World Applied Sciences Journal 23 (9): 1171-1175, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.23.09.13138

Productivity of Red Clover in the Environmental Conditions of Different Relief Elements

Sergei Leonidovich Eliseev, Elmart Danifovich Akmanaev
and Sergei Vasilyevich Likhachev
FSBEI HPE "Perm state agricultural academy named after academician D.N. Pryanishnikov",
23, Petropavlovskaya st., 614990, Perm, Russia

Submitted: Jun 22, 2013; **Accepted:** Jul 16, 2013; **Published:** Jul 20, 2013

Abstract: Importance of red clover for agriculture has been emphasized in the presented article. Results of the experiment on study of seed and feed productivity of late-maturing clover (*Trufolium pratense*) variety *Permskii mestnyi* (local) and timothy (*Phleum pratense*) in single-crop and mixed sowing have been presented. Investigations have been held in different relief elements: hill point, hill side and foot hill. Soil, agro-climatic conditions and grass agro-technique are shown. Environmental conditions of different hill elements and their effects on grass development and productivity have been studied. Esteem to feeding productivity of perennial grass on gathering of crude protein, feed units output and available energy. The investigations enable recommending to production enterprises sowing red clover and its mixture with timothy for fodder in foot hill. Clover cropping for seed is preferable to be placed in slopes, timothy cropping in foot hill.

Key words: Red clover (*Trufolium pratense*) · Timothy (*Phleum pratense*) · Single-crop sowing · Mixed sowing · Environmental conditions · Relief · Seed · Fodder · Available energy · Raw protein

INTRODUCTION

Agricultural production in conditions of broken relief connects with the question of choosing optimal technology parameters for field crops growing which solution requires development and introduction of adoptive landscape specific agriculture [1-3].

In Preduralie red clover is the main feed crop. Nowadays the interest to this crop is increasing in world's agriculture. In Europe this culture occupies approximately 6 mio. ha. It is a consequence of price rises for synthetic nitrogen fertilizers and development of scientific basis of organic agriculture. [4]. Clover production enables receiving high and sustainable yield of qualitative and cheap fodders, increasing soil fertility due to accumulation of bio nitrogen and organic matter. [5, 6]. Clover is often sown as a mix with other grass such as meadow timothy, cocksfoot (*Dactylus glomerata*), red darnel (*Lolium perenne*). Mixed sowing has a number of advantages over single crop sowing; one of them is balanced feed value [7]. However on farms in Permskii Krai the yield of fodder clover and its mixture with grass remains low and unstable, varying from 2.5 to 12.3 t/ha (about 0.5-2.5 t/ha of dry matter).

Enhancement of clover sowing in the region and in the world is restrained by the lack of seed, since the seed productivity still remains low despite high potential. [8]. In recent years seed productivity in Permskii Krai does not exceeded 80-90 kg/hà. One of the solutions for this problem can be differentiate crop placing with taking into account conditions in various relief elements.

MATERIALS AND METHODS

In 2008-2010 in the experimental field of the Perm State Agricultural Academy investigations were held on the east-facing slope. The slope length constituted 500 m, maximal altitude difference-5 m.

Following attendance and investigations were carried out: agro-chemical soil analysis: humus level by Turin

Corresponding Author: Likhachev, FSBEI HPE "Perm state agricultural academy named after academician D.N. Pryanishnikov", 23, Petropavlovskaya st., 614990, Perm, Russia

method (GOST 26213-84), hydrolytic acidity by Kappen method modified by CINAO (GOST 26212-91), pH_{kcl} (GOST 26483-85), labile phosphorus and exchange potassium by Kirsanov method modified by CINAO (GOST 26207-91), the sum of exchangeable bases by Kappen and Gilkovits method (GOST 27821-88); determination of seed quality: purity (GOST 12037-81), Methods for determination of germination (GOST 12038-84), thousand seed weight (GOST 22617-91); zoo-technical fodder analysis: raw protein content (GOST 13496-93), raw fat (GOST 13496.15-97), raw fiber (GOST 13496.2-91), raw ash and substance nitrogen-free extractive substance (GOST 26226-95); economic assessment by technological map with due regard to norms of expenditures and cost of production and output funds formed in 2011.

Objects of research were allowed to cultivating in Permskii Krai single-cut clover Permskii local, meadow timothy Utro and spring wheat Irgina.

Experiment scheme: single-crop sowing of clover and timothy as well as mixed sowing of clover and timothy. Feed and seed productivities were determined separately. The experiment was laid in three hill elements: top, slope (gradient 3-4°) and foot.

Variants allocation was systematic. The experiment was carried out in accordance to methodological instructions on execution of field experiment with fodder cultures. [9].

Agrotechnics in the experiment was following. Soil tillage consisted of under-winter plowing at a depth of 20-22 cm (PLN-4-35), early spring harrowing at a depth of 3-4 cm (BZTS-1) and pre-sow cultivation at a depth of 4-5 cm (KPS-4), with harrowing (BZTS-1). Mineral fertilizers were applied under pre-sowing tillage as a ground $N_{30}P_{60}K_{60}$. Clover seeds were treated with bacterial preparation (Rizotrofin) and ammonium heptamolybdate. The grass was sown in rows with the sower SSNP-16 with mixed crops allocation in double-crop sowing. Seeding rate: red clover in single-crop sowing and mixed sowing-5 mio.; meadow timothy in single-crop sowing-20 mio., in mixed sowing-10 mio.; spring wheat Irgina (nurse crop)-5.5 mio. of viable seeds per hectare. The grasses were sown across nurse crop. Postseeding treatment included seed rolling with 3 KKS-6. In the year when experiments were undertaken the nurse crop in tillering stage was treated with the water-soluble concentrate herbicide Agritox (1.5 l/ha). Harvesting the nurse crop was carried out by single-phase method in dead-ripe stage. Grass productivity was counted manually, productivity of herbage-in bud-formation period of red clover, of seeds at browning of 70% clover glomes. Trashing was conducted at a station with the laboratory trashing machine MPSU-500 reaching 100% purity and 13 % humidity.

RESULTS AND DISCUSSION

Educed that soils in different agro micro-landscapes are not similar. On the top and side of a hill soil is sod fine-podsolic heavy clay loam on old alluvial deposits *, in addition-slightly awash **on the slope. At the hill bottom there is a type of sod fine podsolic with glee elements heavy clay loam soil on neoteric diluvium*** (Table 1).

The soil on the hill top was characterized by low humus content, close to neutral medium reaction, mid-level provision with labile forms of phosphorus and exchange potassium. The slope soil differs by very low humus content, week acid medium reaction, mid-level provision with labile forms of phosphorus and low content of exchange potassium. The soil at the hill bottom was marked as the most fertile with neutral medium reaction, mid-level provision with labile forms of phosphorus and exchange potassium.

During all vegetation period at a depth of 10 cm differences in soil humidity on relief elements were observed. The soil at the hill bottom was more humid, the soil at the slope was drier. Educed that soil temperature at a depth of 1 cm on the slope in sunny days was 0.1 and 0.3 °C higher respectively than on the hill top and its foot. In humid and thick weather differences disappeared.

Table 1: Characteristic of tilth-top soil

				Labile eleme nts, mg/kg of a soil	
Relief element	Soil	Humus, %	pH_{kcl}	P_2O_5	k_2O
Hill point	*	1.80	5.8	93	98
Hill side	**	1.55	5.4	87	79
Foot hill	***	2.53	6.0	98	108

Table 2: Quality and quantity of red clover nodule bacteria in single-crop sowing in the stage of three real leaves

	Relief elements					
	hill point		hill side		foot hill	
Year	total	active,%	total	active,%	total	active,%
2008	9.2±0.3	19.5±1.3	9.1±0.4	17.0±1.7	8.4±0.6	19.2±1.8
2009	9.0±0.6	17.9±1.7	7.9±0.4	16.6±1.6	9.7±0.3	18.7±1.8

Meteorological conditions in the years of the investigation were different. The year 2008 was the most favorable in humifying and temperature conditions for perennials and nurse crop planting development, 2009 was droughty. Vegetation period in 2010 was anomalously droughty, in July-August rainfall constituted no more than 17% of average long-term norm, 2011 was temperate warm with uneven rainfall in vegetation period.

Nowadays clover is most of all grown under cover of grain crops. [10]. In our experiment the nurse crop was spring wheat of the Irgina cultivar. Nurse crop seed productivity (spring wheat) depended on a relief element. In average in two years of research (2008-2009) the highest yield of spring wheat was gained at the foot hill (1.98 ± 0.36 t/ha) what is by 0.64 t/ha veridical higher than on the slope. The higher yield at the foot hill is determined by grain size enlargement. This fact in its turn can be explained by higher soil fertility and humidity of the given relief element. Established that spring wheat sprouts at the slope bottom appeared one or two days earlier than at the slope and field germination rate was maximum (71%).

Differences in hydrothermal mode in relief elements influenced on growth and development of perennial grass in the first year of life. Field germination rate of perennial grass in the years of the investigation was high enough and constituted 47-58% at clover, at timothy-29-36%. In all the years of the investigation earlier sprouting was marked at the foot, then on the top and only then at the slope, what can be explained by that fact that seeds at the foot had more humidity available.

Intensity of clover development in the first year of life depends on the activity of its symbiosis with legume bacteria [11]. Stable tendency to increase number of root nodules (including stained nodules containing leghemoglobin) on the clover roots at the foot hill and to decrease-at the slope was marked (Table 2).

Weed affects grass development in the first year of life. For two years of the investigation the maximum weediness was marked on the slope. Weed biomass at the foot hill was less, what is explained by better development of nurse crop which oppressed weed growth.

Productivity of Clover and Timothy Seeds: Productivity of red clover seeds varied depending on agrophytocenosis, relief element and year of use (Table 3). In average for the two years on the hill top clover seed productivity of the first year of use in single-crop sowing constituted 145 kg/ha, what is by 30 kg/ha more than in mixed sowing. Analogue regularity is tracked in all relief elements. On the slope the maximum clover seed productivity was marked (163 kg/ha in single-crop sowing). The highest yield was marked in the droughty 2010. The highest seed productivity in single-crop clover sowing on the slope is explained by formation of biggest quantity of inflorescence number per area unit.

Decrease of plant height before harvesting (69-70 cm) contributed to clover seed productivity increase on the slope in comparison to its level on the top and bottom, that is respectively by 8-15 cm less.

It contributes better pollinating, decreases degree of lodging and facilitates harvesting seminal crops. Plant formation lodging resistance in single-crop sowing on the hill top and at the foot was minimal.

Seed yield from the sowing of the second year of use tripled decreased in comparison with clover yield of the first year of use. It is explained by plant formation thinning in the previous year and also by death of the most part of plants at wintering.

Viability, germination readiness and laboratory germination of clover seeds gained in single-crop and mixed sowings in all agromicrolandscapes were equitable.

The results of economic assessment show that maximal profitability of red clover growing in the first year of use for seeds was marked in single-crop sowings on the slope (259 %).

Thus, red clover for seeds is recommended to grow in single-crop sowing on the slope. Meadow timothy for seeds should be cultivated in single-crop sowing at the foot hill. Where its productivity in the first year of use constituted 94 kg/ha, what is by 23 kg/ha higher than on the hill top and 45 kg/ha higher than on the slope.

Table 3: Productivity of red clover and meadow timothy if the first and the second year of use in different relief elements, kg/ha

	Grass, 1st year of use		Grass, 2nd year of use	
Plant formation	2009	2010	average	2010
Hill point				
Clover	135±17	155±20	145±12	45±8
Clover + timothy	123±11 / 96±20	171 ± 21 /133±16	148±10 /115 ±13	60±8 / 36 ± 8
Timothy	49±5	93±12	71±10	51±8
Least significant difference LSD_{05} (clover)	39	$F_\delta < F_{05}$	26	3
LSD_{05} (timothy)	15	20	11	9
Hill side				
Clover	139 ± 16	187 ± 16	163 ± 12	63 ± 8
Clover + timothy	122±16 / 98±14	200±26 /173±12	162±16 / 136±7	68±12 /48±12
Timothy	48±5	50±12	49±7	35±12
LSD_{05} (clover)	$F_\delta < F_{05}$	$F_\delta < F_{05}$	29	$F_\delta < F_{05}$
LSD_{05} (timothy)	11	15	8	$F_\delta < F_{05}$
Foot hill				
Clover	138 ± 13	149 ± 20	144 ± 13	57 ± 14
Clover + timothy	122±15 / 91±10	177±26 /132±13	150±16 /112 ±15	66±12 / 40±3
Timothy	80±18	107±19	94±14	60±11
LSD_{05} (clover)	30	$F_\delta < F_{05}$	21	13
LSD_{05} (timothy)	16	39	18	16

Note: in the denominator clover seed productivity is given, %; Least significant difference$_{05}$ was calculated for comparison of crop productivity in single-crop and mixed sowing; veridical interval was calculated for possibility to compare productivity in different agro micro-landscape.

Table 4: Feed mass productivity of single-crop and mixed sowing of perennials in the first year of use, in total for two cuts (t/ha of dry matter), 2009-2010

	Yield, t/ha of dry matter		
Plant formation	2009	2010	Average
Hill point			
Clover	4.67	4.39	4.53
Clover + timothy	5.68 / 16.0	4.87 / 26.0	5.27 / 21.0
Timothy	2.28	1.84	2.06
LSD_{05}	1.55	0.85	0.79
Hill side			
Clover	4.67	4.04	4.35
Clover + timothy	5.61 / 12.8	4.59 / 23.0	5.10 / 17.9
Timothy	2.07	1.72	1.89
LSD_{05}	1.47	0.88	0.78
Foot hill			
Clover	4.97	4.65	4.81
Clover + timothy	5.59 / 17.0	5.23 / 29.0	5.41 / 23.0
Timothy	2.34	1.85	2.14
LSD_{05}	1.29	0.74	0.66

Note: in the denominator associated grass share is given, %.

Table 5: Fodder assessment of grass yield of the first year of use, in total for two cuts (average for 2009-2010)

		Output from 1 ha	
Plant formation	Harvest of raw protein, kg/ha	feeding unit	exchange energy, GJ/ha
Hill point			
Clover	770	3212	45.0
Clover + timothy	806	3562	50.8
Timothy	117	1122	16.9
Hill side			
Clover	700	2895	41.8
Clover + timothy	732	3135	46.5
Timothy	97	961	15.1
Foot hill			
Clover	890	3465	48.8
Clover + timothy	844	3452	47.4
Timothy	140	1194	17.8

Grass Feeding Productivity: Feed mass productivity of clover in the first year of use in single-crop and mixed sowing with meadow timothy in all relief elements was equal. The tendency to dry matter productivity growth of all agrophytocenoses at their allocation at the foot hill by 0.08-0.28 t/ha in comparison to its level at the hill top and by 0.25-0.46 t/ha on the hill slope. Timothy share in the yield varies from 2 till 5 % (Table 4). Meadow timothy yield in the first year of use in single-crop sowing was very low (from 1.89 to 2.06 t/ha in average per two years).

The yield of red clover in the second year of use at the foot hill constituted 4.15 t/ha what is by 13 % and 20 % higher than on the hill point and its slope respectively.

We calculated protein collection with the yield in variants as well as energetic fodder nutrient ability in fodder units and exchange energy.

Analysis of feed productivity in grass agrophytocenoses of the first year of use in average in 2009-2010 showed that on the hill top raw protein collection in mixed sowing was by 37 kg higher than in single-crop sowing and constituted 806 kg/ha and by 689 kg higher than in single-crop sowing of timothy (Table 5). Fodder units output in mixed sowing constituted 3562 from 1 ha what is by 350 higher than in single-crop clover sowing and by 2440 than in single-crop timothy sowing. Exchange energy output was higher in mixed sowing (50.8 GJ/ha) in comparison to single-crop clover sowing (45.0 GJ/ha) and timothy sowing (16.9 GJ/ha). On the slope analogue tendency was noticed.

In mixed sowing at the foot hill the share of timothy in the yield was substantially higher than on the hill top and side. Because of this fact harvest of raw protein was higher at the foot hill in single-crop sowing (890 kg/ha) in comparison to mixed sowing (844 kg/ha) and single-crop timothy sowing (140 kg/ha). Fodder units output was insignificantly (by 13 fodder units) higher in single-crop sowing. Gross exchange energy harvest in mixed sowing was by 2.1 GJ/ha higher in comparison to single-crop clover sowing (48.8 GJ/ha) and single-crop timothy sowing (17.8 GJ/ha). In general maximal figures of raw protein and exchange energy harvest and fodder units output were noticed at the foot hill.

CONCLUSIONS

In Preduralie at growing perennials for fodder and seeds conditions of relief must be taken into account. To reach maximum feeding productivity red clover and its mixture with timothy are preferable to be placed in hill foot. At growing clover for seeds it is reasonable to allocate clover in the slope and timothy in the foot hill.

REFERENCES

1. Ivanov, D.A., O.V. Karaseva and S.I. Ageeva, 2006. Effect of agrolandscape on fodder crops productivity. Fodder production, 10: 15-18.
2. Iulushev, I.G., 2005. Soil-agrochemical bases of adaptive landscaping agricultural systems organization VKZP. Moscow: Academic project, pp: 368.
3. Darnhofera, I., S. Bellonb, B. Dedieuc and R. Milestadd, 2008. Adaptive farming systems. A position paper 8th European IFSA Symposium, 6-10 July 2008, Clermont-Ferrand (France), pp: 339-351.
4. Hejduk, S., 2011. Differences in persistence in red clover cultivars as an important trait. For their use in permanent grasslands. Grassland Science in Europe, 16: 76-78.
5. Kadziuliene, Z., 2004. Lucerne, white clover and red clover in leys for efficient n USE. Grassland Sience in Europe, 9: 492-494.
6. Svirskis, A. and S. Juknevicius, 2006. Breeding of red clover varieties for conventional and organic agriculture. Agriculture, 93(4): 314-321.
7. Nesheim, L. and J. Øyen, 1994. Nitrogen fixation by red clover (Trifolium pratensel) grown in mixtures with timothy (Phleum pratensel.) At different levels of nitrogen fertilization. Acta agriculturae Scandinavica, section b-Soil and Plant science, 44(1): 28-34.
8. Geras'kin, M.M. and M.I. Kudashkin, 2006. Technique of area micro-zoning at agro-landscaping land management. Zemledelie, 4: 4-6.
9. Instruction guide on experiment conducting with fodder crops, 1997. All-union SII of fodder n.a. V.R. Willams. Moscow, Publishers VNIIK, pp: 197.
10. Blaser B.C., L.R.Gibson, J.W. Singer and J. Jannink, 2006. Optimizing seeding rates for winter cereal grains and frost-seeded red clover intercrops. Agronomy journal-abstract, 100(5): 1436-1442.
11. Ronson, C.W. and W.L. Lowther, 1996. Issues affecting the competitiveness of white clover rhizobia in new zealand pastures. Agronomy society of new zealand special publication, no. 11 / grassland research and practice series, 6: 87-90.