Journal of Crop and Weed, ***9****(1):151-155(2013)*

Formation of dry matter yield in alfalfa, depending on the meteorological conditions

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Received: 30-01-2013, Revised: 25-3-2013, Accepted:03-4-2013

ABSTRACT

Field trials with alfalfa were conducted during the period 1996 – 2012 under the meteorological conditions of Obraztsov chiflik, Rousse – Bulgaria. The objective of the study was dry matter yield to be estimated in alfalfa depending on the age of the stand under the meteorological conditions of Northeastern Bulgaria. Dry matter yield of alfalfa, precipitation and temperature sums were determined during the period of vegetation of crop. Annual hydrothermal coefficients (HTC_Y) were calculated for estimation of moisture - providing also and HTC for vegetation (HTC_V) and autumn-winter periods (HTC_{AW}). Dry matter yield in alfalfa without irrigation under conditions of North-East Bulgaria for four years was 499.28 kg ha $^{-1}$. It varied most strongly during the first and the fourth year of cultivation. The Hydro-Thermal Coefficient from January to December effects positively on yield, comparing with the precipitation and temperature sums.

Keywords: Alfalfa, dry matter yield, hydrothermal coefficient, precipitation, temperature

Alfalfa is the most important forage crop in Bulgaria because of its high productivity and superb quality. Under environmental and climatic conditions of Bulgaria, it provides the most protein per unit area (Michev, 1989). The yield of forage mass per hectare since the last two decades has decreased greatly due to many reasons, one of which is the lack of irrigation and increase of temperature sums, while quantity of precipitation has remained constant. Number of cuts depends on precipitation not only during vegetation of alfalfa, but throughout the year. This crop has a longer duration of active vegetative growth and needs frequent irrigation than other forage crops (Solanki and Patel, 2000). In different regions of the country during the first year of the development of alfalfa 2 to 4 cuts may occur and over the next 2-3 years - 4 to 7 cuts resulting in 60 - 100 kg ha^{-1}hay in the first year and 120 – 220 kg ha^{-1} during the following years (Marinova and Ivanova, 2005; Vasileva, 2004). According to Putnam (2005) the highest quality hay is produced in late autumn and early spring. Alfalfa is tolerant to drought and can survive in 65 to 75% of the available sum of precipitation during the period of intense transpiration (Malinowski *et al*., 2007; Vasileva *et al*., 2011]. The average annual sum of precipitation during the period 1960-2009 in the area of Obraztsov Chiflik – Rousse varied from 558.5 mm in 1980 - 1989 to 637.7 mm, in 1970-1979, the norm being 605.9 mm (average for 117 years). During the same period (1960 - 2009) the average daily values of air temperature were from 10.9°C to 11.9°C, respectively with a norm of 11.3°C. The objective of the study was dry matter yield to be estimated in alfalfa depending on the age of the stand under the meteorological conditions of Northeastern Bulgaria.

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MATERIALS AND METHODS

The study took place at the Institute of Agriculture and Seed Science, "Obraztsov chiflik" – Rousse. Obraztsov chiflik is situated in Northern climatic region of the Danubian hilly plain (152m altitude, 43°48' N latitude and 26°02' E longitude). During the period 1996 – 2012, 15 field trials were conducted at the Experimental field of the Institute and in each trial, one of the variants was Prista 2 variety, standard in the State Variety Testing. The competitive varietal trials were started using block method in four replications, net plot size being 10 m^2. The trials were sown in spring. The adopted technology for growing of alfalfa for forage was applied. The soil type was strongly leached chernozem. Groundwater level was more than 15m from the soil surface. Humus content was low in the plowing layer and varied from 1.78 to 2.27% (Lingova, 1965). Dry matter yield of alfalfa first, second, third and fourth year was determined. During the 15-year period of study 15 first and second cuts were harvested of each alfalfa ages, 15 third cuts of second and third year (the fourth is with 14-year results), 13 fourth cuts of second and third year, 9 – of fourth year and 3 fifth and 2 sixth cuts of the old alfalfa. Precipitation and temperature sums were registered during the period of vegetation of alfalfa (March-October) and autumn-winter period (October-March) for the period 1996-2012. Annual hydrothermal coefficients (HTC_Y) were calculated for estimation of moisture - providing also and HTC for vegetation (HTC_V) and autumn-winter periods (HTC_{AW}). According to Selyaninov (1958), HTC was calculated from the formula: HTC= [Σ P/ Σ t^{o}C]. 10; where: Σ P is the precipitation sum for a period in mm; Σ t is the sum of average daily temperatures for the same period

Data about dry matter yield were processed after the method of the dispersion analysis ANOVA (R Core Team, 2012). An analysis of correlation (Lidanski, 1988) and Coefficient of Variation (CV%) (Kathleen and Acuna 2002), were determined. The results were processed with a set of statistical tools of the program Windows (Microsoft Excel 2003)

RESULTS AND DISCUSSION

Years of study were different both in amount and distribution of precipitation and in temperature sums. 2000 was characterized with the lowest precipitation 339.5 mm, and the highest 1 021.5 mm was in 2005 (Table 1). During the same period, the lowest temperature sum (3877.7 C°) was registered in 1997 and the highest (4687.7 C°) in 2007.

Table 1 : Meteorological parameters during the period of study (1996-2012)

Year	Precipitation (mm)	Temperature (^{0} C)	HTC_Y	HTC_{AW}	HTC_V
1996	460.8	3877.0	1.19	5.10	0.56
1997	918.8	3844.7	2.39	3.83	1.83
1998	745.7	4062.0	1.84	3.96	1.27
1999	646.0	4514.1	1.43	3.17	1.2
2000	339.5	4508.2	0.75	1.61	0.58
2001	581.8	4333.5	1.34	2.05	1.01
2002	824.4	4299.9	1.92	4.18	1.31
2003	500.0	4013.9	1.25	6.57	0.58
2004	539.3	4264.0	1.26	3.64	0.91
2005	1021.5	4066.9	2.51	2.87	2.31
2006	509.1	4365.3	1.17	3.99	0.71
2007	695.2	4687.7	1.48	3.2	0.79
2008	408.1	4487.4	0.91	5.2	0.7
2009	602.1	4499.4	1.34	2.4	0.8
2010	698.2	4270.0	1.64	5.1	2.4
2011	477.5	4061.7	1.18	3.5	0.9
2012	575.0	4428.3	1.30	4.7	0.7

The values of hydrothermal coefficients characterizing moisture providing of alfalfa during the period of study determined 2005 and 1997 with risk of water logging (HTC_Y > 2), 2.51 and 2.39, respectively (Draganov and Gyurova, 1989). In both years, dry matter yield was very good, as in young alfalfa 124.3 kg ha^{-1} (2005), so in the second year alfalfa 264.1 kg ha^{-1}in 1997 (Table 2). The lowest HTC_Y = 0.75 was calculated for 2000. Comparing HTC_V and HTC_{FW}, HTC_V effects stronger on forage productivity of alfalfa. Despite of the low HTC_V = 0.58 in 2003 the comparatively good yield of 67.7 kg ha^{-1} dry matter in young alfalfa was due to the optimal temperature and the insignificant precipitation of 19.91mm m^{-2}in March that allowed early sowing and near-normal 45.41mm $m^{-2}$and 51.61mm m^{-2}in the next two months.

Table 2: Dry matter yield (kg ha^{-1}) of alfalfa first, second, third and fourth year in the period 1996-2012

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average	CV%
I	28.9	49.0	42.0	118.9	44.4	19.0	35.0	67.7	86.9	124.3	32.0	63.5	19.7	39.5	65.9	**55.7**	**54.1**
II	264.1	156.0	189.5	168.8	154.9	169.1	96.7	215.7	165.1	87.3	97.9	206.5	116.1	169.0	207.6	**164.3**	**37.0**
III	176.5	193.5	129.0	156.0	203.3	155.3	192.1	185.2	66.6	67.6	125.1	124.4	159.2	197.6	142.5	**151.6**	**44,.6**
IV	172.6	109.0	93.5	204.9	130.4	194.0	135.1	66.8	76.1	64.8	98.2	162.7	152.4	125.8		**127.6**	**55.1**

The high temperatures coupled with insignificant precipitation were depressing factors especially in intensively growing alfalfa (the growth of young stands was slower). Extremely low were the values of HTC_Y: 0.27, 0.38, 0.11 and 0.01, respectively for May, June, July and August of 2000, which resulted in low dry matter yield in young alfalfa. A similar relation was also observed in 2006 when HTC_Y from May to October was less than 1. That explained the low dry matter yield 32.0 kg ha^{-1}, 87.3 kg ha^{-1}, 66.6 kg ha^{-1} and 66.8 kg ha^{-1}, respectively in alfalfa first, second, third and fourth year (Table 2).

The average dry matter yield during the period 1996 - 2012, in alfalfa first, second, third and fourth years was 55.7 kg ha^{-1}, 164.3 kg ha^{-1}, 151.6 kg ha^{-1}and 127.6 kg ha^{-1}, respectively. The experiment began in 1996 that is why during that year dry matter yield of 28.9 kg ha^{-1} only of first year alfalfa was reported. In the second, third and fourth year yield of the same experiment were respectively: 264.1, 176.5 and 172.6 kg ha^{-1} (Fig. 1). The dry matter yield provided for different years are the respective totals for all the cuts. Yield varied from 19.0 kg ha^{-1} in the first year to 264.1 kg ha^{-1} in the second year. The ontogenesis of alfalfa plants determined difference in yield variability of different ages, as the coefficients of variation from first to fourth year were 52.87%, 36.97%, 44.61%, and 55.09%, respectively. Less stable was the yield in the youngest and the oldest stands that were strongly influenced by the meteorological factors. Variation in yield, depending on the age of alfalfa was expressed by the CV% which is the highest in 4th year alfalfa being, 55.09% and for the 1st year alfalfa it was 54.10%. That was easy to explain, considering that in both ages alfalfa plants were most dependent on the meteorological factor.

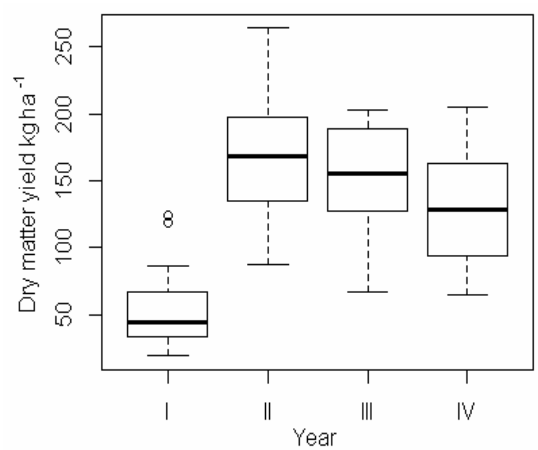

Fig.1. Boxplot diagram for the trait dry matter yield in alfalfa, first, second, third and fourth year

The diagram shows that the dispersion (the size of the rectangles and scope above and below) remains almost constant, but the medians (bold lines) differ significantly in years (R Core Team, 2012). Symmetrical disposal of medians means that averages have similar behavior.

Dispersion analysis of the trait

In order to say that trait averages differ by year ANOVA dispersion analysis was conducted. The analysis required a verification of homogeneity of dispersion by year, and we used the Criterion of Fligner-Killeen (William *et al*, 1981). The result of applying the function to verify the homogeneity of the dispersion was Fligner-Killeen test of homogeneity of variances.Fligner-Killeen:med χ^2= 2.13, df = 3, p-value = 0.55.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Year	3	105722	3524	18.89	1.52e-08*
Residuals	55	102634	1866		

*Note: * significant at 1% level of probability*

It must therefore be assumed that the averages by year were different. The presentation of average values together with the standard error is given in fig.- 2. The function that builds this bar graphics CI of R-library is according to Manuel Morales, with code developed by the R Development Core Team, with general advice from the R-help listserv community and especially Duncan Murdoch. (2012).

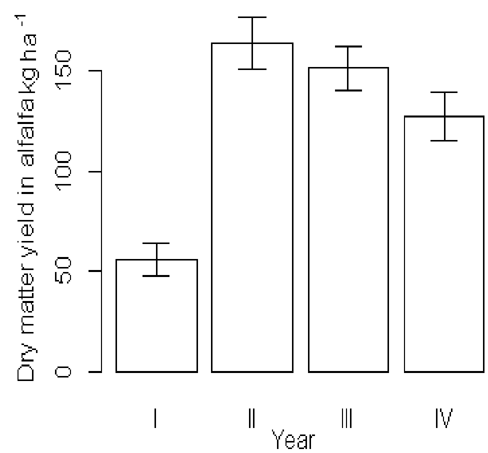

Fig. 2: Average values and standard error for dry matter yield for the four alfalfa ages

Since the standard error intervals overlap, we apply the method of multiple comparison LSD, which should answer the question of how many are the groups by averages, that actually differ (Felipe de Mendiburu, 2012; http://CRAN.R-project.org/package=agricolae). The result of LSD Test is mentioned below:

P value adjustment method: bonferroni

Mean square error: 1866.08

Year, means and individual (95 %) CI

	Yield	SE	Rep	LCL	UCL	Min	Max.
1	55.7800	8.439263	15	38.86734	72.69266	19.0	124.3
2	164.2867	12.788946	15	138.65705	189.91629	87.3	264.1
3	151.5933	11.199743	15	129.14855	174.03812	66.6	203.3
4	127.5929	12.177598	14	103.18841	151.99731	64.8	204.9

Level of significance = 0.05, error df = 55, critical value of t= 2.737, least significant difference= 43.56, harmonic mean of cell sizes 14.737

Groups	Treatments and means
a	2 164.3
a	3 151.6
a	4 127.6
b	1 55.8

Note: Means with the same letter are not significantly different

The record of LSD criterion shows that the 4 averages actually formed two groups - Group "a" - 3 high averages of 2, 3 and 4-th year, group "b" - a low average for the first year. Forage yield of alfalfa is formed mainly by dry matter yield over the years that define it as a persistent (perennial) crop. In this case, if the first year is not taken into account, do the other three years vary statistically significantly between themselves? In elimination of the yield for the first year and conduction the ANOVA we get:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Year	2	999928	499964	2.338	0.109
Residuals	41	8767768	213848		

Here, F-ratio is on the border of the statistical significance i.e. average values of yield from the second to the forth year were not significantly different. This is because the average error intervals were overlapping. Therefore, differences by year tend to reduce yield from the second to the forth year and the trend to establish differences is on the border of statistical significance.

Observing the effects of precipitation, temperature sums and measured in term of correlation coefficient, it was determined that yield variations were stronger expressed under the influence of HTC_Y (Table 3). When considering the effects of precipitation, temperature and HTC_Y it was found that variation of yield was the most strongly expressed under the influence of HTC_Y (Table 3). The coefficients of correlation from first to fourth year were: r = 0.41; r = 0.25; r = 0.40; and r = 0.39 respectively or the relation was moderate with the exception of the second year. There was no a correlation between yield and temperature in young alfalfa. In alfalfa second, third and fourth year there was a moderate negative correlation r = - 0.39. r = - 0.59 (significant) and r = - 0.42, respectively. Though the objective of the study is to estimate dry matter yield, but the dry matter yield depends on different factor like plant height, stem number of leaves etc.

Table 3: Values of correlation coefficients between dry matter yield and some meteorological parameters

First year	**Precipitation**	**Temperature**	**HTC_Y**	**Dry matter yield**
Precipitation	1			
Temperature	-0.34	1		
HTC_Y	0.98	-0.49*	1	
Dry matter yield	0.45*	-0.03	0.41*	1
Second year				
Precipitation	1			
Temperature	-0.42*	1		
HTC_Y	0.99	-0.56*	1	
Dry matter yield	0.18	-0.39	0.25	1
Third year				
Precipitation	1			
Temperature	-0.27	1		
HTC_Y	0.99	-0.41*	1	
Dry matter yield	0.33	-0.59*	0.40	1
Fourth year	Precipitation	Temperature	HTC_Y	Dry matter yield
Precipitation	1			
Temperature	-0.27	1		
HTC_Y	0.99	-0.41*	1	
Dry matter yield	0.36	-0.42*	0.39	1

*Note: * Significant at 5% level*

Average total dry matter yield in alfalfa without irrigation conditions of North-East Bulgaria for four years was 498.6 kg ha $^{-1}$. It varied most strongly during the first and the fourth year. The Hydro-Thermal Coefficient from January to December effects positively on yield, comparing with the precipitation and temperature sums.

REFERENCES

Draganov, D. and Gyurova, M. 1982. *Agricultural Meteorology*. Plovdiv, pp. 326-30.

Kathleen, D.P.E. and Carmen, A .2002. *SPSS for Institutional Researchers*. Bucknell University.

Lidanski, P. 1988. *Statistical Methods in Biology and Agriculture.* Zemizdat, Sofia, pp. 106-95.

Lingova, S. 1965. The climate of Obraztsov chiflik. *Proc. 60 years Agril. Res. Inst. "Obraztsov Chiflik" – Rousse* 1905-1965, pp. 39-48.

Malinowski, D.P., Pinchak, W.E., B.A., Kramp, H. Z. and Butler, T.J. 2007. Supplemental irrigation and fall dormancy effects on alfalfa productivity in a semiarid subtropical climate with a bimodal precipitation pattern. *Agron. J.*, **99**:621-29.

Marinova, D. and Ivanova, I. 2009. Competitive testing of alfalfa varieties. *J. Mountain Agriculture on the Balcans*, **12**: 1379-87.

Mehandzhieva, A. 1989. How many waterings and when to give them. *Agriculture,* **4**:12-14.

Michev, G. 1989. The alfalfa protein is the cheapest one. *Agriculture,* **4**:25-26.

Putnam, D. 2005. Genetic and agronomic effects on the quality of alfalfa for dairies**.** *Proc. South West Nutr*. Conf., pp.139-55.

R Core Team. 2012. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Selyaninov, G. 1958. About the agricultural assessment of climate. *Papers on Agricultural Meteorology,* Publ. 20.

Solanki, R.M. and Patel. R.G. 2000. Response of lucerne to different moisture regimes. Phosphate levels and sowing methods. *Indian J. Agric. Res.*, **34**: 160-63.

Vasileva V. 2004. Effect of nitrogen fertilization on growth. nodulation and productivity of lucerne (*Medicago sativa* L.) at optimal and water deficit conditions. *Ph. D. Thesis*. National Centre for Agrarian Sciences. S. Bg.

Vasileva V., Kostov, O., Vasilev, E. and Athar, M. 2011. Effect of mineral nitrogen fertilization on growth characteristics of lucerne under induced water deficiency stress. *Pakistan J. Bot.*, **43**: 2925-28.

http://CRAN.R-project.org/package=agricolae

http://CRAN.R-project.org/package=sciplot

http://www.mzh.government.bg/

http://www.R-project.org/.