Possibility to grow early maturity corn hybrids for energetically dense silage in Latvian conditions

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Abstract

Demonstration of growing possibilities of corn for energy dense silage in Latvian conditions, marginal for corn growing, as well as timing of planting and harvesting as important management considerations, - have been a matter of great concern for qualitative dairy and livestock forage making. The aim of this study was to show the possibility to obtain high and good quality forage from corn in Latvian conditions, growing early maturity hybrids in meteorologically diverse growing seasons, and to point out importance of planting and harvesting time as determinant factors for high good quality yield. During 2000 to 2003 a total of 18 hybrids were evaluated in RSF “Vecauce” (latitude: N 56? 28′, longitude: E 22? 53′). Two planting times for one standard hybrid and three harvesting times (by sampling) for 3 hybrids were evaluated in addition. Quite good average dry matter (DM) yield was obtained every year (11.54 – 15.85 t ha^{-1}), but average DM content at harvest varied from 23.63 to 35.87 %. Substantial influence of meteorological conditions, mainly air temperature and in connection with this – corn heat units, on DM yield and quality were found. Year as a factor has the main effect on DM yield and DM content of whole corn plant at harvest ($p<0.01$). Planting time influences DM yield, but even more so, quality indices such as content of DM and corn-cob density in the whole plant DM yield. Mainly delay of harvesting time within September improves such important silage characteristics as DM content (increases), NDF and ADF content of whole plant DM (decreases), and energy density measured as net energy for lactation (NEL, increases).

Media summary

It is recommended to grow early maturity corn hybrids for silage in Latvia (latitude 55? - 58?), but hybrid selection, planting and harvesting times should also be carefully considered.

Key words

Corn, hybrid, agro-climatic conditions, yield, quality

Introduction

Corn or maize (*Zea mays* L.) is one of the most important and versatile forage crops in the world today. Corn silage is popular fodder not only for its high energy density, but also because it requires less intensive harvest management, if compared with legumes and grasses: corn for silage is ideally suited for mechanisation from planting to harvest. It maintains more consistent quality over a wider harvest period. Corn silage containing digestible fibre provides excellent forage for all kinds of ruminants. (Perry, 1988, Coors, 1994)

The bulk of the corn is produced between latitudes 30? and 55?, with relatively little grown at latitudes higher than 47? latitude anywhere in the world (Shaw, 1988). Latvia is located between the North latitudes 55? and 58?. Breeding has produced new hybrids exhibiting much improved yields, cold tolerance, lodging and pest resistance, early maturing, so that it is now possible to grow corn in areas previously classed as unsuitable.

During the last decade early maturity corn hybrids from Western Europe and USA became available for researchers, and many of them already for farmers use, too, in Latvia. Since Latvia geographically could not be included in traditional corn growing areas, a suitable corn hybrid has to be high in early vigour, cold tolerant in spring, and early enough to reach at least dough stage of maturity (dry matter [DM] content 25

%) (Gaile, 2000), but better still, early dent (DM at least – 28 %) (Perry, 1988), even if growing conditions are not good during all the vegetative season. Corn-cob content in the whole plant dry matter should be 40 – 60 %. These are not easily achievable aims every year in Latvia. Proper hybrids, sowing and harvesting time should to be specified. There are only little published information on performance of modern early maturity corn hybrids in Latvia, and very few publications on corn quality taking into account individuality of season and harvesting time.

Methods

Field trials were conducted in Research and Studies farm "Vecauce" of Latvia University of Agriculture (latitude: N 56? 28′, longitude: E 22? 53′) in 2000– 2003, testing all together 18 early maturity hybrids. Following hybrids selected as suitable or possibly suitable for growing in Latvia were used: 'Loft ' (standard in 2000 – 2002), Speedy', 'Husar', 'Diamant', 'Impact', 'Helix', 'Target', 'Anna' (standard in 2003) from Germany, 'Brown – 1680' from USA, 'Luch', 'Kolektivna', 'ZPTK-196' from Ukraine, 'RM-996', 'RM-997', 'RM – 20', 'RM-011' from France, 'Crescendo', 'Hudson' from the Netherlands. Original seed was used.

Trials were arranged in four replication randomised blocks with plot size 16.8 m^2, yield was accounted from 8.4 m^2. Row width was 0.7 m. Planted population density was 71000 plants per ha in years 2000 to 2002 and 81000 plants per ha in 2003, that follows from desiderata plant density at harvest – 60000 up to 80000 plants per ha. Soil conditions: sod podzolic loam with plant available P 198 - 253 mg kg^{-1} of soil; plant available K 198 - 224 mg kg^{-1} of soil; pH_{KCl} = 6.3 – 7.1, humus content 1.5 – 3.1 %. Previous crops – potatoes for 2000, and spring barley for 2001 – 2003.

Traditional soil tillage was used: mould-board ploughing in previous fall, cultivation and rototilling before sowing in spring. Given fertilisers: 34 kg ha^{-1} P, 75 kg ha^{-1} K and 148 kg ha^{-1} N (18+70+60). Planting was carried out with by hand handled planter at 3 – 4 cm depth. Corn was planted accordingly early for specific year: on May 9 (19), 2000, May 8 (28), 2001, May 7 (17), 2002, May 15 (24), 2003. Data in parentheses indicate the second, delayed planting date of one (standard) hybrid every year. Weeds were controlled spraying herbicides (metil-primisulfuron 0.04 kg ha^{-1}+ dikamba 0,1 l ha^{-1}) and mechanically. Harvesting was done on September 29, 2000, September 25, 2001, September 17, 2002 and September 19, 2003.

Following observations were carried out: entering of phenological phases - germination and flowering (tasseling and silking), stand density before harvest in plants per ha (data are not presented), plant height before harvesting, m, green and dry matter yield, t ha^{-1}. Following quality analyses for every hybrid were carried out using standard methods: content of DM of whole plant and corn-cob, %, crude protein (data are not presented), % in dry matter, NDF and ADF, % in dry matter, ash, Ca, P, in % (data are not presented). Sampling was done three times during September with 10 days' interval: 1st ten-day period, 2nd ten-day period and 3rd ten-day period for demonstrating quality changes and designation the more suitable harvest time of corn. One time of sampling every year synchronized with harvesting date.

Three plants were taken for each sample, hand harvested by cutting 5 cm above the soil surface. Some parameters were calculated in addition: digestible dry matter DDM % = 88.9 – (0.779 x ADF); net energy for lactation NEL MJ kg^{-1} of dry matter = (0.0245 x DDM % - 0.12) x 4.184.

Results were statistically analysed using ANOVA procedures, correlation and regression analyses.

Meteorological conditions

Meteorological conditions were variable in the years of experimentation, and the main indices, average daily temperature and precipitation, are characterized in Table 1.

Table 1. Temperature and precipitation compared with meteorological norm during 2000 - 2003.

Month	Average daily air temperature, ?C					Precipitation, mm				
	2000	2001	2002	2003	Norm	2000	2001	2002	2003	Norm
May	11.5	11.0	14.5	12.0	11.2	62	37	16	16	43
June	13.7	12.6	15.8	14.3	15.1	33	170	100	49	51
July	15.2	19.1	18.8	19.7	16.6	78	124	174	44	75
August	14.5	16.3	19.5	16.1	16.0	46	75	0	115	75
September	13.1	11.7	12.2	11.9	11.5	69	108	35	36	59

Spring frost after corn emergence was observed only in 2002 (min –2.1 ?C), corn was damaged, but not frost-bitten. Fall frost before corn harvesting were observed only in 2000 (between 0 ?C and –1 ?C; corn was not frozen). Summarising meteorological description, one could say that the best suitable for corn growing was year 2002, following by 2003, 2001, and the worst was year 2000.

Results

All hybrids sown in trial were selected as possibly suitable for growing in marginal for corn area, however they were somewhat diverse according to earliness. Despite rather good DM yields obtained in every experimental year (Table 2), year as factor had the main effect on DM yield and DM content of whole corn plant at harvest ($p<0.01$).

Better yields with higher DM content are harvested in years with higher air temperature. Looking on four year period, correlations are found between average air temperature of growing season and DM yield ($r = 0.55$; $p = 0.01$), and accumulation of corn heat units (CHU) and DM yield ($r = 0.574$; $p = 0.01$). DM content (y) at harvest is closely correlated with the accumulated CHU (x) during the growing season: $y = 0.02x – 9.63$; $R^2 = 0.82$ ($p<0,001$).

Our data is connected with findings of other researchers reported by Shaw (1988). Substantial correlation was found during four year period between the plant height (x) and DM yield (y): $y = 7.86x – 5.09$; $R^2 = 0.56$; ($p<0.001$). Average plant height in trial was 2.46 m (2.00 – 2.74 m) in 2000, 2.29 m (1.84 – 2.70 m) in 2001, 2.50 m (1.91 – 2.80 m) in 2002 and 2.40 m (2.24 – 2.54 m) in 2003. Looking on separate years, correlation across genotypes were found in 2000, 2001 and 2002 ($r=0.88$, $p=0.01$; $r=0.67$, $p=0.05$; $r=0.91$, $p=0.01$, respectively), but not found in 2003 possibly explained by the similar plant heights among hybrids (coefficient of variation was 4 %). It validates our previous findings (Gaile, 2000).

Table 2. DM yield and DM content of whole corn plant in 2000 – 2003

Indices	DM yield, t ha^{-1}				DM content at harvest, %			
	2000 n = 7	2001 n = 7	2002 n = 11	2003 n = 10	2000 n = 7	2001 n = 7	2002 n = 11	2003 n = 10

Average / min – max of all hybrids	12.61 5.9 - 15.2	11.54 7.79 - 14.86	15.85 11.24 - 17.96	13.79 12.67 - 14.87	23.63 21.42 - 26.02	27.18 23.48 - 30.51	35.87 31.43 - 42.42	30.15 27.94 - 32.84
Standard	13.42	11.81	16.86	13.66	23.36	30.27	34.30	29.54
Standard sown later	12.06	11.00	14.80	12.67	23.02	24.37	34.38	27.94
Latest hybrid in trial*	13.00	14.86	17.96	12.94	23.84	26.84	35.80	29.54
$LSD_{0.05}$ for hybrids	1.09	1.22	2.37	1.09				

*- latest hybrid in trial detected in unsuitable - for - corn growing year 2000 judged by silking date.

For years, the first criteria of the nutritional value of corn hybrids for silage was equated with their grain content and dry matter content at harvest (Coors, 1994, Darby and Lauer, 2002). The proper planting date should be chosen. Our results are in agreement with the data from literature (Lauer, 2003) and show, that right-minded earlier planting date gives higher yield with better DM contents, particularly in years not very favourable for corn growing (Table 2).

Yield difference was substantial in 2000, 2003 and on average for four years ($p < 0,05$). In some years (2001, 2003) notable difference of DM content of whole plant was demonstrated, too. More striking effects of planting date and peculiarities of specific hybrid appears if we speak about DM yield of corn-cobs and density of corn-cobs in whole plant DM yield (Table 3). Yield of corn-cobs in 2003 was affected also by very uneven distribution and small total sum of precipitation. Plants apparently suffered during the critical phase of flowering due to the lack of moisture in late July of 2003.

Table 3. DM yield of corn-cobs and density of corn-cobs in the whole plant DM yield in 2000 - 2003.

Indices	DM yield of corn-cobs, t ha^{-1}				Density of corn-cobs, %			
	2000 n = 7	2001 n = 7	2002 n = 11	2003 n = 10	2000 n = 7	2001 n = 7	2002 n = 11	2003 n = 10
Average / min – max of all hybrids	6.10 2.89-8.95	6.12 4.63-7.44	8.10 6.53-9.84	5.67 3.85-7.43	48.21 37.19-59.03	51.45 42.05-58.22	51.49 44.42-59.64	40.96 26.86-54.05
Standard	7.92	7.41	8.79	6.06	59.03	58.22	52.32	44.39
Standard sown later	5.13	5.27	6.57	4.76	42.70	47.84	44.42	37.66

Latest hybrid in trial*	5.30	6.37	8.52	3.90	40.86	42.05	47.91	29.96
$LSD_{0.05}$ for hybrids	0.60	1.10	0.82	0.91	3.66	10.09	5.77	5.92

Data in literature suggest that corn quality varied across the harvest times. Harvesting forages when they are too wet or too dry makes the silage susceptible to effluent losses and respiration losses, respectively (Darby and Lauer, 2002). In Latvian conditions the main problems could arise due to very cool growing season (1998, 2000), inappropriate hybrid selection or incorrect growing manner, including planting and harvesting dates. The first ten-day period of September mainly is not the proper time for corn harvesting in Latvia (Figure 1). Only in very few years (for instance, 2002) it is possible to start harvesting before September 10 and to get yield with proper DM content, high energy, and low NDF and ADF content. In connection with data found in literature (Darby and Lauer, 2002) our experiments show that generally concentration of DM increases, but that of NDF and ADF decreases as the season progressed. A decline in fibre concentration with increasing maturity can be attributed to the dilution effect created by increasing content of grain as corn matures (Coors, 1994).

Differences from these general regularities are documented in year 2002, when samples taken in the very end of September show increase of NDF and ADF content, and decline of NEL. It could be explained at first by very mature grain – maturity stage very close to black layer. Darby and Lauer (2002) reported similar data in that NDF began to increase as corn approaches black layer. Besides they referred to findings of Bal et al. (1997) and Wiersma et al. (1993) who reported analogous results. But other condition determining higher NDF and ADF content in the whole plant DM could be the fall frost with the following rain some days before the third sampling of corn in 2002 (already after the main yield harvest).

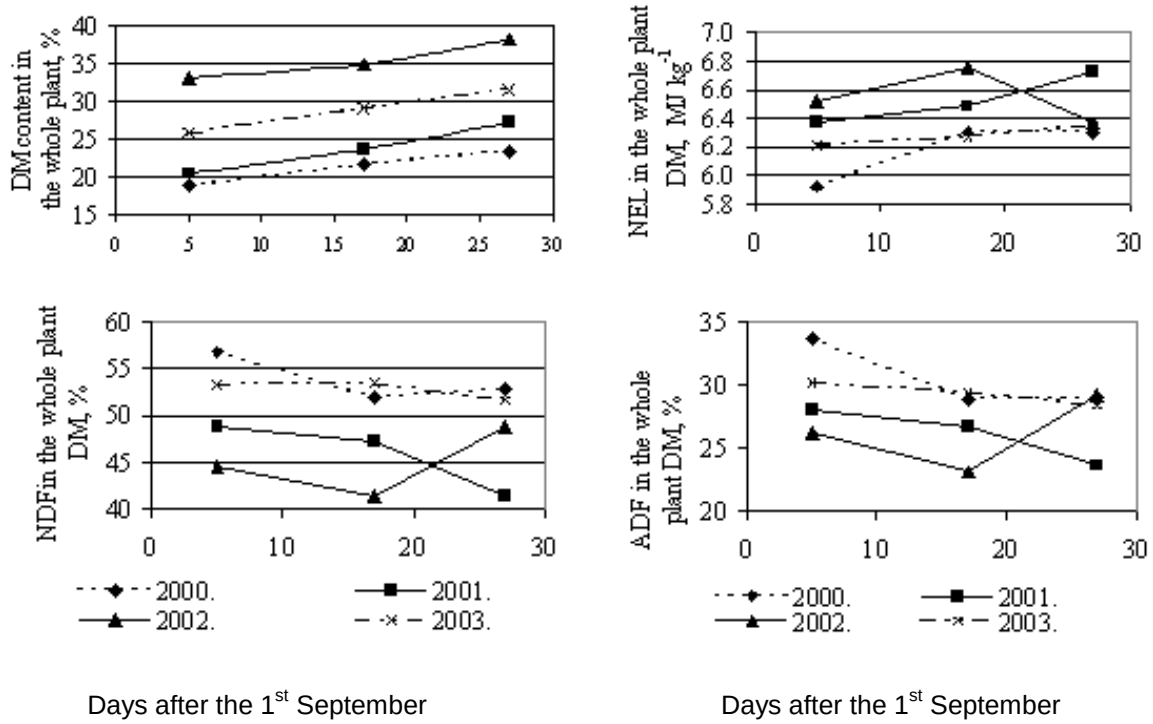

Figure 1. Changes of DM, NEL, NDF and ADF content in DM during September. Each data point is the mean across three hybrids in specific year.

Conclusion

Generally, it is possible to grow corn for energetically dense silage making in Latvian conditions despite of several cool seasons. Main points to consider are right-minded early planting date that depends from conditions of particular season, mainly temperature, and proper harvesting date which should be chosen by results of DM analyses, but not by date in calendar. Certainly, proper hybrid selection is very important, too, but so far forth hybrids tendered in Latvian market mainly all are early maturity it is hard to highlight now some of them as the best suitable due to diversities of growing seasons. If the season is wormer – little later maturity hybrids showed the best performance and in addition – good quality (2002), but if season is cool – one should choose earlier hybrid for good performance and satisfactory quality (2000).

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