does not exceed 23.6 thousand m^2/ha. Studied agrophytocenoses of annual forage crop differ by yield of fodder units, digestible protein, feeding protein units (FPU) per unit of land, and the accumulation of the metabolic energy. Over 5-year study period, the highest yield of green mass was provided by sorghum and Sudan grass crop - 26.1 t/ha and 16.2 t/ha, respectively. Productivity of barley was significantly inferior to sorghum and Sudan grass, accounting for just 12.0 t/ha.

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Introduction

Strong fodder base is the basis for the livestock development. However, many countries do not have enough feedstaff and its quality is poor that results in low productivity of farm livestock.

Bioclimatic potential of the frontier zone of Russia (the Saratov region) and the Republic of Kazakhstan (the West Kazakhstan Province) is currently used only by 35-40%, the yield of white straw crop over the last 50 years does not exceed an average of 12-13 kg/ha. At high prices on farm machinery, fertilizers, herbicides, fuels and lubricants, highly profitable grain production is scarcely probable. Increase of productivity of the part of tillable land is possible by growing high producing fodder crop adapted to the moisture deficit, such as sorghum, Sudan grass, and course millet.

Change in cropping patterns in favor of feed crop is dictated by the need to increase the number of livestock and its productivity.

Forages serve the basis to increase in livestock and its productivity. In the farms of frontier zone, comprehensive measures are taken to address the problem of fodder production. One of the ways to increase productivity per hectare of tilled field and strengthening fodder base is the selection of more productive crops, biologically relevant to local climate conditions. In this context the Sudan grass and course millet are of great interest [1, 2, 3, 4, 5].

Climatic parameters of frontier zone are favorable for growing fodder millet, Sudan grass and sorghum. Sudan grass has a good regrowth. Sorghum provides high and stable yields. Millet holds one of the first places among the crop is terms of xerophytism and ability to withstand to wind burn. All these croppers have well-developed highly branched fibrous root system, are well responded to madefaction, their green mass is an excellent raw material for the preparation of hay, haylage, grass meal, and silage. Feedstaff made of military crop is eaten by all kinds of livestock. It is considered that the digestibility of forage organic matter from millet and Sudan grass is good and satisfactory [6, 7, 8, 9, 10, 11, 12].

Methodology. The studies were carried out during the years 2008-2012 in Kaztalovka township situated in the frontier zone between the Saratov region of the Russian Federation and the West Kazakhstan Province of the Republic of Kazakhstan.

The aim of the research was to study the agro-biological features and patterns of harvest formation of annual forage crop for the production of various types of feedstaff in the frontier zone between Russia and Kazakhstan.

The objects of the investigations were conventional cropper agrophytocenoses of barley (reference) (*Hordeum sativum*), sorghum (*Sorghum*), Sudan grass (*Sorghum sudanense*), and coarse millet (*Panicum millaceum*). The area of sample plots was 50 m^2, the study was conducted at triple tier. Agro-techniques of forage crop cultivation was applied according to the methodology adopted to the frontier zone.

Soil of the test plot was light chestnut. When conducting field experiments with forage crops, inventories, observations of the onset of phenological phases and the forage crop growth, as well as analyses were performed by standard practices [13]. Photosynthetic activity of forage crop was studied by the method of Nichiporovich [14]. Harvesting and crop inventories were held by a continuous method followed by reduction to the standard moisture. Statistical processing of the research data was carried out by dispersion, correlation and regression analyses using computer programs [15]. Determination of the chemical composition and nutritional value of plant mass was performed by standard technique.

Weather conditions during the years of study were typical for the zone with the exception of 2008 and 2012, when the effect of drought was manifested.

The main part. According to research techniques, phenological observations were carried out during the growth seasons. Height and leaf area were measured at certain phases of plant growth and development.

During the first half of the crop vegetation, short day croppers grow more slowly compared with barley (reference) due to their biological characteristics. The first four leaves are formed during the five-six weeks. During this period plants give rooting accompanied by intense growth of root system, and development of the secondary roots. By the time of first inventory (June 10), the plants had 4 to 7 leaves, the average height of barley was 29.1 cm, sorghum - 19.0 cm, millet - 19.5 cm, and Sudan grass – 24.2 cm (see Table 1) .

Table 1. The height growth pattern of the annual forage crop during the growth season, West Kazakhstan Agro-Technical University (ZKATU), 2008 - 2012.

Option	Inventory dates					
	June 10		June 30		July 20	
	Height, cm	Daily gain, cm	Height, cm	Daily gain, cm	Height, cm	Daily gain, cm
Barley (reference)	29.1	1.0	63.2	1.7	73.5	0.5
Sorghum	19.0	0.7	56.1	1.9	90.5	1.7
Sudan grass	24.2	0.8	78.7	2.7	116.0	1.9
Coarse millet	19.5	0.6	57.5	1.9	79.0	1.1

Average daily gain during the initial period of development for barley plants was 1.0 cm, while for short day croppers it was no more than one centimeter. By the middle of the vegetation, the pattern changes dramatically; the average daily gain of coarse millet and sorghum, and especially, Sudan grass, far exceeds this factor for barley crops.

By July 20, the growth of barley plants has almost ceased, while for millet and Sudan grass, and especially, for sorghum, daily gain is practically not reduced and comes to 1.7 cm for sorghum, 1.9 cm for Sudan grass, and 1.1 cm for coarse millet.

Active photosynthetic activity of the crop is very important for its formation. Noteworthy is the fact that at the time of the first survey, all indicators of photosynthetic activity for barley are almost 2 times higher than those for sorghum, Sudan grass and coarse millet. However, by June 30, the picture changes dramatically - sorghum and Sudan grass come out on top in terms of these indicators.

Over 5-year study period, the average maximum leaf area in sorghum crop comes up in average to 52.0 thousand m^2/ha, in Sudan grass and coarse millet crops - 46.0 thousand m^2/ha and 42.2 thousand m^2/ha, respectively, and for barley crop it does not exceed 23.6 thousand m^2/ha (Table 2).

Table 2. The productivity of the photosynthetic activity of annual forage crops, ZKATU, 2008 - 2012.

Option	Maximum leaf area, thousand m2/ha	Photosynthetic potential, mln m2/day ha	Net photosynthetic productivity, g/m2/day	Gross energy of the output yield, GJ	Photosynthetic active radiation (PAR) utilization rate of, %
Barley (reference)	23.6	1.2	2.64	65.5	0.8
Sorghum	52.0	1.8	4.0	134.0	1.8
Sudan grass	46.0	1.8	3.0	91.1	1.2
Coarse millet	42.2	1.4	2.5	56.0	0.7

Photosynthetic potential in sorghum and Sudan grass crops is the same and equals to 1.8mln m^2/day/ha. However, the net photosynthetic productivity in sorghum crop is much higher. This may explain the higher yield of gross metabolic energy per hectare. The lowest photosynthetic active radiation (PAR) utilization rate was received for course millet (0.7%), while for barley crop it was somewhat higher (0.8%). The highest PAR utilization rate was received for sorghum (1.8%) and Sudan grass (1.2%) crops.

Over 5-year study period, sorghum and Sudan grass crops ensured the highest yield of green mass - 26.1 t/ha and 16.2 t/ha, respectively. Productivity of barley was significantly inferior to sorghum and Sudan grass, accounting for 12.0 t/ha. In terms of productivity, the smallest value of green mass turned out to be in course millet crop - 11.0 t/ha.

Yield of dry basis is more objective index to indicate crop's productivity. For barley which is a reference plant, dry basis yield at the pipe formation phase before coming into ear increases by 15%. For sorghum and Sudan grass this index increases by 25% and 20%, respectively. Millet provides increased yield of dry basis by 29%, indicating its high producing ability in the second half of the growth season (Table 3).

Table 3. Productivity of annual forage crops, ZKATU, 2008 - 2012.

Option	Yield per 1 ha, t				Metabolic energy, GJ/ha	Availability of fodder units by digestible protein
	dry mass	fodder units	digestible protein	feeding protein unit		
Barley (reference)	3,2	2,6	0,24	2,3	24	92
Sorghum	6,0	5,8	0,45	4,1	49	78
Sudan grass	4,0	3,7	0,34	3,1	34	92
Coarse millet	2,7	2,6	0,28	2,5	25	107
HCP_{05} c/ha	0,8					

[1]LSD - least significant difference

Maximum yield of dry basis in the average 5-year period per area unit was provided by the sorghum crop - 6.0 t/ha. That of Sudan grass crop is less by 2.0 t/ha. Barley, as conventional cropper, makes it possible to obtain 3.2 t/ha in similar conditions. The least amount of dry basis was shown in the millet crop - 2.7 t/ha.

Chemical composition of feed crop is very important for feed assessment. The highest content of dry basis in the green mass equal to 26.6% was shown in barley crop. The lowest content of dry basis (22.9%) was indicated in sorghum biomass.

Most of the crude protein is contained in the green mass of millet - 3.6%. The lowest content of crude protein is in sorghum - 2.4 %, while in terms of this indicator, Sudan grass occupies a middle position - 3.0%. Barley crop contains 1.3% of fat in the vegetative mass, Sudan grass and course millet - 0.9% each, and sorghum – just 0.8%. It should be noted that the content of nitrogen-free extractive substances (NFES) is considerably higher in millet plants - 11%. For green mass of sorghum and Sudan grass NFES equals 10% and 10.3%, respectively. In the vegetative mass of barley NFES amounts 8.2 %.

It should be noted that the plants of Sudan grass and course millet have 7-8% of fiber that makes 79-88 grams per kilogram of green weight. Most of it is in barley plants - 10.9%, or 109.3 grams per kilogram, the lowest of its content is in course millet crop, just 75.1 grams.

No significant difference was found in the content of fodder units per kilogram of feedstaff, it is slightly higher in course millet and barley plants - 0.24 and 0.25 fodder units, respectively. The lowest content of crude protein per kilogram of vegetative mass was found in sorghum - 23.5 grams.

Most of the metabolic energy is stored in the course millet crop - 2.3 MJ per kilogram, the lowest value was indicated in the sorghum crop - 1.9 MJ. Oats and Sudan grass have metabolic energy content of 2.0 and 2.1 MJ, respectively per kilogram of feedstaff.

Sorghum ranks the first in terms of nutrients and gross energy output per hectare. Providing harvesting of 6.0 tons of dry basis per hectare, sorghum has the highest output rate of major nutrients per area unit. Thus, for example, the digestible protein amounted 0.45 t/ha, fiber and NFES - 2.1 and 2.6 t/ha, respectively. Sorghum holds first place in terms of gross energy content in the crop - 108 GJ/ha. Such indicators in the dry climate conditions of the frontier zone can be obtained only in fodder beet, sunflower, and corn agrocoenoses.

Second place in terms of nutrients and gross energy yield per hectare belongs to Sudan grass. Providing an average 5-year yield around 4.0 t/ha, the yield of digestible protein was 0.34 t/ha, fat - 0.15 t/ha, and gross energy 73 GJ/ha.

It should be noted that in terms of crude and digestible protein output, course millet is superior to barley crop at a lower yield of green mass. This is probably due to the fact that course millet plants have better foliage that makes up 50-60% of total biomass yield. This may explain also the fact that in case of course millet we have received the lowest yield of fiber, just 0.81 t/ha, whereas this figure for barley crop is 1.4 t/ha.

Feed crop productivity is strongly dependent on the following indicators: yield of fodder units, digestible protein, FPU per area unit, metabolic energy accumulation, and content of digestible protein per fodder unit.

It is believed that the content of 105-110 grams of digestible protein per fodder unit provides the most efficient use of all other nutrients, virtually for all feedstaff types. Research data obtained indicates that the coarse millet crop which contains 107 grams of digestible protein, is the only cropper which conforms the livestock standards. The lowest rate of digestible protein per fodder unit was found in sorghum crop - 78 grams, and slightly higher rate - 92 grams - in barley crop s. However, due to the high yield of green mass and dry basis, the greatest value of feeding protein units was provided by sorghum - 4.1 tons per hectare.

The lowest yield of FPU was received in case of barley – just 2.3 t/ha. The cultivation of Sudan grass gives increase in FPU up to 3.1 t/ha.

The same pattern holds true for metabolic energy output. For example, for barley crop this figure is 24 GJ per hectare, for coarse millet - 25 GJ, for Sudan grass and sorghum - 34 and 49 GJ, respectively.

During the studies we have analyzed the total yield depending on growth season conditions.

Hydrothermal conditions significantly affect all phases and periods of vegetation development and inhibit or, alternatively, facilitate better development of plants depending on quantitative indices of these conditions that results in decrease or increase in amount of crops.

Obtained data shows the close relationship between the green mass yield per hectare and hydrothermal conditions. Thus, the highest degree of such relationship, characterized by the correlation ratio of 4.9, was observed in sorghum, while the lowest correlation ratio - 1.9 – was indicated in coarse millet (Table 4).

Table 4. The correlation ratio between the crop yield and hydrothermal conditions during the growth seasons, ZKATU, 2008-2012.

	Barley (reference)	Sorghum	Sudan grass	Millet
xlyx	0.378	0.602	0.349	0.239
hxy	0.615	0.776	0.591	0.488
Sh	0.211	0.158	0.216	0.252
tn	2.919	4.917	2.742	1.939

According to this correlation ratio we can judge about the adaptability of the crop and its responsiveness to favorable conditions.

The yield of studied croppers depends to varying degree on the availability of moisture and its distribution throughout the growing season. To study this problem, the correlation coefficients were calculated, and regression equations were derived for correlations between the crop yield and the rainfall in the first and the second half of the growth season. At the correlation coefficient less than 0.3, the relationship between indicated factors is weak, within the range 0.3-0.7 it is medium, and at coefficients greater than 0.7 the relationship is strong.

The studied croppers depend on the availability of moisture during certain phases of growth and vegetation to a variable degree because of their biological peculiarities. As compared with the conventional plants, short-day croppers are less dependent on the rainfall in the first half of the growth season. The lowest relationship between yield of crop and the rainfall during the period from May to June is observed in the millet crop r =0.09±0.27. This suggests that the given cropper can germinate even with a small amount of moisture and requires for springing up just 25% of seeds weight. The same may also be noted with regard to sorghum, whose correlation coefficient is equal to r =0.19±0.26. Croppers of the late sowing grow very slowly and require a small amount of moisture during this period. The strongest relationship is noted for barley crop r =0.56±0.22. In the second half of the growth season, the average relationship is observed in crop of millet and Sudan grass. The growth and vegetation of oats and its mix with pea depends to a large extent on the July rainfall.

Performed calculations show (Table 5) that the lowest relationship between the crops yield and the rainfall during the whole growth season is observed in the sorghum crop r =0.12 ±0.27 that characterizes sorghum as one of the most drought-resistant crops. The correlation coefficient is quite high for conventional barley crops, r =0.80±0.16 that shows the great influence of the rainfall on the amount of crop. Millet and Sudan grass have an average dependence on the rainfall, r =0.39 ± 0.16 and r =0.61 ± 0.21, respectively.

Table 5. The dependence of crop yield on the rainfall during the period from May to July, ZKATU 2008-2012.

Option	Correlation coefficient	Regression equation
Barley (reference)	0.80 ± 0.16	y = 61.8 ± 0.46 * x
Sorghum	0.12 ± 0.27	y = 326.9 ± 0.29 * x
Sudan grass	0.61 ± 0.21	y = 46.3 ± 0.87 * x
Millet	0.39 ± 0.16	y = 121.5 ± 0.13 * x

Final part

1. The soil and climatic conditions in the frontier zone between Russia (the Saratov region) and Kazakhstan (the West Kazakhstan Province) provides high productivity of millet feed crops. Over 5-year study period, the average yield of dry basis for the sorghum crop was 6.0 t/ha and for Sudan grass - 4.0 t/ha which is higher than that at the cultivation of convectional barley crop by 0.8-2.8 t/ha. These croppers utilize solar radiation most efficiently (PAR utilization rate is 1.8 and 1.2, correspondingly).
2. Provision with digestible protein per fodder unit is higher in the vegetation mass of millet (107 g/f.u.) that meets the requirements of livestock. Sorghum ranks first in terms of the metabolic energy output per hectare (49 GJ/ha), while barley holds the last place (24 GJ/ha).
3. The weak dependence of course millet crop on the vegetation argue for the evidence of high stability in crop production in the concerned frontier area.
4. The correlation coefficient between the feed crop productivity and the rainfall during the vegetation season for barley fields is 0.80±0.16. For sorghum crop this figure does not exceed 0.12±0.27, indicating a high adaptability of sorghum to the climate conditions of the frontier zone.

Conclusions. In the frontier zone between Russia and Western Kazakhstan, the croppers such as sorghum, Sudan grass and course millet provide high yields with high fodder qualities. These croppers are more productive than barley crop, more adapted to arid conditions, and should be used more widely in the system of field fodder production.

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References

1. Bogomolov V.A., 2001. The organization of the feeding pipeline for high-protein feed production. Fodder production. 6. pp. 5-18.
2. Adlen S., 2007. From the Land. Natural Farming at Stahrland. New Jersey. Washington, DC. pp: 331-336.
3. Alien, J.R., 2003. Agron. V. 65 (2). pp: 233.
4. Kutuzova A.A., 2004. The increase in the vegetable protein production. M. p. 190.
5. Daynard, T.B., 2002. Agron. V. 64. (6). pp: 716-719.
6. Dutton, J., 2009. Growing interest in peas. What's new in Farming. V.12. (9). pp: 56.
7. Sikorskiy I.A., 2004. The feed deficit: how to eliminate the gap. Ural crop fields. (3). p: 28.
8. Hardin B., 1996. Intercropping for more forage and less erosion. Agricultural research. Vol. 44 (3). pp: 15.
9. Hillson, M.T., L.H., Penny, 1965. Agron. V. 57 (2). pp: 150-153.
10. Tyutyunnikov A.I., 2012. The major issues of annual forage crop agrobiology. Pushkin. p: 52.
11. Nasiev B.N., 2013. Creation of highly productive agrocoenoses in the Cisurals. Science News. 1. pp: 13-15.
12. Bohle, H., 2007. Yield and quality of grass-clover in autumn varierter - and spring sowing ver different mixtures. Wirtschaftseigene Futter. 8. pp: 102-121.
13. Recommended practices for field experiments with feed crops. 1987. M. p: 187.
14. Nichiporovich A.A., 1961. Photosynthetic activity of plants in fields. M. p: 135.
15. Dospekhov B.A., 1985. Field experience methodology. M. Agropromizdat. p: 358.

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